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Some Soil Characteristics Affecting Capillary Rise

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THE CURRENT study was performed at the Aboshrouf Land Reclamation Project in Siwa Oasis, Egypt. Three field Locations at virgin areas were chosen . The water table at the studied areas ranged between 90 and 120 cm . OM . soil structural unit size fractions , $CaCO_3$, $CaSO_4 . 2H_2O$, bulk density, cation exchange capacity and water dissolved salts and soil pH were determined . These soil characteristics let θ_v amounted to 15.30-29.80 % at 90 - 110 cm above water table through capillary rise. Such upward capillary flow at a field location was in equilibrium in occurrence of natural vegetation (halophytes) ,with ETo and Rs of 7.7 - and 10.7 mm / day, respectively. At the three locations , increased θ_v downward reaching near to saturation point at water table.

Data reveal that the main characteristics enhancing upward capillary flow in the studied area are : high OM - , soil structural unit size fractions of < 45 and < 63 µm in diameter - , $CaCO_3$ - , $CaSO_4.2H_2O$ - and Ca^{2+} content and high cation exchange capacity , low content of Mg^{2+} and Na^+, and bulk density of low value of layers above water table that induce formation of effective continued capillary pores of 8.6 - 0.2 µm in diameter.

Such upward capillary flow should be subtracted from the irrigation duties. High salt tolerant crops (halophytes) production is preferred . So, irrigation water could be partially saved and its costs would be reduced. Hence more land reclamation could be achieved . Also, such utilizing of upward capillary flow would control high level water table problems attaining suitable root zone aeration and minimizing salt accumulation where there are no drainage outlets in Siwa Oasis. In other words, soil pollution through unsuitable (resultant through reduction processes) gases and salt accumulation would be controlled.

Keywords : OM , soil structuial unit size fractions, $CaCO_3$, $CaSO_4$. ZH_2O, bulk density, cation exchange capacity, Ca^{2+}, Mg^{2+}, Na^+ , water table, capillary rise, upward capillary flow, wetting and θ_v, effective continued capillary pores of 8.6-0.2 µm in diameter, soil moisture retention.

Schakschouk (1998 and **1999)** found that upward capillary flow **(UCF)** let θ_v at 117 cm above water table amonted to 1.83 vol. % through soil of 1.598 **g/cm3** soil bulk density and **1.35** and **33.31 w/w%** soil structural unit size fraction diameters of < 63 and <250 µm, respectively, on the average . He added that upward capillaiy flow let θ_v at 235 cm above water table amounted to 6.30 vol. % through 1.400 g / cm^3 soil bulk density and 2.05 and 20.09 **w/w** % soil structural unit size fraction diameters **of<** 63 and **< 212 µm,** respectively, on the average. **Wolkewitz** (1964) , **Digleria** ***et al.*** **(1962)** and Busch (1956) in **Supersperg (1981)** reported capillary rise of 88.5 , 122 - **37** and 30 - 100 cm through soil structural unit size fraction diameters of 60 - 200µm, respectively.

The research aimed to control and make use of water table.

Material and Methods

The current study was performed at the **Aboshrouf Land** Rectamation Project, Siwa Oasis , Egypt. three field locations at virgin areas were chosen for this study **(Fig.1).** The three locations received no irrigation water . Three soil profiles were dug to the water table (WT); 0 - **90** , 0 -120 and 0 - 110 cm at locations 1,2 and 3, **respectively.** At midday, representative disturbed and undisturbed soil samples were taken every 10 cm . Water soluble salts (WSS) , organic matter (OM) , cation exchange capacity (CEC) , pH , θ_v , $CaCO_3$, $CaSO_4 .2H_2O$ content , bulk density (D_b) and soil structural unit size fractions **(SSUSF)** were determined according to **Rowell (1994).** One month later , soil cores were collected to determine soil moisture retention . WT raised to be at - **110** and **-80 cm** at locatioins 2 and 3, respectively, but it did not vary at location 1. Tables (1-4) and Fig. (2-5) present the results . D_b was determined at θ_v shown in Table 1. The mean climatic data during the study period (4 -13 Sept., 1995) were 30.7°C air temperature, 45.18 % RH , 1.17m /s day time wind speed and **10.84** h / day sun shine . according to the Egyptian Meteorological General Organization (1995). For such study period , **ETo** equaled 7.7 **mm/** day. Rs , in equivalent evaporation from an open water surface , equaled 10.70 mm/ day, using the Radiation method after Doorenbos and **Pruitt** (1977). Precipitation did not occur . Dew point impact was neglected , because sampling occurred at midday.

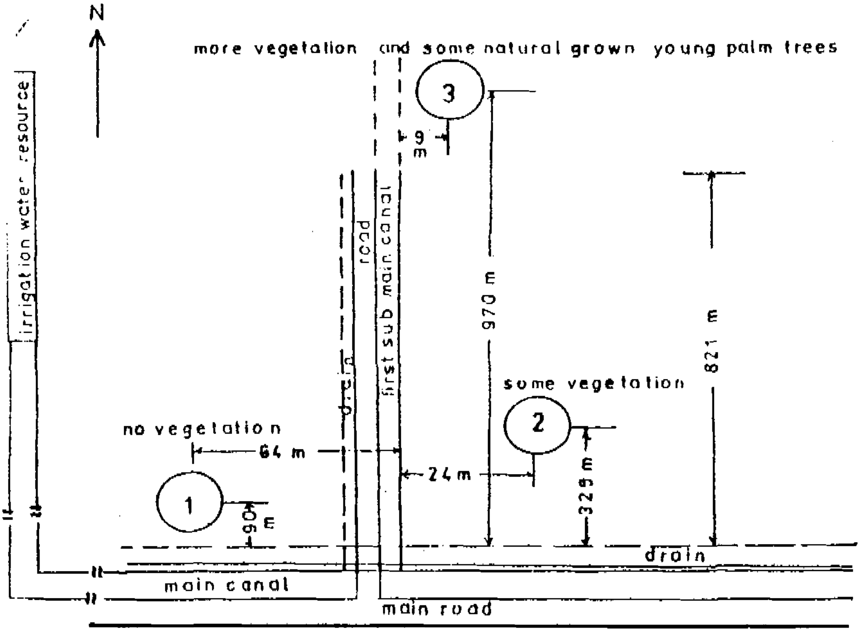

Fig. 1 Field locations (soil profiles) 1 3 at aboshrouf land reclamation project in Siwa Oasis, with no scale

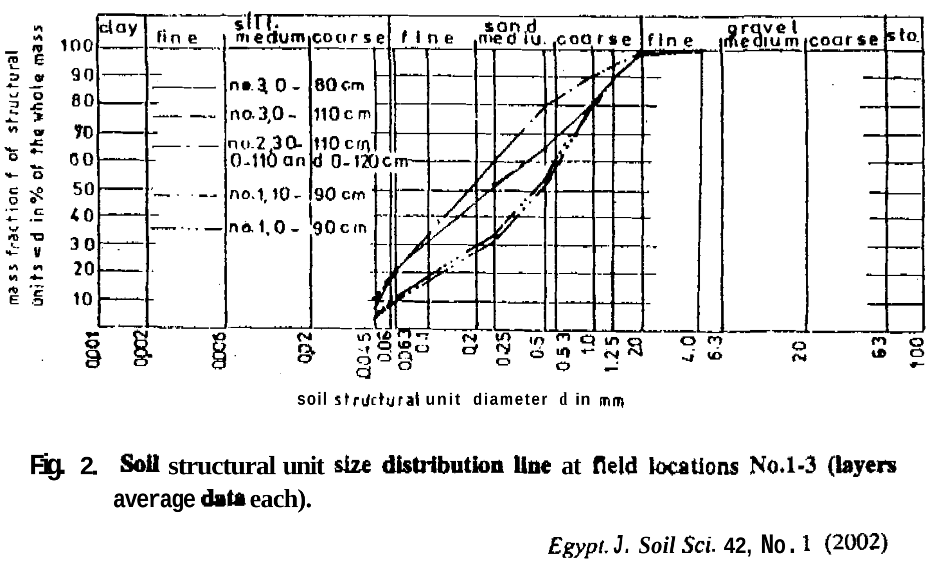

Fig. 2 **Soil** structural unit **size distribution line** at **field** locations No.1-3 **(layers** average **data** each).

TABLE 1. Some soil chemical properties at **studied field locations.**

Field location No.	Depth, cm	Soluble ions, mequiv. / 100 g. soil								OM, %	CEC, Mequiv. / 100 g soil	pH
		Cations				Anoins						
		Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	CO_3^{2-}	HCO_3^-	CL^-	SO_4^{2-}			
1	0 - 10	32.77	60.39	496.30	62.43	-	28.90	207.28	415.70	8.81	31.40	8.54
	10 - 20	45.96	95.98	269.74	14.08	-	14.33	18.58	392.85	14.61	27.44	8.63
	20 - 30	10.11	43.80	105.90	8.92	-	3.73	4.67	160.33	14.02	33.34	8.54
	30 - 40	9.80	29.88	83.54	8.18	-	2.64	3.12	125.64	14.92	36.14	8.48
	40 - 50	9.90	30.27	45.64	8.16	-	3.45	2.11	88.41	10.69	45.89	8.45
	50 - 60	9.28	38.65	45.67	7.65	-	3.41	2.09	95.55	10.98	41.30	8.45
	60 - 70	13.36	26.56	35.45	6.46	-	4.09	1.98	75.76	16.31	36.72	8.42
	70 - 80	3.97	16.50	31.28	2.67	-	2.24	1.70	50.48	9.59	32.84	8.42
WT	80 - 90	5.92	24.55	57.55	5.04	-	4.56	3.04	85.46	10.08	43.96	8.42
2	0 -10	20.73	163.24	548.04	55.56	-	25.57	42.92	719.08	14.14	76.22	8.57
	10 - 20	18.63	99.60	507.04	8.36	-	5.90	23.60	604.13	17.46	64.98	8.39
	20 - 30	15.76	45.94	418.06	20.18	-	6.16	18.36	475.42	14.52	82.60	8.20
	30 - 40	13.07	55.28	327.48	16.48	-	5.04	17.20	390.07	15.38	96.38	8.02
	40 - 50	10.52	48.94	427.33	20.33	-	2.99	19.84	484.29	19.61	78.10	8.00
	50 - 60	11.20	58.71	359.61	18.27	-	3.03	18.05	426.71	16.90	92.50	7.94
	60 - 70	12.80	88.37	252.11	14.14	-	2.97	11.47	352.98	19.26	93.60	8.01
	70 - 80	10.96	58.80	279.01	14.35	-	2.92	12.43	347.77	20.84	102.12	7.97
	80 - 90	11.86	63.32	129.42	9.14	-	2.98	6.34	204.42	21.67	95.90	8.01
	90- 100	17.91	60.96	455.77	23.62	-	3.03	9.96	545.27	15.34	84.30	8.23
	100 - 110	11.92	45.79	230.90	13.85	-	3.00	11.59	287.87	18.21	104.82	8.28
WT	110 - 120	12.40	50.82	298.99	16.69	-	3.03	12.31	363.56	-	-	8.18
3	0 - 10	30.67	44.79	349.90	52.96	-	17.73	26.00	434.59	17.46	68.07	8.40
	10 - 20	21.05	64.17	328.13	11.57	-	25.49	15.35	387.86	17.72	79.29	8.19
	20 - 30	20.49	40.00	289.38	13.03	-	8.86	22.00	322.06	11.36	50.10	8.23
	30 - 40	13.26	8.34	182.30	9.50	-	24.38	10.00	179.02	22.19	179.87	8.28
	40 - 50	22.22	21.80	212.43	25.92	-	14.41	14.00	253.96	18.58	110.34	8.20
	50 - 60	45.42	12.50	210.72	20.10	-	9.95	21.33	257.46	19.09	79.23	8.08
	60 - 70	18.53	32.00	143.57	10.59	-	16.63	11.33	176.73	16.92	71.94	8.13
	70 - 80	16.08	40.00	161.50	7.31	-	8.29	9.04	207.56	34.17	96.37	8.23
	80 - 90	32.70	72.12	406.23	4.38	-	37.51	60.00	417.93	-	-	8.16
	90- 100	43.75	68.75	474.50	21.92	-	38.01	86.12	484.79	-	-	8.22
WT	100-110	54.50	90.00	461.37	22.65	-	11.37	62.60	554.55	-	-	8.19

Results and Disscusions

Some lines representing the results in Fig. (2 - 5) are overlapping completely; as in Fig.(2) or to some extent in the others , due to some similarity of such results. It is evident from Table (2) and Fig. (2) that the finer SSUSF < 45 µm ranges from 3.03 to 5.88 , 4.26 to 14.47, ignoring the abnormal values , and 3.47 *to* 11.91 w /w % for the soil profiles 1, 2 and 3, respectively . In other words , the content of colloidal SSUSF of< 2 µm in diameter would be low . Hence , impact of soluble Ca-cations upon coagulation and soluble Na-and

Mg-cations upon dispersion of colloidal SUSSF would be ignored. In this case, the effect of such cations upon port size distribution is neglectable. Their impact upon enhancing or inhibition of soil water capillary movement would be ignored. Moreover, water movement by osmoses in soil in large scale is not included due to lack of semi-permeable membrane according to Rowell (1994). On the other hand, there might be an organic colloidal fraction as sole fractions or cementing other SSUSF. The impact of soluble Ca-cations upon coagulation and soluble Na- and Mg-catioins upon dispersion of the organic colloidal fraction is pronounced. The OM-content of soil profile 2, ranging from 14.14 to 21.67 w/w %, is similar to that of soil profile 3 (11.36 to 34. 17). Both were higher than that of soil profile 1 (8.81 to 14.92), (Table 1). Hence, the range of the organic colloidal fraction of each of locations 2 and 3 may be greater than that of

TABLE 2. Other soil chemical properties and some physical at studied field locations.

Field location No.	Depth, cm	θ_v, %	$CaCO_3$, %	$CaSO_4.2H_2O$, %	D_b, g / cm^3	SSUSF, % < 45 μm	< 63 μm	< 250μm
1	0 - 10	15.30	-	17.43	1.180	5.88	15.16	49.11
	10 - 20	30.20	-	2.57	1.112	3.69	11.74	38.21
	20 - 30	25.00	-	2.88	0.966	5.24	12.14	37.87
	30 - 40	41.40	-	2.32	0.776	4.00	7.11	30.10
	40 - 50	25.00	4.44	2.72	0.845	3.18	6.32	25.89
	50 - 60	25.10	2.51	1.49	0.744	3.03	5.69	23.96
	60 - 70	29.70	-	2.03	0.707	3.47	6.85	28.44
	70 - 80	31.30	29.65	5.14	0.647	3.66	7.01	32.71
WT	80 - 90	55.30	15.02	3.60	0.692	4.71	8.56	36.26
2	0 - 10	21:50	0.27	5.40	0.898	14.47	32.46	72.20
	10 - 20	48.10	-	2.76	0.976	10.06	20.68	60.89
	20 - 30	33.40	-	5.17	0.748	6.14	12..98	52.72
	30 - 40	35.40	-	3.64	0.797	4.26	9.57	46.07
	40 - 50	36.90	-	4.17	0.739	8.31	15.11	58.75
	50 - 60	47.70	-	3.39	0.733	8.10	14.74	53.70
	60 - 70	38.30	-	2.49	0.828	8.95	15.70	54.23
	70 - 80	56.70	-	2.20	0.904	16.71	31.04	79..53
	80 - 90	31.50	0.25	5.00	0.861	6.07	10.46	48.43
	90 - 100	79.00	6.68	3.73	0.764	21.83	36.27	77.86
	100- 110	66.90	4.19	3.10	0.861	11.78	25.02	63.49
WT	110 - 120	58.70	-	3.39	-	-	-	-
3	0 - 10	29.80	39.92	13.17	0.476	11.91	24.43	59.19
	10 - 20	43.10	32.82	10.20	0.417	8.57	18.80	55.22
	20 - 30	45.30	51.48	5.44	0.510	11.42	22.19	50.33
	30 - 40	45.00	49.21	3.01	0.528	3.47	.19.03	48.35
	40 - 50	56.20	48.14	6.95	0.542	5.34	21.62	49.72
	50 - 60	58.70	50.47	5.38	0.453	5.18	21.59	51.06
	60 - 70	59.60	59.77	3.86	0.454	5.57	21.43	57.00
	70 - 80	73.60	43.48	3.24	0.930	3.78	18.24	44.72
	80 - 90	73.90	41.05	3.80	-	-	-	-
	90 - 100	77.40	39.45	3.02	-	-	-	-
WT	100 - 110	87.00	35.43	2.35	-	-	-	-

location **1**. Ignoring the abnormal measurement values, especially at 0 - 20 cm soil layers due to salt accumulation, the range of soluble Na^+ at location 2 (**129.42 - 427.33** mequiv. /100 g soil) is higher than that at location 3 (143.57 - **349.90**) and much higher than that at location 1 (**31.28-83.54**), (**Table1**). Thus, the dispersion impact upon the organic colloidal fraction at location 2 would be greater than that at location 3 and much greater than that at location 1. In other words, the formation of effective and continued capillary pores at location 2 would be less than that at location 3 and much less than that at location **1**, ***i.e.***, less capillary water flow at location 2. Such capillary water movement inactivation might be compensated by the capillary water movement enhancing at location 2, that might be induced by the higher occurring range of finer **SSUSF** < 45 μm mentioned above. The explanation of soluble Na-cations and conclusions about inactivation of capillary movement of water are also valid for soluble Mg-cations (Table 1). Moreover, the range of soluble Ca-cations at location 3 (**13.26-45.42** mequiv. /**100** g soil) equals about the double of that both at 1 (3.97 **-32.77**) and **2** (**10.52-20.73**), (Table **1**). **Thus**, the coagulation impact of soluble Ca-cations upon the organic colloidal fraction at location 3 would be greater than that at both locations 1 and 2. In other words, the formation of effective continued capillary pores at location 3 would be greater than that at both locations 1 and 2, *i.e.*, greater capillary water movement at location 3 than that at both locations **1** and 2. The higher the CEC, the higher the impact of ions is upon coagulation or dispersion of soil colloidal fractions CEC of location 3, ranging from 50.10 to **110.34** mequiv. /**100 g** soil and of location 2 (64.98 **-104.82**) was higher than that of location 1 (**27.44 - 45.89**). This can be interpreted as higher upward capillary flow (**UCF**) at locations 2 and 3 than the one at location 1.

TABLE 3. Partially- and undecomposed plant residues (P.R.) of >4 mm length, >4 mm diameter gravel (G.) and gravel calcium carbonate ($G.CaCO_3$) content in W/W% in location No. 3.

DEPTH, CM / ITEMS	0 -10	10 - 20	20 - 30	30-40	40 - 50	50 - 60	60 - 70	70 - 80	80 - 90	90 - 100	100 - 110
P.R., %	1.66	3.90	1.45	0.31	0.50	1.61	1.39	0.54	-	-	-
G., %	2.89	6.07	4.94	9.26	12.00	8.03	6.20	22.51	-	-	-
$G.CaCO_3$, %	45.15	52.26	75.27	74.16	83.1	71.50	72.67	74.20	72.60	84.70	67.30

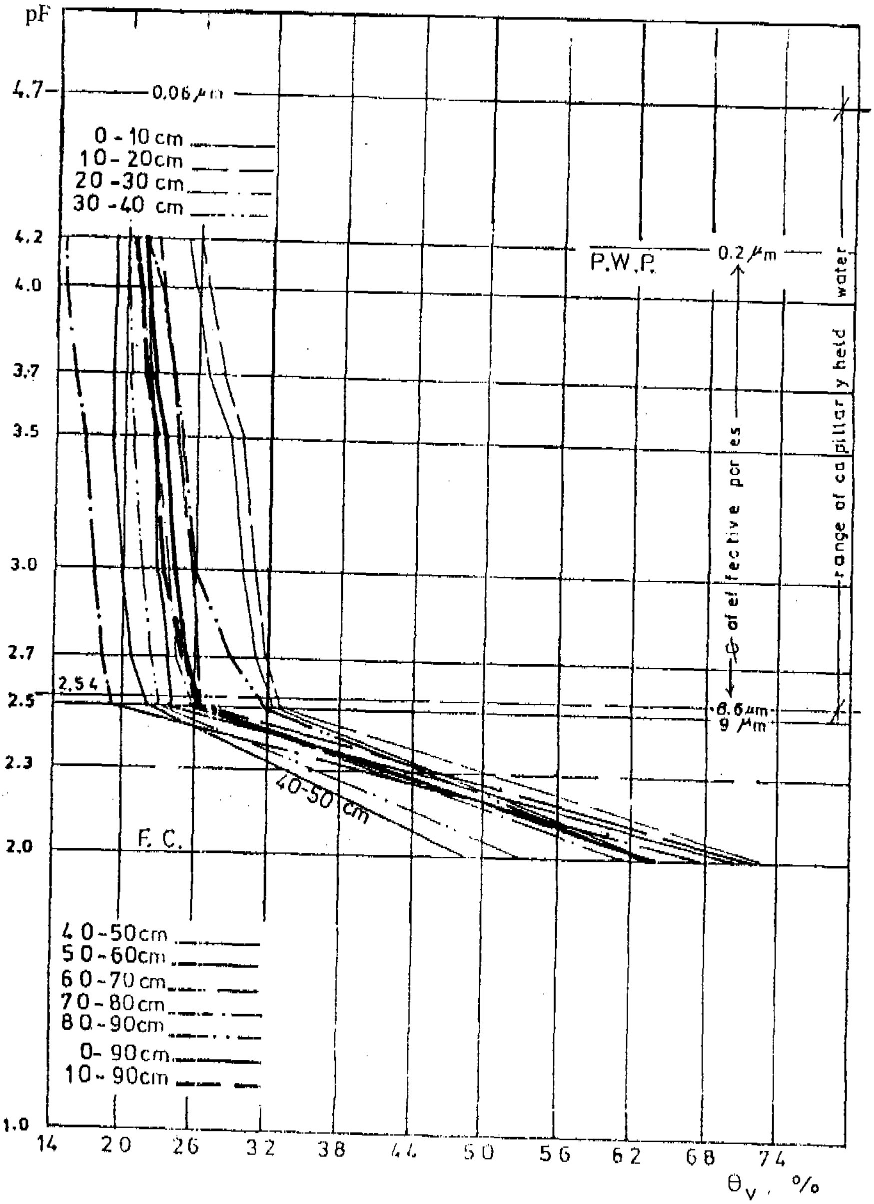

Fig. 3. Soil moisture retention at location No. 1.

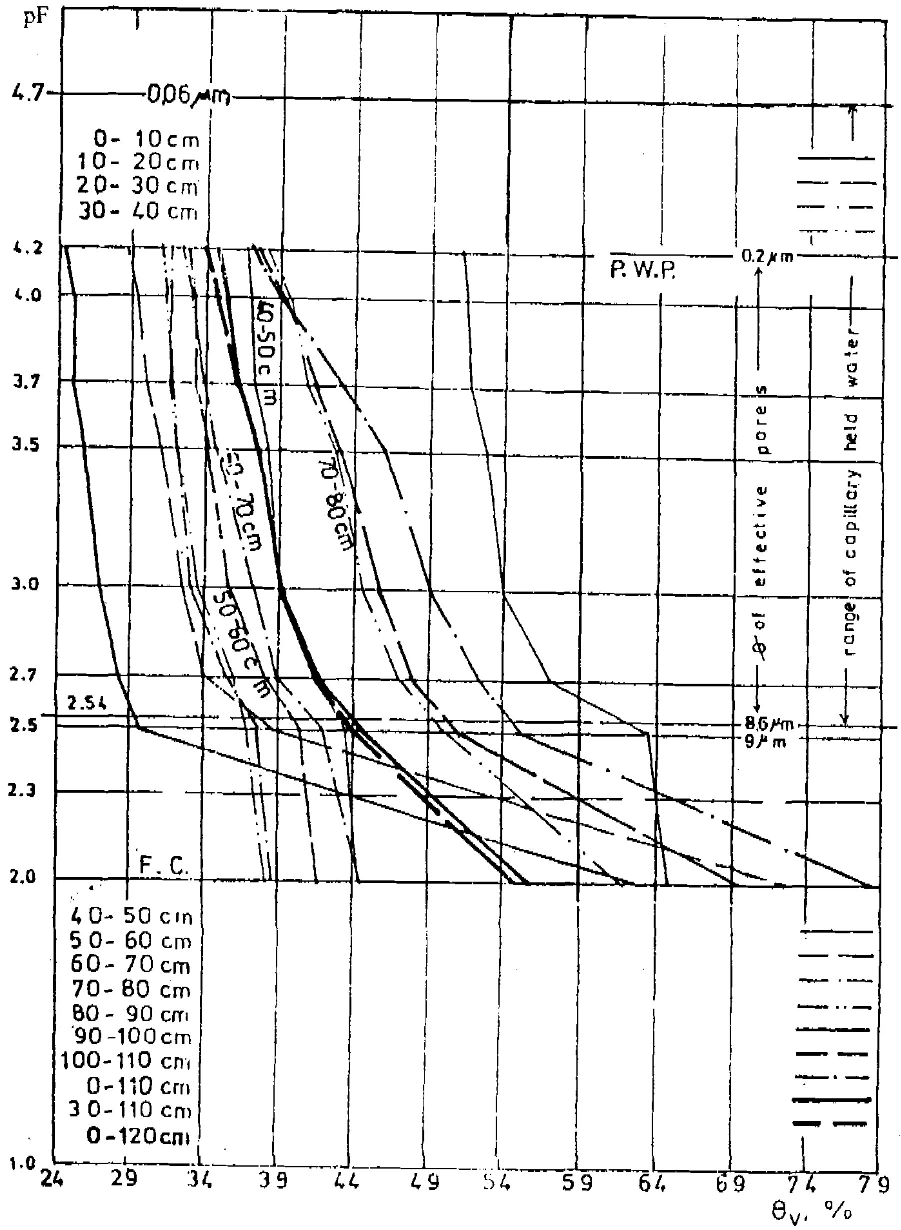

Fig. 4. Soil moisture retention at location No.2.

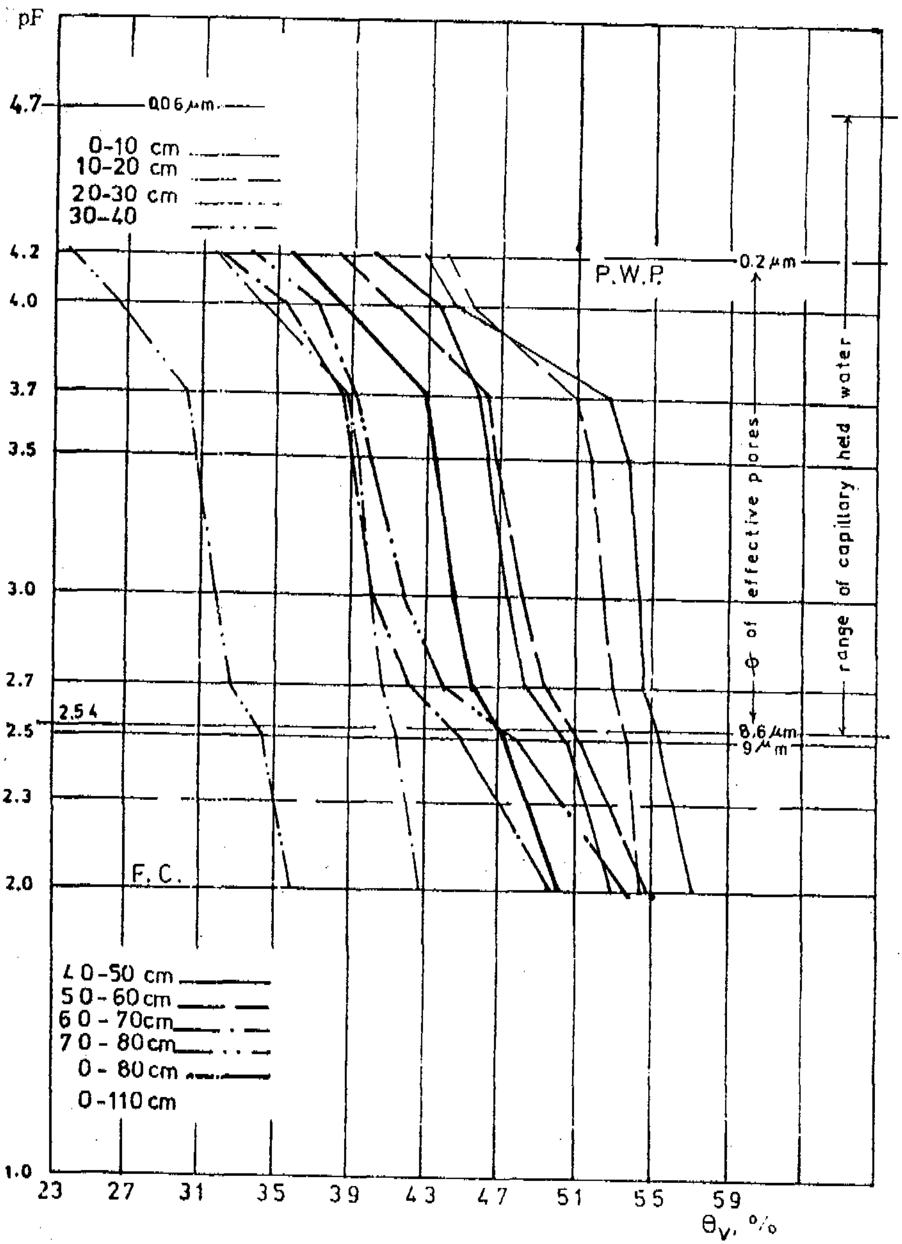

Fig. 5. Soil moisture retention at location No. 3.

Figure 3 shows that the 10 - 90 cm soil layers at location 1 have θ_v at FC ranging from 48.19 to 72.36 ,with an average of 63.38 . It reveals also that θ_v at PWP is ranging from 14.70 to 26.00, with an average of 20.68 . Thus , θ_v at the available water equals 63.38-20.68=42.70, on the average. Table 2 discloses that UCF attained θ_v at 10 - 90 cm soil layers of location 1 ranging from 55.30 at WT to 25.00 at 80 cm above WT with an average of 32.90. Thus the attained θ_v through UCF equaled { (32.90 -20.68) /42.70} 100 = 28.62 % of available water, on the average . Via such explanation , it would be concluded that UCF produced θ_v of 64.88 and 154.4% of available water, on the average, at soil layers of 10 - 110 and 20- 80 cm depth at locations No. 2 and 3, respectively, Table 2 and Rg. 4 & 5. The attained wetting in 0-10 , 0-10 and 0 - 20 cm soil layers at locations No.1,2 and 3, respectively , was less than PWP, (Table 2 and Fig. 3 - 5). As mentioned in material and methods, the WT oscillates . In one month, such oscillation at location No. 1 was neglectable. Absence of halophytes at location No. 1 emphasizes that wetting of 0 - 10 cm soil layer , which might be attributed to probable raising of WT, is Continuously lower than PWP . As for location No.2, in one month WT raised 10 cm, meaning raise of θ_v of 0 -10 cm layer above PWP enhancing halophytes germination . Some plants occur at location No. 2 . At location No, 3 , WT raised 30 cm only in one month. Hence , it might be concluded that θ_v at 0-10 - and 10 - 20 cm layers would be higher than PWP facilitating germination at a rate higher than that at location No. 2, where attainedd available water at location No.3 would be higher than at No, 2. More halophytes occurred at location No. 3 than at No. 2.

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تأثير بعض خواص التربة على رفع المياه بالخاصة الشعرية

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تميز أحد المواقع في مشروع استصلاح الأراضي بأبي شروف بواحة سيوة بمصر ، بمدى من قيم بعض خواص التربة مثل المادة العضوية ، وأجزاء حبيبات التربة ذات القطر الأقل من ٤٥ . ٦٣ . ٢٥٠ ميكرومتر ، والجير والجبس ، والكثافة الظاهرية ، وسعة التبادل الكاتيونية ، وكاتيونات الكالسيوم والماغنسيوم والصوديوم الذائبة . حفز ذلك المدى من تلك الخواص رفع المياه بالخاصة الشعرية من مياه أرضية على عمق ١١٠ سم حتى تبلل طبقات التربةمن صفر-١١٠ سم ، وساعد ذلك الرفع بالخاصة الشعرية أن يصل محتوى التربة من المياه الى ٨٠ و٢٩٪ على أساس الحجم على إرتفاع ١١٠سم فوق منسوب المياه الأرضية. وقد توازن هذا الابلال لطبقات التربة مع ٧و٧مم/يوم بخر نتح، حيث نمت بالموقع بكثرة نباتات ذات تحمل عالي للملوحة وكذلك فسائل نخيل طبيعيا، وكذلك مع ٧و١٠ مم/يوم بخر من سطح ماء حر كإشعاع شمسي .

كذلك إحتوت التربة في موقع أخر على مدى أخر من الخواص المذكورة عاليه ، حفز ذلك المدى من تلك الخواص رفع المياه بالخاصة الشعرية من مياه أرضية عند عمق ٩٠ سم ليساعد علي زيادة محتوى التربة من المياه الى ٣و١٥٪ على أساس الحجم عند ٩٠ سم فقط فوق منسوب المياه الأرضية، وقد حدث هذا الإبلال مع عدم وجود نباتات.

وفي كل من الموقعين، زاد محتوى التربة من المياه الي اسفل حتي وصل الي قرب نقطة التشبع عند منسوب المياه الأرضية .

وعلى أية حال، فإن المحتوى العالي من المادة العضوية ومن أجزاء التربة ذات الحبيبات ذات القطر الأقل من ٤٥، ٦٣ ميكروميتر وكربونات الكالسيوم والجبس ، وكاتيونات الكالسيوم الذائبة وكذلك سعة التبادل الكاتيونية العالية، والكثافة الظاهرية المنخفضة للتربة، والمحتوى القليل من كاتيونات الصوديوم والماغنسيوم الذائبتين هي

والمحتوى القليل من كاتيونات الصوديوم والماغنسيوم الذائبتين هى العوامل الرئيسية التى تشجع تكون المسام الشعرية الفعالة ذات القطر ٢و٠-٦و٨ ميكروميتر والمتصلة التي تزيد رفع الماء شعريا لأعلى.

يجب الاكتفاء بممارسة الرى التكميلى فقط مع زراعة محاصيل عالية التحمل للملوحة، حيث لا توجد مخارج للصرف فى واحة سيوة. ذلك سيؤدى الى توفير مياه الرى وسيقلل كذلك من تكاليفه مما ييسر استصلاح مساحات أوسع من الأراضى لوضعها تحت الزراعة ، كما يعتبر ذلك احدى الوسائل المناسبة لاستغلال المياه المنخفضة الجودة ، وأيضا فان ذلك سيهيىء تهوية افضل بمنطقة نمو الجذور وسيقلل من تجمع الأملاح ، وذلك يعتبر مقاومة لتلوث التربة عن طريق المياه الأرضية .