LAND EVALUATION OF SELECTED AREA REPRESENTING EL-TINA PLAIN SOILS IN THE NORTH WESTERN PART OF SINAI PENINSULA.

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ABSTRACT

The aim of this study is to evaluate the soil characteristics of the reclaimed soils of El-Tina plain. The study area occupies 36000 feddans and located between latitudes of 30^{o}, 48 to 31^{0}, $15^{\backslash}$ N and longitudes of 32^{0}, $19^{\backslash}$ to 32^{0} – $40^{\backslash}$ E.

Seven soil profiles were selected to represent the reclaimed soils of El-Tina plain and were morphologically described. Some physical and chemical properties were assessed. Soil classification, land capability and land suitability were also done.

The results indicated that the values of soil moisture content at field capacity, wilting point and available water are mainly related to soil texture and salinity.

According to the taxonomic system, the studied soils could be classified into two orders (i.e Vertisols and Aridisols), three suborders (i.e. Aquerts, Torrerts and Gypsids) and their degradation up to the family level (i.e. five families).

The current suitability of the studied soils could be categorized into two suitability classes (i.e. marginally (S_3) and not suitable CN.) , which are suffering from wetness (W), some soil properties (i.e. soil) texture, salinity, sodicity, gypsum and $CaCo_3$ as soil limitations with different intensity degrees.

By matching the parametric approach of land indices and the requirements of some specific crops, the obtained data of soil suitability for some selected crops (22 crops) which are presented for

the studied soils as land suitability guide Tables, reveal that the current suitability classes were moderately suitable (S_2) for growing Maize, Barley, Cotton and Olive, marginally suitable (S_3) for cubage and not suitable (N_1) for other crops.

INTRODUCTION

Particularly from 1952 on words, the Egyptian Governorate devaluated a considerable effort for land reclamation to accelerate horizontal. Most of the reclaimed lands are desert soils and salt – affected soils having different properties which would change after reclamation practices.

El-Tina plain are occupies 36000 feddand and is situated east of the Suze Canal laying between latitudes $30^0 48^/$ and $31^0 15^/$ North and longitudes $32^0 19^/$ and $32^0 40^/$ East. The area extends from the south at El-Kantara to the North at Port Foad for 45 Km and a width of 30 Km. of El-Bardawil Lake. The land has an elevation of 0 to 20m. above Sea level.

The geomorphologic formations given here are according to Elwan et al (1983) and El-Taweel et al (1997) who pointed out that the northwestern part of Sinai (where El-Tina plain lies) embodies four distinct land forms (Fig. 1) they are coastal sand beach, El-Tina plain, deflated sand Terrain and Mobile elevated sand dunes.

From the geological point of view, El-Tina plain is located in this region, occupied by different rocks belonging to Holocene period. El-Fayoumy (1968), stated that they are mainly of Holocene epoch. They occur as beach, lacustrine, young evaporates upper territory deposits and aeolian deposits.

The natural vegetation in El-Tina plain is very poor and the most striking features in the area are barren. However, some ephameral grasses and desert shrubs apper during the rainy seasons in the wadis and between the dunes. Halophytes are also observed particulaly in the wet and salt affected areas. (Desert Inst. Staff 1981 and Hassan and Sharaf El-Din 1994)

The metrological recorded of port Said station (means of 10 years, 1989 to 1999) show that:

- The total mean rainfall is 7.8 ml/year
- The mean relative humidity is 70.0%
- Evaporation values range from 5.1 ml/day in January to 17.4 ml/day in July.

- Mean monthly temperature ranges between 14.2 C^{o} in Junuary and 27.3 C^{o} Augest.

According to the Egyptian Meteorological Authority (1996) and the American soil taxonomy (USDA 2006).The soil temperature regime of the study area is thermic and the soil moisture regime is torric.

The present study aims at evaluating soil characteristics of El-Tina plain soils after reclamation essential to a ssess their capability, characteristics including physical, chemical and mineralogical characteristics, soil classification, land capability for cultivation as well as land suitability for growing crops were carried out.

MATERIALS AND METHODS

Seven soil profiles were selected for this study to represent the new reclaimed project in Sinai peninsula (El-Tina plain project) Fig.1).

The morphological description for the studied soil profiles was done according to criteria given by the FAO guidelines for soil profile description (FAO 1994).

The collected soil sample (total of 22 soil samples) were air-dried crushed and sieved through 2mm sieve and subjected to the following analyses.

For determination of moisture retention cerves , bulk density, real density and hydraulic conductivity, undisturbed soil cores (2.5, 5 and 15cm high and 5 cm diameter) were collected in the location of the study area.

1- Laboratory analysis.

1.1. Chemical analysis

1. Soil reaction was measured in the soil paste using a pH meter, soil salinity was determined on the saturated paste extract using an electrical conductivity (EC) meter. Soluble ions were determined as follows:

Ca++ and Mg++ by the versenate method; Na+ and K+ by the flame photometer; Cl- by using Mohr,s method (Jackson 1958), CO3 = and $HCO3^-$ by titration against HCl; $SO_4^=$ by difference between total cations and anions (Jackson 1958).

- Organic matter content was determined according to the Walkey and Black method, (Black et al 1965).
- Calcium carbonate was determined using a calcimeter to give total carbonate in soil which is considered as $CaCO_3$ (Black et al 1965).
- Gypsum content was determined by precipition with acetone (Jackson 1958).

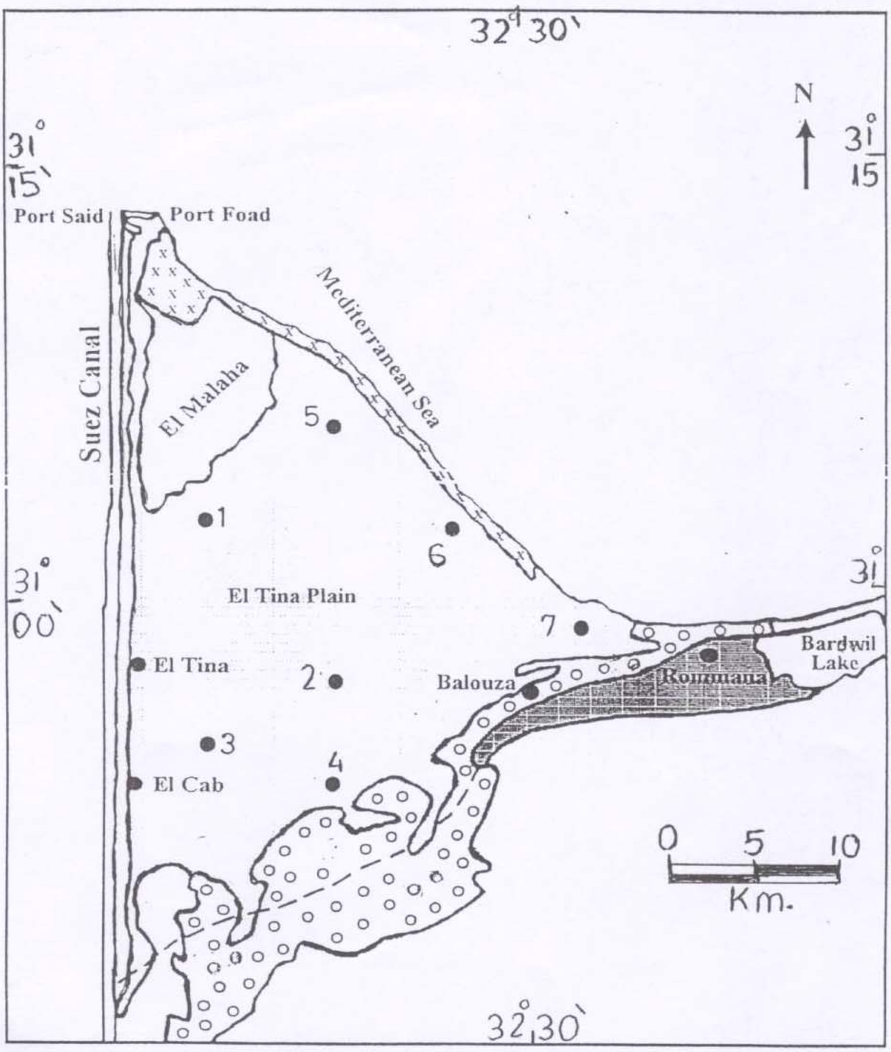

Fig (1) Location of the studied area and soil profiles

Exchangeable cation were determined according to (Tucker 1954)

- Total exchangeable cation were calculated as the some of exchangeable Ca^{++}, Mg^{++}, Na^{+} and K^{+} i.e. the cation exchange capacity

1.2. Physical analysis

- Particle size distributain was carried out by the pipette method (Piper 1950) often removal of soluble salts soil texture was determined using the American texture triangalon (U S D A 1975)
- Soil particle density (real density) was determined using kerosene as a displacing liquid according to Abd El- Aal (1974)
- Soil moisture retention curues were determined using undisturbed soil cores. Completely saturated soil corse were exposed to constant levels of 0.1, 0.33, 1.0, 2.0, 3.0 and 15.0 bars (i.e. 0.10, 33, 100, 200, 300 and 1500 kpa) using a pressure membrane apparatus (Stakman 1966). Moisture at 0.33 atm was considered field capacity; moisture at 15 bars was considered as the welting point (De Leenheer and De-Boodt 1965).
- Pore size distribution, the pore size of 28.8, 8.62 and 0.19 um diameter correspond to water contents at tensions of 0.1, 0.33 and 15 bars respectively. Such values of moisture content (considered on volume basis) were used for calculating the percentage of quickly drainable pores (QDP) > 0.28.8 um diameter; slowly drainable pores (SDP) i.e. 28.8 – 8.62 um diameter; water holding pores (WHP) i.e. 8.62 – 0.19 um diameter; and fine capillary pores (FCP) < 0.19 um diameter (De- Leenher and De-Boodt, 1965). Pore size distribution was calculated as percent of total volume as well as percent of total porosity.
- Saturated hydraulic conductivity was determined using the method reported by Richards (1954)
- Soils were classified according to the soil Taxonomy system, USDA 1975 and USDA 2006

- Land suitability classification was carried according to Sys and Verheye (1978). The main land characteristics which are considered as limiting factors for irrigation agriculture and land use are:

T: topographic limitation.
W: Wetness limitation (mainly based on drainage conditions)
S: Limitation with regard to physical soil conditions
S_1: Texture including stoniness
S_2: Soil profile depth
S_3: Calcium carbonate status, and
S_4: Gypsum status
N: Salinity and alkalinity limitation

Land suitability index was calculated for each soil profile. The suitability indices for irrigated land (Ci) would be calculated according to the following equation.

$$Ci = t \times (W/100) \times (S_1/100) \times (S_2/100) \times (S_3/100) \times (S_4/100) \times (n/100)$$

With respect to the current system, the soils are classified according to the following Table guidance:

Class	suitability index (ci)
S_1	+ 75
S_2	50-75
S_3	25-50
N	- 25

A suitability index of 22 crops for the studies soils was done according to Sys et al (1993).

RESULTS AND DISCUSSION

Soils are the product of the integrated environmental factors which act upon the parent materials with respect to the area under investigation the soils are formed and developed under desert to semi desert environments in arid regions pedological processes are relatively limited

The morphological characteristics of soil profiles could be due processes of soil formation and the modes of deposition and the nature of soil forming factors. The morphological description of the studied soil profiles are give in Table (1).

Table (1) Summary of the morphological description of the studied soil profiles.

Profile No.	Depth (cm)	Colour		Texture Classes	Structure	Consistency		Lower Boundary
		Dry	Moist			Dry	Moist	
1	0-15	10YR4/1	10YR3/1	C	w.c.s.	h	VS,VP	CS
	15-40	10YR4/3	10YR3/3	C	w.f.a	f	VS,VP	GS
	0-20	10YR4/3	10YR3/3	C	m.m.a	f	VS,VP	
2	0-35	10YR7/3	10YR6/3	C	m	h	VS,VP	CS
	20-40	10YR7/3	10YR7/3	C	w.c.s.	f	VS,VP	C
	40-50	10YR6/6	10YR6/6	SL	s.g	Lo	SS,SP	C
	50-75	10YR5/3	10YR5/3	C	m.m.a	f	VS,VP	CS
	75-120	10YR5/3	10YR5/3	C	w.f.a	f	VS,VP	CS
3	0-20	10YR6/3	10YR6/3	C	m	f	VS,VP	CS
	20-45	10YR3/3	10YR3/3	C	m.m.a	f	VS,VP	
4	0-25	10YR5/3	10YR5/3	C	m	f	VS,VP	C
	25-60	10YR5/4	10YR5/4	C	w.f.sa	f	VS,VP	CS
	25-100	10YR5/3	10YR5/3	C	m.m.a	f	VS,VP	
5	0-30	10YR5/6	10YR5/6	C	m	f	VS,VP	CS
	30-70	10YR4/3	10YR4/3	C	m.m.s	f	VS,VP	CS
	70-125	10YR7/1	10YR7/1	C	m	f	VS,VP	
6	0-20	10YR4/2	10YR4/2	C	m	Sf	VS,VP	C
	20-50	10YR5/4	10YR5/4	C	m	Sf	VS,VP	C
	50-100	10YR7/8	10YR7/8	C	m	Sf	VS,VP	
7	0-30	10YR5/1	10YR5/1	C	M	h	VS,VP	CS
	30-70	10YR3/2	10YR3/2	C	m.m.a	f	VS,VP	GS
	70-125	10YR4/3	10YR4/3	C	w.f.a	f	VS,VP	

Structure

w.c.s.b: weak coarse sub angular blocky

w.f.a.b: weak fine anglur

m.m.a.b: moderate medium angular

m.f.a.b : moderate fine angular blocky

w.f.sa.b: weak fine sub angular blocky

Consistency

h: hard f: fine sf: slig

Vs : very stick vp: very plastic

C: clear cs: clear smooth

Lower boundary

Gs: gradual smooth

Texture

C: Clay

SL: Sandy Loam

1- **General soil properties**

Soils of El-Tina plain are represented by seven soil profiles. It occupies the north western portion of Sinai peninsula. Topography in this area in almost flat surface. The soil parent material constitutes a mixture of Nile alluvium and lacustrine deposits some times having some sediments of Aeolian sand. The surface salt crust is a common feature in many patches

Soil colour varied from dark brown (10YR 3/3) to very pale brown (10YR 7/3), dry and very dark gray (10YR3/1) to pale brown (10YR6/3) moist. Soil texture in commonly clay throughout the entire profile depths. Soil structure is massive or weak coarse subangular blocky in the uppermost profile layers changing into moderately medium angular blocky in the lowermost layer. Soil consistence slightly sticky and slightly plastic to very sticty and very plastic.

As shown in Tables 2 and 3 calcium carbonate content ranges from 1.9% to 8.1%. The lowest is detected in the 40-50 cm depth of profile 2, while the highest content is found in the sub surface layer of profile 4 low percentage of these $CaCO_3$ is due to the alluvium nature of the deposit from which the soils are formed. Organic matter content is very low and does not exceed 1.9%. The extremely low contents of organic matter are due to the prevailing aridity of the region and its very scanty vegetation. Gypsum content ranges from 0.88 to 12.2% .The highest value of gypsum in El-Tina plain may be attributed to precipitation from the under ground water table and is also a consequence of soil salinity.

Data in Table (3) revel that the soil are slightly alkaline to moderately alkaline with pH of 7.7 to 8.3.The electrical conductivity values of the soil paste extract indicate a prevalence of salinity in the area The ECe rang from 3.45 to 174.0 dSm-1. The highest value is detected in the surface layer of profile 3 while the lowest is found in the 0-20 cm depth of profile 7.

Chemical composition of the soil saturation extract indicates that the dominant cations are Na+ followed by Ca+ and or Mg++1 while K+ ion is the least abundant.

The anionic composition is CL- >SO4-->HCO3- with no CO3--

Table (2) Particle size distribution, calcium carbonate, organic matter and gypsum contents of the studied soil profiles.

Profile No.	Depth (cm)	$CaCO_3$ %	O.M.%	Gypsum %	Particle size distribution %				Texture Class
					C. sand	F. sand	Silt	Clay	
1	0-15	4.66	1.45	3.44	3.20	29.60	22.00	45.20	Clay
	15-40	5.75	0.99	1.16	7.30	25.60	20.30	46.80	Clay
	40-65	6.45	0.45	2.17	6.30	15.80	25.30	52.60	Clay
2	0-20	3.45	1.30	0.88	3.00	27.00	23.00	47.00	Clay
	20-40	6.25	0.85	4.30	6.50	14.50	27.00	52.00	Clay
	40-50	1.90	0.10	12.20	9.40	72.10	8.50	10.00	SL
	50-75	4.35	0.20	9.10	2.60	24.00	25.30	48.10	Clay
	75-120	5.95	0.25	1.70	2.30	14.20	21.00	62.50	Clay
3	0-20	4.55	1.90	6.16	2.10	16.70	27.30	53.90	Clay
	20-45	4.00	1.40	5.65	2.40	16.60	25.50	55.50	Clay
4	0-25	6.15	0.99	3.17	2.00	17.00	21.30	59.70	Clay
	25-60	8.10	0.49	4.25	1.40	12.70	25.50	60.40	Clay
	60-100	5.35	0.20	1.40	1.80	11.30	22.00	64.90	Clay
5	0-30	6.05	1.00	2.10	2.90	20.80	21.20	55.10	Clay
	30-70	5.45	0.70	1.90	3.00	17.50	22.50	57.00	Clay
	70-125	3.25	0.30	2.00	2.80	11.30	25.30	60.60	Clay
6	0-30	5.15	1.15	1.60	2.20	15.70	21.00	61.10	Clay
	30-70	4.67	1.00	1.40	2.50	10.90	23.70	62.90	Clay
	70-100	3.15	0.30	1.80	3.80	5.70	25.60	64.90	Clay
7	0-20	6.69	0.85	2.10	2.00	21.60	21.40	55.00	Clay
	20-50	6.12	0.60	2.30	2.70	17.50	22.70	57.10	Clay
	50-100	4.75	0.40	1.20	3.50	6.40	26.30	63.80	Clay

SL: Sandy Loam

Table (3) Chemical composition of the soil saturation extract of the studied soil profiles.

Profile No.	Depth (cm)	pH	EC dS/m	Cation mmolc/L				Anion mmolc/L			
				Ca^+	Mg^+	Na^+	K^+	CO^{--}	HCO^{-}	Cl^-	SO_4^{--}
1	0-15	7.90	6.33	8.10	14.30	40.20	0.28	0.00	1.20	40.00	21
	15-40	8.20	7.92	29.20	16.80	35.00	0.30	0.00	1.00	34.00	47
	40-65	8.00	11.45	13.00	12.00	150.00	0.53	0.00	1.00	148.00	17
2	0-20	7.80	5.27	18.90	6.40	30.60	0.28	0.00	1.00	29.00	26
	20-40	8.00	7.33	22.10	12.30	39.80	0.46	0.00	1.20	40.00	33
	40-50	8.10	11.64	80.00	29.00	55.00	0.53	0.00	2.00	50.00	113
	50-75	8.20	12.86	16.00	38.00	270.00	0.48	0.00	1.40	275.00	48
	75-120	8.30	14.60	39.00	31.00	285.00	0.45	0.00	1.40	280.00	74
3	0-20	7.70	174.00	388.90	616.40	3600.00	15.30	0.00	2.80	4300.0	318
	20-45	8.00	111.00	277.70	616.70	2900.00	11.20	0.00	3.00	35. 00	207
4	0-25	7.80	9.80	15.90	17.20	65.00	1.00	0.00	2.00	80.00	17
	25-60	7.90	12.50	12.30	18.50	144.00	1.10	0.00	2.40	154.00	20
	60-100	8.00	13.40	36.50	41.20	270.00	1.20	0.00	2.80	280.00	66
5	0-30	8.00	4.48	3.40	7.30	36.00	0.80	0.00	1.60	38.00	8
	30-70	8.10	6.38	5.80	6.90	53.20	0.30	0.00	2.40	57.00	7
	70-125	8.00	8.39	15.40	17.30	52.00	1.00	0.00	2.80	68.00	15
6	0-30	8.20	4.66	8.88	5.10	35.60	0.55	0.00	2.00	39.00	9
	30-70	8.00	6.32	6.90	2.70	53.10	0.30	0.00	2.40	53.00	8
	70-100	8.10	8.52	29.16	16.80	39.00	0.40	0.00	1.40	34.00	50
7	0-20	8.00	3.45	6.00	4.50	23.50	1.20	0.00	2.00	29.00	4
	20-50	8.00	3.78	7.92	5.04	25.00	0.30	0.00	2.00	23.00	13
	50-100	8.00	5.35	7.66	4.49	41.35	1.33	0.00	3.00	40.00	12

2. Cation exchange properties of the soils

The values of CEC as well as exchangeable cations of the investigated soils are shown in Table (4). Considering the soil of EL-Tina plain which are represented by profiles 1 to 7 exceptional cases of the layer 40-50 cm of profile 2 which has a CEC value of 6.51 cmolc kg^{-1}, the CEC values ranged between 42.47to 57.42cmolc kg-1. The lowest value is found in the deepest layer of profile 4, whereas the highest value characterizes the subsurface layer of profile 3. High values of CEC in the soils of El-Tina plain reflect their high contents of silicate clays. Exchangeable cations of El-Tina plain soils are in the most cases Mg^{++}>Ca^{++}> +, in the 40-50 cm layer of profile 2 exchangeable cations follow the order Ca^{++}>Na^{+}>Mg^{++}>K^{+}

The dominance of exchangeable Mg^{++} in the soils of El-Tina plain is a manifestation of the very high salinity of these soils particularly and they are adjacent to the sea waters of Suez Canal and the Mediterranean Sea.

Physical properties

Soil water relation

Soil water relations reflect status of soil moisture at various levels. Moisture of soil is affected by many factors such as, soil texture soil structure ,soil mineralogy exchangeable cation and soluble salts Breazeale and Mc George (1955) reported that saline soils have greater field capacity and wilting point (WP) that non saline soils particularly concerning the wilting point. Soils of the current study were subject to determination of moisture at 330 KPa, (i.e. 0.33 bar) which corresponds to field capacity (FC) wilting point i.e. moisture content at 1500 KPa (i.e. 1.5 MPa i.e 15 bar) and available water (AW) parameters which are given in Table (5).

Soil moisture properties in the soils of El-Tina plain are presented in Table (5). Except for one sample (out of 22 samples representing layers and horizons of these soils whose FC is as low as 7.78% the range was 32.50 to 36.40% times manifesting the clayey soils the wilting point (except) for the same aforementioned samples of 5.01% ranges from 15.55 to 21.78%. available water (except for the same aforementioned sample of 2.77 available water ranges from 13.03 to 20.75%, the rather high contents of filed capacity, wilting point and available water of El-Tina plain soils is a consequence of the heavy texture of El -Tina plain soils.

Table (4) Cation exchange capacity CEC: exchangeable cations and exchangeable sodium percent (ESP) of the studied soil profiles.

Profile No.	Depth (cm)	CEC Cmolc kg^{-1}	exchangeable cations Cmolc kg^{-1}				ESP
			Ca^{++}	Mg^{++}	K^{+}	Na^{+}	
1	0-15	52.60	15.90	25.90	3.00	7.80	15
	15-40	53.60	16.30	26.80	2.90	7.60	14
	40-65	55.50	18.10	27.40	3.60	6.40	12
2	0-20	58.90	19.20	29.30	3.90	6.50	11
	20-40	50.40	15.20	28.50	2.80	3.90	8
	40-50	6.51	2.40	1.60	0.21	2.30	35
	50-75	48.60	15.30	28.20	1.61	3.50	7
	75-120	49.34	14.60	26.10	2.72	5.92	12
3	0-20	55.70	19.60	27.80	2.60	5.70	10
	20-45	57.42	18.70	30.60	2.12	6.00	10
4	0-25	48.20	13.80	27.30	1.80	5.40	11
	25-60	47.78	15.20	21.90	1.58	9.10	19
	60-100	42.47	14.26	22.31	1.10	4.80	11
5	0-30	43.06	16.35	20.15	1.20	5.36	12
	30-70	47.55	17.10	23.25	1.50	5.70	21
	70-125	45.76	13.25	20.46	2.80	9.25	13
6	0-30	50.56	16.76	22.35	1.30	10.15	13
	30-70	48.50	17.60	21.90	1.60	7.40	24
	70-100	46.56	18.30	20.46	2.30	5.50	8
7	0-20	48.01	15.95	22.36	1.90	7.80	10
	20-50	50.37	17.46	21.95	1.66	9.30	9
	50-100	50.51	18.31	20.25	2.30	9.65	17

2. Soil Densities

2.1. Particle density (R.D.)

Particle density values of the soils of El-Tina plain ranges from 2.65 to 2.89 g/cm^3. The high values of real density of El-Tina plain soils may be due to the highest in the clay contents.

2.2 Bulk density (B.D.)

Table (5) reveals that the soil bulk density in the soils of El-Tina plain varied from 1.14 to 1.40 g/cm^3. The lowest values of bulk density in El-Tina plain soils due to the heaviest in texture El-Tony (1982), Salim (1995), and Abdel Razik (2002) reported that soil bulk density is affected by soil texture, CEC and organic matter contents.

Hydraulic conductivity (HC)

Table (5) showed that, hydraulic conductivity of soils of El-Tina plain are a ranges from 0.05 to 6.50 cm/hr. The generally low values of hydraulic conductivity reflect the high contents of clay. Also, El-Tina plain could be termed as having (in general) very slow to moderately slow hydraulic conductivity (FAO 1994).

Soil moisture characteristic curves

The shape of soil moisture curves depends mainly on some properties of the soil as texture, structure, soluble salts and exchangeable cation. The effect of soil texture is mainly related to the specific surface, of particles which affects the adhesion force. Data on moisture retention are presented in Table (6).

Table (5) Soil moisture content, hydraulic conductivity (HC), real density (RD), bulk density (BD) for the studied profiles.

Profile No.	Depth (cm)	RD g/cm^3	BD g/cm^3	HC cm/h	Soil moisture content (w/w%)		
					FC	WP	AW
1	0-15	2.89	1.40	2.20	36.30	15.55	20.75
	15-40	2.76	1.30	1.80	32.60	17.26	15.34
	40-65	2.57	1.29	0.30	35.20	19.81	15.39
2	0-20	2.84	1.17	0.60	35.40	18.53	16.87
	20-40	2.76	1.27	0.20	33.20	17.26	15.94
	40-50	2.84	1.70	0.50	7.78	5.01	2.77
	50-75	2.86	1.28	0.10	32.70	18.79	13.91
	75-120	2.80	1.20	0.05	35.20	19.55	15.65
3	0-20	2.79	1.18	1.80	35.60	19.67	15.93
	20-45	2.67	1.14	1.00	36.40	20.28	16.12
4	0-25	2.65	1.14	0.50	35.80	21.78	14.02
	25-60	2.75	1.25	0.20	33.50	17.62	15.88
	60-100	2.80	1.15	0.05	34.90	18.19	16.71
5	0-30	2.83	1.20	0.70	34.50	18.29	16.21
	30-70	2.81	1.24	0.40	33.80	18.16	15.64
	70-125	2.65	1.20	0.20	32.90	18.39	14.51
6	0-30	2.70	1.17	1.10	35.10	18.65	16.45
	30-70	2.75	1.18	0.70	33.20	18.66	14.54
	70-100	2.76	1.14	0.20	35.50	19.59	15.91
7	0-20	2.74	1.30	2.30	32.50	19.19	13.31
	20-50	2.77	1.30	1.00	33.40	20.37	13.03
	50-100	2.79	1.22	0.40	33.60	19.95	13.65

Table (6) Soil moisture (% by weight) determined at different levels of moisture tension of the studied profiles.

Profile No.	Depth (cm)	Moisture tension (MPa)						
		0.01	0.033	0.10	0.20	0.30	1.00	1.50
1	0-15	39.20	36.30	28.19	23.21	22.97	17.24	15.55
	15-40	40.50	32.60	26.45	24.25	21.82	20.13	17.26
	40-65	41.30	35.20	26.19	25.16	24.63	22.88	19.81
2	0-20	44.20	35.40	28.69	26.51	25.23	23.54	18.53
	20-40	42.20	33.20	26.11	24.56	22.68	21.02	17.26
	40-50	11.98	7.78	5.69	4.98	5.21	5.06	5.01
	50-75	41.70	32.70	25.58	23.66	22.19	20.55	18.79
	75-120	43.70	35.20	28.51	26.34	25.16	23.49	19.55
3	0-20	44.40	35.60	28.68	26.89	25.25	23.55	19.67
	20-45	45.20	36.40	29.51	27.10	26.06	24.34	20.28
4	0-25	44.60	35.80	28.81	27.02	25.38	23.67	21.79
	25-60	42.10	33.50	26.88	25.36	24.71	21.80	17.62
	60-100	43.30	34.90	27.12	26.17	23.12	20.22	18.19
5	0-30	43.53	34.50	27.34	25.96	23.89	22.19	18.29
	30-70	42.40	33.80	26.93	25.43	23.61	21.96	18.16
	70-125	42.50	32.90	25.38	24.16	21.87	20.18	18.39
6	0-30	44.40	35.10	27.81	26.66	24.47	22.63	18.65
	30-70	42.90	3.20	25.67	23.12	22.67	20.45	18.66
	70-100	44.30	35.50	28.68	24.75	25.27	23.57	19.59
7	0-20	40.90	32.50	25.77	24.15	22.61	20.92	19.19
	20-50	41.40	33.40	26.91	24.82	23.71	22.12	20.37
	50-100	42.40	33.60	26.72	55.06	23.38	21.74	19.95

The results obtained reveal that the soils of El-Tina plain are characterized by high moisture contents at any of the applied suction, and is greatly influenced by both heavy clay and soil structure. Therefore, this behavior could be ascribed mainly to the presence of relatively high contents of fine fractions especially clay which is identified miner logically to be mostly smectite Abd El-Aziz (2002).

Total porosity and pore size distribution

Soil porosity depends generally on the nature of pore size distribution and soil structure. Pore size distribution is classified according to De leenheer and De Boodt (1965) into the following four main classes.

1- Quickly drainable pores (QDP) representing pores of > 28.8 um diameter.
2- Slowly drainable pores (SDP) representing pores of 8.62 to 28.8 um diameter.
3- Water holding pores (WHP) representing pores of 0.19 to 8.62 um diameter.
4- Fine capillary pores (FCP) representing pores of <0.19 um diameter.

Total porosity and pore size distribution for the soils of the present study are calculated as percent of total soil volume (v/v) and data obtained are presented in Table (7).

Total porosity values in the soils of El-Tina plain ranged between 32.7 to 66.1% with a general means of 58.8%. The lowest values of total porosity is 40-50 cm depth of profile 2, while the highest value is in the surface layer of profile 1. Soil total porosity decrease with increases soil depth.

Regarding the pore size distribution data in Table (7) show that the ranges of quickly drainable pores (QDP), slowly drainable pores (SDP), water holding pores (WHP) and fine capillary pores (FCP) are 3.9 to 14.4; 4.8 to 11.4; 4.7 to 28.3 and 8.5 to 26.5%, respectively.

The averages mean values of QDP, SDP, WHP. And FCP are 5.2, 10.1, 20.7 and 22.8% respectively the trend of pore size distribution follow the order.

FCP>WHP>SDP>QDP.

The results show that high contents of coarse sand lead to increased values of quickly drainable pores. Mean while, the water holding pores and fine capillary pores increase by increasing the clay content. These results are in agreement with those of Pandy and Pattak (1975), Salime (1995) and AbdEl-Razik (2002). Hance, it could be concluded from the above – mentioned discussion that pore – size distribution is of great importance as it is usually taken as an indication of the status and behavior of soil water movement .

Table (7) Total porosity and pore size distribution of the studied soil profiles.

Profile No.	Depth (cm)	Total porosity v/v%	Soil moisture content (w/w%)			
			QDP	SDP	WHP	FCP
1	0-15	66.10	11.20	4.80	28.30	21.80
	15-40	60.20	3.90	10.30	23.60	22.40
	40-65	59.50	4.90	7.80	21.20	25.60
2	0-20	60.30	5.60	11.30	20.70	22.70
	20-40	57.80	4.20	11.40	20.30	21.90
	40-50	32.70	34.40	7.10	4.70	8.50
	50-75	57.50	4.60	11.00	17.80	24.10
	75-120	56.50	4.10	10.20	18.70	23.50
3	0-20	56.40	4.00	10.40	18.80	23.20
	20-45	55.40	3.90	10.00	18.40	23.10
4	0-25	61.40	4.00	10.00	22.60	24.80
	25-60	60.80	4.20	10.70	22.90	23.00
	60-100	59.70	4.10	9.70	23.00	22.90
5	0-30	56.40	4.20	10.80	19.50	21.90
	30-70	56.70	4.10	10.70	19.40	22.50
	70-125	55.80	4.80	11.50	17.40	22.10
6	0-30	62.20	4.10	10.80	24.50	22.80
	30-70	60.90	4.10	10.70	23.60	22.50
	70-100	61.80	5.80	11.50	21.40	23.10
7	0-20	62.30	4.10	10.90	22.30	25.00
	20-50	62.70	3.90	10.40	21.90	26.50
	50-100	59.90	4.20	10.70	20.70	24.30
$\bar{X}$		58.80	5.20	10.10	20.70	022.80

X : Mean

Soil classification

In the present study, the classification was carried out accordibg to the soil Taxonomy System of the USDA (USDA1975 and 2006).

Members of the Vertisols and Aridisols orders were identified in soils of the current study. Table (8) suggestes the taxonomy of the soils down to the family level.

1. **Order Vertisols**

The soils belonging to this order occur in El-Tina plain. The soils have more than 30% clay in all the horizon, with montmorillonite as the predominant clay mineral throughout the control section. These soils have a worm soil temperature regime with no lithic or paralithic contact or pertrocalaic horizon or duripan within 50 cm of the soil surface. During some period in most years the soils have cracks that are open to the surface, or to the base of the plough layer that are at least 1 cm wide. There are two suborders Aquerts and Torrerts.

1.1. Suborder Aquerts

Aquerts are wet Vertisols which have aquic regime at or near the surface for extended periods during the year and are dry for periods long enough in normal years for cracks to open. These soils are placed in the Salaquerts as great group and containing the sub great group of "Aridic Salaquerts.

In the studied area one family can be identified under this sub group this family is

Aridic Salaquerts, fine clayey smectite, thermic (profile 3).

1.2. Suborder "Torrerts"

This suborder is represented by fine profiles and have cracks 6 years or more out of 10 years; cracks of 5 mm or more wide through a thickness of 25 cm or more within 50 cm of the mineral soil surface for 90 or more cumulative days per year at a period when the soil temperature at a depth of 50 cm in continuously higher than 8 c^0 the profiles are placed as Haplotorrerts at the great group level; and Typic Haplo torrerts at the subgroup level. Three soil families were identified under this subgroup. They are as follows:

1. Sodic Haplotorrerts, very fine clayey, smectite thermic (profiles 4,6 and 7)
2. Sodic Haplotorrerts, fine clayey, smectite, thermic (profile 5)
3. Typic Haplotorrerts, fine clayey, smectite, thermic (profile 1)

Table (8) Soil classification categories of the studied area according to USDA soil taxonomy (1975-2006).

Order	Suborder	Great Group	Subgroup	Family	Soil Profiles No.
Vertisols	Aquerts	Salaqerts	Aridic Salaquerts	Fine clayey, Smectitic, Thermic	3
	Torrets	Haplotorrerts	Sodic Haplotorrerts	Very Fine clayey, Smectitic, Thermic	4,6 and 7
				Fine clayey, Smectitic, Thermic	5
			Typic Haplotorrerts	Fine clayey, Smectitic, Thermic	1
Aridisols	Gypsum	Haplogypsids	Typic Haplogypsids	Fine clayey, Smectitic, Thermic	2

1. Order Aridisols

Aridisoils are defined as soil having ochric eipedones and one or more of the following subsurface horizons argillic, cambic, natric, gypsic, calcic and salic. They are dry or have a standerd extract conductivity of more than 2 dSm^{-1} at $25c^{0}$ in the 18-50 cm layer or above a lithic or paralithic contact which ever is shallower.

In the light of the relevant soil properties, one suborder can be distinguished under the order Aridisols. Soils of profile 2 falls into the suborder Gypsids as these soils have gypsic horizon that has it upper boundary within 100 cm of the soil surface.

1.1. Suborder Gypsids

The Gypsids suborder includes one great group i.e. Haplogypsids which in term includes one subgroup i.e. Typic Haplogypsids which contain one family

1. Typic Haplogypsids, fine clayey, smectite, thermic (profile 2).

Land suitability for irrigated agriculture

The current suitability of the studied soils was estimated by matching between the present land characteristics and their outlined by Sys and verheye (1978). Suitability indices and classification of the studied soils are shown in Table (9) and revealed that two suitability classes i.e. marginally suitable (S_3) and not suitable (N_1) were recognized in the studied area.

1- Soils of class III (S_3)

The soils of this class (profiles 1, 2 and3) have capability index ranging from 26 to 34. The limitations are moderate and different in their kind and degree. The main limitation are wetness, texture and salinity and sodicity.

1. Soils of class N

These related to three soil profiles (profiles 3,4 and 6) they have many severe limitation including wetness, texture, salinity, sodicity, gypsum and $CaCO_3$. The capability index Ci values are little, ranging from 14 to 17.

It could be concluded that the soils of the current study would be utilized efficiently if management and conversation practices are applied in proper mannere.

1.1. Land suitability for specific crops

According to Sys et al (1993). The main soil parameters considered in calculating suitability index of a given soil for cultivating certain crops are soil depth (A), gravel percent (B), climate (C), slope (D), drainage (E), texture (F), $CaCO_3$% (G), gypsum (H), salinity (I) and alkalinity (J). Although soil fertility is important, due to the deficiency of nutrients in these soils, it was not included in estimating the suitability index.

As done with the system of land capability the equation used for calculating the suitability index"Si" is as follows:

$$Si = (A.B.C.D.E.F.J.H.I.J) x100$$

The studied crops are

1. Field crops; wheat, maize, barley, rice, groundnuts soybean, sunflower, sesame, cotton, alfalfa, and sugarcane.
2. Vegetable crops: green pepper, potato, tomato, cabbage, beans, onion and watermelon.
3. Fruit crops: Olives, guava, mango and citrus.

Table (10) reveals that the studied soil profiles representing the soils of El-Tina plain are moderately suitable (S_2) for growing maize, barley, cotton and Olives, marginally suitable (S_3) for growing wheat, sunflower, alfalfa, sugarcane and cabbage; and not suitable (N_1) for growing rice, groundnuts, soybeam sesame, green pepper, potato, tomato, beans, onion, watermelon, guava, mango and citras.

Table (9) Land capability grades for the studied area (according to Sys and Verhye 1978).

Profile No.	Limitation Rates							capability	Class (Grade)
	t	w	S_1	S_2	S_3	S_4	n		
1	100	60	100	75	90	90	80	29	S_3
2	100	90	100	75	90	100	50	30	S_3
3	100	40	100	75	100	90	50	14	N1
4	100	60	100	50	90	100	60	16	N1
5	100	80	100	75	90	90	70	34	S_3
6	100	60	100	50	90	90	70	17	N1
7	100	60	100	75	90	90	30	26	S_3

T= topography		W= wetness		S1 = depth
S2= texture		S3=$CaCO_3$ content		S4 = gypsum
N = salinity and alks				

Table (10) Suitable index (Sl) and Suitable class (SC) for soils of the studied area according to Sys et al (1993)

Crop	El-Tina Plain	
	S.1	S.C
Wheat	43.00	S3
Maize	58.50	S2
Barley	70.70	S2
Rice	21.50	S1
Groundnuts	21.20	S1
Soya	11.50	S1
Sun Flower	25.80	S3
Sesame	15.90	N1
Cotton	55.00	S2
Alfalfa	35.60	S3
Suger Cane	33.50	S3
Green Papper	16.10	N1
Potato	18.30	N1
Tomato	18.00	N1
Cabbage	24.20	S3
Beans	2.50	N1
Onion	17.90	N1
Water Melon	21.70	N1
Olives	53.90	S2
Guva	19.70	N1
Mango	12.60	N1
Citrus	4.80	N1

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تقييم اراضى سهل الطينة فى الجزء الشما لى الغربى شبه جزيرة سيناء

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تهد ف هذة الدراسة الى تقيم خواص الاراضى المستصلحة فى سهل الطينة حيث تقع منطقة الدراسة والبالغ مسا حتها 36 الف فدان ما بين خطى عرض 30 º 48 / 31 º 15 / شما لى وخطى طول 32 º 19 / 32º 14 / شرقا.

وقد تم حفر عدد 7 قطاعات ارضية ممثلة للاراضى المستصلحة فى سهل الطينة وقد وصفت هذه القطاعات وصفا مورفولوجيا دقيقا وتم تقدير بعض الخواص الطبيعية والكيميائية وتم تصنيفها وتقسيمها وتقدير القدرة الانتاجية لها ودرجات الصلاحية لتمو المحاصيل المختلفة.

وتشير نتائج الدراسة الى ان المحتوى الرطوبى لكل من السعة الحقلية ونقطة الذبول والماء الميسر تعتمد اعتمادا كليا على قوام التربة والملوحة.

وطبقا لنظام التقسيم فأن الاراضى تحت الدراسة تنتمى الى رتبتى Vertisols والـ Aridisols وثلاثة تحت رتبة (Gypsids – Torrerts , Aquerts) وقد تدرج مستويات التقسيم حتى العائلات (5 عائلات)

وتوضح نتائج ادلة ملائمة الاراضى تحت الدراسة الى انتمائها الى رتبتى الاراضى هامشية الصلاحية (S_3) وغير ملائمة للزراعة (N_1) والتى تعاتى من سوء حالة الترطيب وبعض خواص التربة (القوام ، الملوحة والقلوية ، الجبس ، كربونات الكالسيوم، كمحددات لصلاحية التربة وبدرجات متفاوتة.

وبعمل توافق بين القيم الكمية المتحصل عليها من أدلة تقييم التربة وتلك الخاصة باحتياجات بعض المحاصيل المحددة فان نتائج مدى ملائمة التربة لبعض المحاصيل المختارة (22 محصول) تبين ان درجات الصلاحية كانت متوسطة الصلاحية (S_2) لنمو الذرة والشعير والقطن، الزيتون، وهامشية الصلاحية (S_3) لزراعة القمح ودوار الشمس والفول وقصب السكر والكرنب وغير صالحة (N_1) لزراعة باقى المحاصيل.