RESULTS AND DISCUSSION

4- RESULTS AND DISCUSSION

4.1. Mapping and soil taxonomic units:

As previously mentioned the chosen two areas are selected based on the semi detailed soil survey carried out by **FAO (1964)**. The existing soil mapping units were carefully checked in the field by soil observations, and the boundaries between the various soil mapping units were examined and demarcated on the recent cadestal map of scal 1: 50.000 (Fig.6).

The morphological description of the representative soil profiles and laboratory analysis of the collected soil samples, were used to define the dominant soil taxonomic units in each mapping unit. In this respect, the correlations between field notes and the final analysis were made for naming and classifying soil mapping units. Then, the legend was written and the mapping units were finally expressed in the different taxonomic units (Table, 4).

4.1.1. Soil taxonomic units:

The current study had followed the soil taxonomy system after **U.S. Soil Survey Staff, (1999)**, to identify the different taxonomic units of the studied soils up to the family level. The soil family was further differentiated to the series level. The soil taxonomy system is based on the following:

- Soil moisture and temperature regimes.
- Presence or absence of diagnostic horizons and other diagnostic soil characteristics.
- Characteristics of soil profile control section.

Generally, the studied soils are characterized by Torric moisture regime, as the control section in most years is dry in all parts more than half the time that the soil temperature at a depth of 50cm is above 5°C. Also, the soil temperature regime is defined as thermic, since the mean annual soil temperature is less than 22°C and the difference between mean summer and mean winter soil temperature is more than 5°C (Tables1 and 2).

In the light of relevant soil properties, the examined soils are characterized by a calcareous nature and display common features, but differ in one or more of their characteristics such as; surface layer, intensity of secondary formations, and sequence of soil texture including coarse fragments. Accordingly, the soils could be placed mainly in the order Aridisols and partly in the order Entisols. Two suborders can be distinguished under the order Aridisols namely; Calcids and Gypsids, and one suborder of Orthents is related to the Entisols.

The Calcids is the common suborder in the studied areas and characterized by secondary accumulations of lime that enough required to qualify a diagnostic calcic horizon. It is considered to be "diagnostic" when it reach a minimum thickness and a minimum degree of expression, which is determined by appearance, measurability, importance, relevance and quantitative criteria. The calcids in the studied area don't have; a petrocalcic horizon, lithic contact within 50cm of the soil surface, aquic conditions, surface cracks and slickensides. Therefore, it could be classified as Typic Haplocalcids at the subgroup level. Also, based on particle size and soil mineralogy classes of the active soil depth representing so-called control section, four soil families were

Table (4) Legend of soil classification map.

Soil mapping unit	Description	Taxonomic unit (family level)
K1	Deep, reddish sandy clay loam soils, calcareous with many lime accumulations.	Typic Haplocalcids, fine-loamy, mixed, thermic
K1s	Do, sand to loamy sand surface layer phase.	
K11	Deep, reddish clay loam soils, calcareous with many lime accumulations.	
K2	Deep, loamy sand till 50-60 cm. over reddish sandy clay loam soils, calcareous with many lime accumulations.	Typic Haplocalcids, coarse -loamy, mixed, thermic.
K3	Deep, pale brown sandy clay loam over silty loam soils,strongly calcareous with many lime accumulations.	TypicHaplocalcids, fine-loamy,carbonatic,thermic.
K4	Deep, pale brown sandy clay loam over gravelly silty clay loam soils, strongly calcareous with many lime accumulations.	Typic Haplocalcids, loamy-skeletal ,carbonatic, thermic
Y1	Deep, reddish gypsiferous sandy clay loam soils, calcareous with few lime accumulations.	Typic Haplogypsids, fine loamy, mixed, thermic.
O1	Deep, pale brown clay loam over loamy soils, calcareous with few lime accumulations.	Typic Torriorthents, fine loamy, mixed, thermic.
O11	Deep, pale brown clay loam over sticky silty clay loam soils, calcareous with few lime accumulations.	

identified within the Typic Haplocalcids. These four families were differentiated to represent the characteristics of six soil mapping units at the series level (Table, 4).

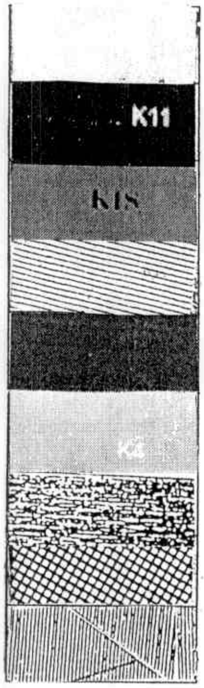
The suborder Gypsids are characterized by a diagnostic gypsic horizon. It is a non-cemented horizon containing secondary accumulations of gypsum in various forms. Because the gypsum in the studied area don't have; a petrogypsic or petrocalcic horizon, calcic horizon, gypsic horizon within 18cm of the soil surface, and lithic contact within 50cm of the soil surface, therefore, it could be classified as Typic Haplogypsids at subgroup level, one soil family represents the characteristic of one soil series was identified in this subgroup.

The Orthents as a suborder that belong to the Entisols order were found in a relatively small portion in the studied areas. It is in recent development and don't have the criteria required for any diagnostic horizon. Moreover, these soils are characterized by deep medium texture, with no evidence of stratification layers or aquic conditions, and could be classified as Typic Torriorthents at the subgroup level. One soil family that differentiated to represent the characteristics of the two soil mapping units at the series level was identified under the Typic Torriorthents (Table, 4).

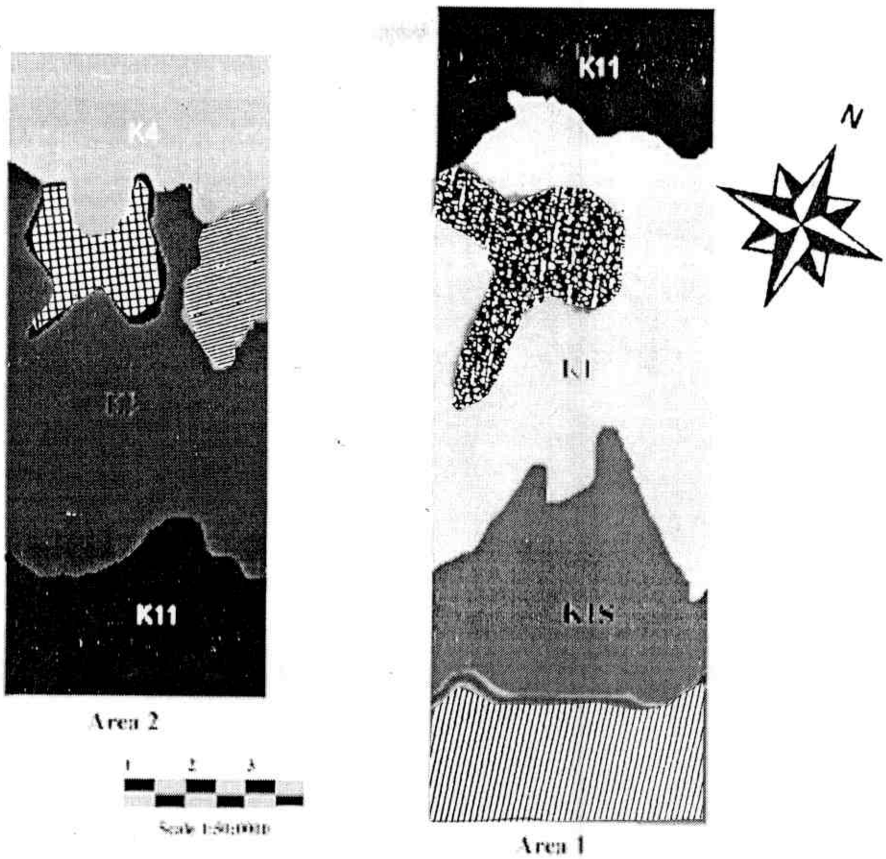
4.1.2. Description of soil mapping units:

The soil mapping units, as shown in the soil map(Fig.,6) and that outlined in the soil legend of Table 4, were used to be described and discussed including the inside soils of the studied areas. The description of these soil units were based on the morphological variations of soil profiles (Appendix) and soil

Legend of soil classefication map.



K1
K11
K1s
K2
K3
K4
Y
O1
O11



Fig(6) Soil classification map of the two studied sample areas.

analysis that used for definition soil taxonomic units (Table 4). The obtained soil mapping units could be described as the following:

4.1.2.1. K1 soil mapping unit:

This mapping unit represents a considerable portion of the Gianaclis plain soils. This plain is an old sea floor occuping most of the southern-east part of west Noubaria area. It has a relatively low elevation and located in the studied area No. 1 (Fig.6). This unit consists of deep calcareous loamy textured soils, with subsurface calcic horizon, and is represented by soil profiles Nos.5 and 6.

As shown in the morphological description (Appendix), the soil profile is very deep with a surface layer rather uniform in colour and texture. The moist soil colour in the surface layer ranges from pale brown (10 YR 6/3) to light yellowish brown (10 YR 6/4). The colour is mainly reddish yellow (7.5 YR 6/8) in the subsoil layers and the gray mottles are commonly found below 50 cm depth. The surface layer is characterized by sandy loam texture, massive structure and friable consistency. The soil becomes heavier and more compacted with depth, as dominated by firm sandy clay loam texture and weak subangular blocky structure. The remarkable feature is the occurrence of a diagnostic calcic horizon, with upper boundary within 20-60 cm from the soil surface. The calcium carbonate found in soft and hard segregations which form a conspicuous horizon.

The analytical data of soil profiles Nos.5 and 6 (Table, 5) show the main soil characteristics of this mapping unit. The clay content ranges from 17.37 to 24.36%, with a tendency of increase with depth, while silt content ranges from 9.64 to 19.16% with no specific pattern with depth. The relatively high calcium carbonate content (26.88 – 37.78%) reflects the strongly calcareous nature of these soils. The higher values of $CaCO_3$ are found in the calcic horizon. Also, the data indicates a relatively low gypsum content that ranged from 0.58 to 3.15%, with no specific pattern with depth.

4.1.2.2. K1s soil mapping unit:

This mapping unit represents the sandy phase of the previous Kl unit. It is extended to the Gianaclis plain that mainly covered by a thin sheet of wind blown sand. Upon cultivation, the very shallow sandy sheet could be largely mixed or plowed during reclamation. This unit is located also in the studied area No. 1 (Fig.,6) and represented by soil profiles Nos.3 and 4.

Morphologically, this unit is nearly similar to Kl soils, but overlying by a coarse textured surface layer (Appendix). The typical soil profile is characterized by pale brown, very friable loamy sand lying over a reddish yellow more compacted sandy loam layer. Below 50 cm depth, the gray mottles are also common and are mainly associated with lime accumulations (calcic horizon) and firm sandy clay loam soils.

The data in Table (5) show that the clay and silt contents are rangeing from 9.71 to 23.88% and 6.67-13.92%, respectively. The lower values of both fractions were found in the surface layer being increased gradually with soil depth. However, the calcium carbonate and gypsum contents are almost

Table (5): Particle size distribution, calcium carbonate and gypsum contents of the studied soils

Soil mapping unit	Profile No.	Depth (cm)	Particle size distribution %				Textural class	Coarse fragments%	$CaCo_3$ %	Gypsum %
			Clay	Silt	Fine sand	Coarse sand				
K1	5	0-20	17.37	19.16	31.49	31.98	SL	0.00	37.78	3.15
		20-60	23.40	16.76	31.64	28.20	SCL	5.00	32.96	2.30
		60-130	24.36	13.71	39.20	22.73	SCL	0.00	26.88	1.87
	6	0-25	17.50	9.64	29.76	43.10	SL	0.00	28.54	2.60
		25-50	20.07	15.92	40.45	23.56	SCL	0.00	31.76	0.58
		50-150	22.45	15.33	50.21	12.01	SCL	5.00	35.33	1.66
K1s	3	0-20	9.71	11.07	31.49	47.73	LS	0.00	18.49	3.16
		20-50	19.40	11.81	33.16	35.63	SL	3.00	24.12	3.79
		50-100	23.88	13.44	30.43	32.25	SCL	10.00	36.53	1.57
	4	0-20	10.45	6.67	32.66	50.22	LS	0.00	20.50	0.59
		20-55	18.53	13.92	33.41	34.14	SL	0.00	26.53	2.04
		55-130	22.60	13.21	31.26	32.93	SCL	10.00	35.10	1.56
k11	7	0-25	27.90	15.68	37.32	19.10	SCL	0.00	31.36	2.20
		25-60	31.24	24.22	30.58	13.96	CL	0.00	33.36	2.47
		60-150	35.10	20.63	10.52	33.75	CL	0.00	30.22	2.29
	11	0-25	26.41	17.56	28.62	27.41	SCL	0.00	29.75	0.62
		25-55	30.85	28.00	20.45	20.70	CL	0.00	32.19	0.30
		55-120	32.95	28.28	18.75	20.02	CL	0.00	38.96	0.58
K2	1	0-25	9.98	11.56	28.18	50.28	LS	0.00	19.96	2.30
		25-60	7.56	10.35	54.50	27.59	LS	0.00	20.96	3.16
		60-100	22.37	14.74	23.97	38.92	SCL	0.00	29.70	4.90
	2	0-20	7.36	3.74	32.60	56.30	LS	0.00	15.70	2.26
		20-50	12.86	4.78	27.85	54.51	LS	0.00	20.50	3.80
		50-150	21.24	13.42	26.59	38.75	SCL	0.00	30.15	3.90

Table (5): Cont.

Soil mapping unit	Profile No.	Depth (cm)	Particle size distribution %				Textural class	Coarse fragments%	$CaCo_3$ %	Gypsum %
			Clay	Silt	Fine sand	Coarse sand				
K3	12	0-25	28.60	22.80	34.38	14.22	SCL	0.00	32.96	0.60
		25-60	22.60	22.80	36.62	12.00	SCL	0.00	38.14	0.68
		60-80	39.97	36.64	18.39	5.00	CL	0.00	47.81	0.64
	13	0-20	39.74	32.72	14.04	13.50	CL	0.00	34.17	0.68
		20-55	33.82	30.90	23.28	12.77	CL	0.00	47.17	0.50
		55-80	39.38	42.49	12.56	5.57	SICL	0.00	55.38	3.30
K4	16	0-25	32.76	18.96	33.27	15.01	SCL	0.00	29.75	0.38
		25-70	33.98	23.75	27.52	14.75	CL	0.00	49.94	1.36
		70-125	33.17	49.30	12.03	5.50	SICL	40.00	47.03	0.74
	17	0-25	37.45	20.28	22.26	20.01	CL	0.00	36.85	1.50
		25-60	29.28	20.43	33.35	16.94	SCL	50.00	46.63	0.74
		60-150	33.48	48.20	10.67	7.65	SICL	35.00	65.12	0.73
Y1	8	0-25	18.65	11.94	19.06	50.35	SL	0.00	23.72	1.56
		25-50	21.86	13.61	39.70	24.83	SCL	0.00	26.13	2.90
		50-120	31.86	22.96	22.98	22.20	CL	0.00	28.14	7.50
	9	0-30	21.26	10.45	49.76	18.53	SCL	0.00	18.89	0.69
		30-55	24.22	13.86	11.92	50.00	SCL	2.00	17.29	3.07
		55-90	20.55	30.61	34.22	14.62	L	0.00	18.09	7.44
	10	0-30	21.26	9.17	32.36	37.21	SCL	0.00	16.13	0.74
		30-65	22.15	11.25	30.85	35.75	SCL	0.00	14.82	15.02
		65-95	20.42	18.17	14.75	46.66	SCL	0.00	12.42	24.80
O1	15	0-25	29.11	21.07	33.32	16.50	SCL	0.00	32.16	1.86
		25-50	35.34	25.81	21.92	16.93	CL	0.00	30.87	0.74
		50-150	25.21	31.20	32.03	11.56	L	0.00	31.76	0.31
O11	14	0-25	37.50	28.42	27.82	6.26	CL	0.00	26.53	0.63
		25-65	34.70	25.97	17.55	21.78	CL	0.00	25.87	0.69
		65-125	34.94	35.19	19.30	10.57	SICL	0.00	32.56	0.77

similar to those in K1 soils, with a relatively moderate content of calcium carbonate (18.49-20.5%) in the surface layer.

4.1.2.3. K11 soil mapping unit:

This mapping unit represents the gentle slopes of Mariut tableland. This unit is located on two parts, the first part occupied the northern portion of the studied area No. (1), while the second one lies at the southern portion of the area No. (2) and they are represented by soil profiles Nos. 7 and 11, respectively.

This unit is characterized by a deep calcareous soil profile with subsurface calcic horizon.

As shown in the morphological description (Appendix), the moist soil colour in the surface layers of soil profiles 7 and 11 ranged from brown (10 YR 4/3) to reddish yellow (10YR 6/6), and becomes yellowish brown 7.5 YR 5/6 to reddish yellow (7.5 YR 6/6), respectively. the gray mottles are commonly found below 50 cm depth.

The surface layers are of sandy clay loam texture with weak subangular blocky structure. The soil becomes heavier and compacted with depth as dominated by firm clay loam texture with a moderate subangular structure. The remarkable feature is the occurrence of a diagnostic calcic horizon, within a 25-60 cm depth. The calcium carbonate found in diffuse, soft and hard segregations which form a conspicuous horizon

The analytical data of soil profiles Nos.7 and11 (Table, 5) show that the clay content ranged from 26.41 to 35.10%, with a tendency of increase with depth. While silt content ranged between 17.56 and 28.28%, with no specific pattern with soil depth. The calcium carbonate content reflects the strongly calcareous nature of these soils ranging from 29.75 to 38.96%, the higher values are found in the calcic horizon. Also, the data indicated a relatively low gypsum content that ranged from 0.30-2.47%, with no specific pattern by depth.

4.1.2.4. K2 soil mapping unit:

This mapping unit represents the interference zone between Gienaclis plain and wind blown sand soils. It is located at the southern side of the area No.(1), Fig.(6), and represented by soil profiles Nos. 1 and 2. The soils are mainly covered by a thin sheet of wind blown sand, this very shallow sandy sheet could be discovered upon cultivation process.

Morphologically, soils of this unit are characterized by a calcareous loamy sand texture till 60 cm depth underlain sandy clay loam. The soil profile description (Appendix) indicate that the moist soil colour ranges from yellowish brown (10 YR 5/4) to strong yellowish brown (10YR 5/6) in the surface layers and becomes strong brown (7.5 YR 5/8) in the subsoil layers. The surface layer is characterized by a massive structure and friable consistency. Then, the soil becomes heavier and compacted, as dominated by firm weak subangular blocky structure.

The data obtained in Table (5) show that the clay and silt contents were 7.36-22.37% and 3.74-14.74%, respectively. The lower values of both fractions were found in the surface layer and increased gradually with soil depth. However, the calcium carbonate content range was 15.7 - 30.15% which reflects the strongly calcareous in nature of these soils. The relatively high values of $CaCO_3$ are found within the calcic horizon. Also, the data indicated a relatively low gypsum content that ranges 2.2 to 4.9%, with no specific pattern by soil depth **(Mekhail, 1998)**.

4.1.2.5. K3 soil mapping unit:

This mapping unit is represented by relatively low elevation portion of the slope of the Mariut tableland at the studied area No 2 (Fig.,6). This unit is characterized by a medium textured grade (sandy clay loam and clay loam) and deep calcareous in nature, with subsurface calcic horizon. It is represented by soil profiles Nos. 12 and 13. As for in the morphological description (Appendix) the moist soil colour in the surface layer ranges from dark brow (10 YR 4/3) to yellowish brown (10 YR 5/4). Soil colour in the subsoil layers becomes yellowish brown (10 YR 5/6) to light yellowish brown (10 YR 6/4), with scattered gray mottles which are commonly found below a 55 cm depth. The surface layers are characterized by sandy clay loam texture, with a massive structure and friable consistency. The subsoil layers become heavier and compacted, as dominated by firm clay loam and silty clay loam texture and with a weak subangular blocky structure. The calcic horizon within the uppermost depth of 25-80cm. The calcium carbonate found is diffuse, soft and hard segregations, which from a conspicuous horizon **(Yehia, 1998)**.

The analytical data of soil profiles Nos.12and13(Table, 5) show that the clay content ranges from 28.6 to 39.97%, with a tendency of increase with depth, whereas, silt content ranges from 16.72 to 42.49%, with a tendency of increase with soil depth. The calcium carbonate content reflects the strongly calcareous in nature of these soil, ranging from 32.96 to 55.38%, with a relatively high occurrence in the calcic horizon. Also, the data obtained indicate a relatively low gypsum content that ranges from 0.50 to 3.30%, with no specific distribution pattern with depth.

4.1.2.6. K4 soil mapping unit:

This mapping unit is represented also by a relatively low elevation at the slope of the Mariut tableland. This unit is located also in the northern portion of the studied area No. 2 (Fig., 6) and represented by soil profiles Nos.16 and 17.

Morphologically, this unit is similar to the previous unit of K3, but the subsoil layers attained a relatively high content of gravels (35-50%), as shown in Appendix.

The typical soil profile is characterized by pale brown sandy clay loam to clay loam over gravelly silt clay loam. Below 50 cm depth, the gray mottles are also common with lime accumulations (calcic horizon).

The data in Table (5) show that the clay and silt contents ranged 29.28-37.75 and 18.96-49.3%, respectively. The calcium carbonate content reflects the strongly calcareous in nature of these soils and it ranges from 29.75 to 65.12%, the higher values are found in the calcic horizon. The data indicate also a relatively low gypsum content that ranges from 0.38-1.36%, with no specific pattern with depth.

4.1.2.7. Y1 soil mapping unit:

This mapping unit represents small scattered spots throughout the Gianaclis plain at area No.,(1) Fig,(6) which is represented by the lowest elevation portions.

The soils of this unit are characterized by relatively low elevation, deep reddish gypsiferous sandy clay loam and with few lime accumulations. This unit is represented by soil profiles Nos. 8, 9 and 10. Morphologically, the soils of this unit are mainly attained a pronounced content of secondary gypsum that is enough required to qualify subsurface gypsic horizon, poorly drained and deep effective soil depth.

The moist soil colour in the surface layer ranges from yellowish brown (10 YR 5/6) to (10 YR 5/4), and becomes grayish brown (10 YR 5/2) in the subsoil layers. The gray mottles are commonly found below 50 cm depth. Soil structure is weak fine subangular blocky in the surface layers, then dominated by firm massive structure in the subsoil ones. The calcium carbonate is dominated by fine or medium sizes and found in hard subrounded nodules and moderate to common fine cemented gypsum crystals.

The data in Table (5) show that the clay and silt contents ranges 18.65-31.86% and 9.17-30.61%, respectively. The low relatively values of both fractions are found in the surface layers being increased gradually with soil depth. However, the calcium carbonate content of these soils is relatively high (12.42-28.14%), it is found mainly in a primary form, and in turn it is not enough required to qualify a calcic horizon.

Also the obtained data indicated a pronounced gypsum content that ranges from 0.69 to 25.47, with a tendency of increase with soil depth. The relative high values of gypsum are found in the subsoil gypsic horizon **(Mohamed, 1992)**.

4.1.2.8. O1 soil mapping unit:

This mapping unit is represented by the soils of the Abu Mina valley area No. (2), Fig. (6).

The representative soil profile No.15 is deep calcareous with few lime accumulations and a texture grade of clay loam underlain loam. As shown in the morphological description (Appendix), the soil profile is very deep, with alternative pattern in soil colour and texture. The moist soil colour is dark brown (10 YR 3/4) and yellowish brown(10 YR 5/8) in the surface 0-50 cm depth and deepest ones, respectively. The surface 0-50 depth is characterized by sandy clay loam to clay loam texture, with a weak subangular blocky structure, then becomes a relatively light texture with massive structure.

The data in Table (5) show that the clay and silt contents range from 25.12 to 35.34% and from 21.07 to31.20%, respectively. The highest values of both fractions were found in the subsoil layers. The calcium carbonate content reflects the strongly calcareous in nature of these soils and ranges from 30.87 to 32.16%, but with no evidences of calcic horizon. Also, the data indicate a relatively low gypsum content that ranges from 0.31-1.86%, with a tendency of decrease with soil depth.

4.1.2.9. O11 soil mapping unit:

This mapping unit represents an extension area of the previous O1 soil unit towards the southern-east side. This unit is located also in the studied area No. (2), Fig. (6), and represented by soil profile No. 14.

Morphologically, this unit is almost similar to the O1 soil unit, but the soil texture is rather uniform throughout whole soil profile, with silty clay loam textured soils. The typical profile is characterized by a moist soil colour of yellowish brown (10 YR 5/4), friable clay loam over yellowish brown (10 YR 5/6), more compacted and sticky clay loam soil with subangular blocky structure.

Data in Table (5) show that the clay and silt contents range from 34.70 to 37.50% and from 25.19 to 28.42%, respectively, with almost similar trend throughout soil profile layers. The calcium carbonate content reflects the strongly calcareous in nature of these soils and ranges from 26.53% to 32.56%. Also, the data indicate a relatively low gypsum content that ranges from 0.63 to 0.77%, with a slightly increase with soil depth.

4.2. Soil physical properties:

4.2.1. Bulk density:

Data in Table (6) reveal that the bulk density values of the studied soil profiles range from 1.25 to 1.79 g / cm^3.The highest and lowest values of bulk density were obtained in the surface and deepest layers of profiles Nos. 2 and 14, respectively. Also, data obtained indicate that the relatively high values of bulk density were associated with the relatively coarse textured soils (K2, soil unit), the reverse was true for the relatively fine textured soils, which exhibited relatively low values (O11, soil unit). These results are in agreement with those obtained by

El-Tony (1982), who found that, the values of bulk density were affected by soil texture and organic matter content.

Regarding the effect of soil depth on the values of bulk

Table (6): Soil bulk density, porosity, hydraulic conductivity and soil moisture constants for the studied soil profiles

Soil Mapping Unit	Profile No.	Depth (cm)	Bulk density (g/cm^3)	Total prosity %	H.C. (cm/h)	Soil moisture constants %		
						F.C. %	W.P. %	A.W.
K1	5	0-20	1.68	36.60	2.78	15.14	6.50	8.64
		20-60	1.50	43.40		19.38	8.90	10.48
		60-130	1.47	44.53		18.43	9.43	9.00
	6	0-25	1.61	39.30	2.65	16.87	7.81	9.06
		25-50	1.45	45.30		18.63	8.24	10.39
		50-150	1.37	48.30		20.16	9.92	10.24
K1S	3	0-20	1.58	40.40	2.20	12.20	3.80	8.40
		20-50	1.53	42.30		15.60	5.86	9.74
		50-100	1.47	44.53		17.67	6.90	10.77
	4	0-20	1.68	36.60	3.37	12.02	4.50	7.52
		20-55	1.67	37.00		16.30	5.56	10.74
		55-130	1.45	45.30		17.26	6.36	10.00
K11	7	0-25	1.57	40.80	1.97	17.95	5.00	12.94
		25-60	1.48	44.15		27.42	12.29	15.13
		60-150	1.33	49.80		33.19	14.49	18.70
	11	0-25	1.35	49.10	1.63	28.70	12.23	16.47
		25-55	1.34	49.40		28.81	15.82	12.99
		60-120	1.31	50.60		30.70	16.25	14.45
K2	1	0-25	1.58	40.40	2.24	10.27	4.13	6.14
		25-60	1.56	41.20		18.51	5.44	13.07
		60-100	1.47	44.53		19.85	9.29	10.56
	2	0-20	1.79	32.50	3.09	11.93	5.80	6.13
		20-50	1.60	39.60		14.62	6.61	8.01
		50-150	1.47	44.53		18.12	7.45	10.67

Table (6): **Cont.**

Soil Mapping Unit	Profile No.	Depth (cm)	Bulk density (g/cm^3)	Total prosity %	H.C. (cm/h)	Soil moisture constants %		
						F.C. %	W.P. %	A.W.
K3	12	0-25	1.37	48.30	1.54	22.78	9.46	13.32
		25-60	1.35	49.10		21.73	10.50	11.23
		60-80	1.35	49.10		27.74	12.07	15.67
	13	0-20	1.31	50.60	1.37	29.65	13.62	16.62
		20-65	1.26	52.50		23.95	10.78	13.17
		65-80	1.29	51.30		26.70	12.63	14.07
K4	16	0-25	1.33	49.80	1.76	29.61	13.24	16.37
		25-70	1.27	52.10		33.74	18.43	15.31
		70-125	1.27	52.10		30.60	17.28	13.32
	17	0-25	1.30	51.00	1.91	30.27	13.55	16.72
		25-60	1.27	52.10		27.52	12.50	15.02
		60-150	1.26	52.50		32.22	16.95	15.27
Y1	8	0-25	1.58	40.40	2.47	18.04	8.57	9.47
		25-50	1.55	41.50		24.00	10.01	13.99
		50-120	1.56	41.20		29.64	14.20	15.44
	9	0-30	1.38	47.93	2.94	23.30	11.05	12.25
		30-55	1.36	48.70		26.80	12.05	14.75
		55-90	1.31	50.60		22.52	9.10	13.42
	10	0-30	1.45	45.30	2.66	22.25	10.66	11.59
		30-65	1.43	46.00		22.87	12.50	10.37
		65-95	1.33	49.80		19.72	9.70	10.02
O1	15	0-25	1.39	47.60	2.06	26.27	13.55	12.72
		25-50	1.30	51.00		31.52	14.50	17.02
		50-150	1.31	50.60		24.22	12.95	11.27
O11	14	0-25	1.34	49.43	1.40	32.02	16.12	15.90
		25-65	1.27	52.10		31.17	13.22	16.95
		65-125	1.25	52.90		27.60	14.56	15.94

density, it is obvious that the values of bulk density were gradually decreased with depth. This behaviour could be mainly attributed to a load of the upper layers and a decrease in the organic matter content, somewhat, the increase of inorganic colloids (clay) with soil depth, **Higgy (1983).**

4.2.2. Total porosity:

Total porosity is an index of the relative volume of pores in soil. Data presented in Table (6) reveal that the values of total soil porosity for the different soils under study range between 32.5 and 52.9%. The lowest value is occuring in the surface layer of profile No.2 (K2, soil unit), which is represented by the soils haveing a relatively coarse texture.

The effect of soil depth on total soil porosity is obvious, as a gradual increase was occurred with soil depth, therefore, the highest value is obtained in the deepest layer of profile No. 14 (O11 soil unit), which has a relatively fine texture. These findings are in agreement with those obtained by **Higgy (1983),** who referred that the difference in soil porosity values, may be attributed to the variations in soil texture, structure mineralogical characteristics and soil depth.

4.2.3. Hydraulic conductivity:

The values of soil hydraulic conductivity coefficient, Table (6), are ranging between 1.37 and 3.37 cm/h.

The lowest value is obtained from profile No.13 (K3, soil unit), which is represented by the relatively fine texture. While, the highest value is obtained from profile No.4 (K1s, soil unit), which is represented by a relatively coarse texture. The variations in the soil hydraulic conductivity can be attributed to the influence of soil texture, structure and porosity. These results are in agreement with the findings of **Talha *et al.* (1979) and El-Bakry (2001)** who concluded that hydraulic conductivity values of soils are varied mainly according to soil texture.

4.2.4. Soil moisture constants:

Field capacity(F.C.), wilting point(W.P.) and available water(A.W.) are considered the three main moisture constants. These constants could be calculated from the soil moisture characteristic curve and the obtained data are illustrated in Table (6). The data show that the moisture content at field capacity of the different soils under study ranging between 10.21 and 33.74%. The highest values of soil moisture content at field capacity were found in soil profiles having a relatively high content of both clay and organic matter (Table, 5), as well as, soil structure, i.e. profiles Nos. 7, 8, 9, 10, 11, 13, 15, 16 and 17 (K_{11}, K_3, K_4, Y_1, O_1 and O_{11}, soil units).

However, an opposite trend was true for soil profiles of relatively low content of clay and organic matter, i.e. soil profiles Nos. 1, 2, 3, 4, 5 and 6 (K_2 , K_{IS} & K_I, soil units).

Data in Table (6) show that, the moisture contant at the wilting point in the tested soils are ranging between 3.8% (profile No.3, K_{IS}) and 18.43% profile (No.16, K4) Results of soil moisture content at wilting point, may suggest that they are positively related to soil fine particles(clay content) Soil available moisture content for the different studied soils(Table,6) are ranging between 6.13(profile No.2, K2) and 18.7%(profile No.7, K_{11}). In general, the values of available water showed an irregular trend with soil depth seeing to be depend on the distribution pattern of clay content. The relatively low values are observed in the relative coarse textured soils, which are characterized by very low water holding capacity, i.e., (profile No.2, K2), such results are in accordance with those of **(Yehia, 1998)**.

4.3. Soil chemical properties:

4.3.1. Soil salinity and ionic composition:

Data of the chemical composition of soil saturation extract are represented in Table (7) and indicate that the soils under consideration are representing by variable ECe values ranging from 0.91 to 7.98 dS/m.

The ECe values reveal that soils under consideration are non saline to slightly saline, as the soils represented by soil profiles Nos.1 & 2 (K2), 3 & 4 (K_{IS}), 5 & 6 (K1), 7 (K11) and 8 (Y1) are non-saline, whereas, those represented by 9 & 10 (Y1), 11 (K11), 12 & 13 (K3), 14 (O11), 15 (O1) and 16 & 17 (K4) are slightly saline. Also, the distribution pattern of soil salinity is tended an irrigular trend throughout the profile layers, which may be attributed to intensive surface irrigation and/or active upward movement of saline soil solution with drawn as a result of the relatively high saline water table.

Table (7): Chemical analysis of the soil paste extract of the studied soils

Soil mapping unit	Profile No.	Depth (cm)	EC (dSm^{-1})	Anions(mel^{-1})				Cations(mel^{-1})				SAR	pH soil paste
				CO_3^{--}	HCO_3^{-}	CL^-	SO_4^{--}	Ca^{++}	Mg^{++}	Na^+	K^+		
K1	5	0-20	1.59	-	3.20	6.00	6.08	6.00	1.70	7.20	0.38	3.66	7.93
		20-60	1.21	-	2.00	5.00	4.96	6.50	1.20	4.00	0.26	2.04	8.12
		60-130	1.19	-	3.20	3.00	4.91	5.00	3.17	2.72	0.22	1.35	8.11
	6	0-25	4.03	-	3.60	11.00	25.21	11.00	4.86	21.10	1.85	8.35	8.03
		25-50	3.20	-	2.00	8.00	21.92	6.50	7.00	17.60	0.82	6.77	8.27
		50-150	3.03	-	2.00	8.00	19.12	20.00	0.30	8.50	0.32	2.67	8.28
K1S	3	0-20	1.22	-	2.80	3.00	5.60	3.00	2.30	5.80	0.30	3.56	8.24
		20-50	1.54	-	3.80	6.00	6.08	5.00	2.20	7.60	1.08	3.59	8.13
		50-100	1.08	-	3.20	4.00	2.87	4.00	0.33	5.40	0.34	3.67	8.06
	4	0-20	1.98	-	3.40	5.00	11.85	7.00	6.90	5.60	0.75	2.12	8.08
		20-55	1.01	-	2.80	4.00	2.98	4.50	0.80	4.00	0.48	2.46	8.10
		55-130	0.93	-	2.40	3.00	3.86	3.50	2.27	3.25	0.24	1.90	8.14
K11	7	0-25	4.13	-	3.60	10.00	27.70	20.50	7.20	10.85	2.75	4.79	8.14
		25-60	3.69	-	2.40	6.60	27.42	7.50	11.20	16.80	0.92	5.49	8.30
		60-150	3.02	-	3.60	8.00	17.89	13.00	6.23	9.60	0.66	3.09	8.13
	11	0-25	7.80	-	3.20	11.40	63.10	34.00	10.61	32.50	0.59	10.83	7.74
		25-55	7.71	-	3.00	23.00	51.06	20.00	20.27	36.00	0.79	9.90	8.06
		60-120	7.00	-	2.80	3.00	63.10	22.00	15.96	30.00	0.94	9.40	8.07
K2	1	0-25	3.32	-	3.80	10.00	18.80	17.00	7.00	6.60	2.00	1.95	7.92
		25-60	1.70	-	3.40	6.00	7.17	5.00	1.23	9.20	1.14	5.21	7.94
		60-100	4.04	-	2.40	5.00	34.00	27.00	5.69	5.31	2.40	1.88	7.85
	2	0-20	4.09	-	3.00	11.00	26.90	14.50	9.17	14.25	2.98	4.43	5.88
		20-50	1.03	-	1.40	5.00	5.47	3.50	2.27	4.80	1.30	2.83	8.09
		50-150	1.91	-	2.80	3.00	12.28	6.00	6.00	5.40	0.68	2.20	8.01

Table (7): Cont.

Soil mapping unit	Profile No.	Depth (cm)	EC (dSm^{-1})	Anions(mel^{-1})				Cations(mel^{-1})				SAR	pH soil paste
				CO_3^{--}	HCO_3^-	Cl^-	SO_4^{--}	Ca^{++}	Mg^{++}	Na^+	K^+		
K3	12	0-20	7.28	-	2.80	26.00	43.81	25.00	15.86	30.25	1.50	9.35	7.60
		20-60	7.98	-	2.60	25.00	53.15	22.00	9.98	48.00	0.77	9.81	8.10
		60-80	7.06	-	2.60	27.00	40.92	14.00	16.77	39.00	0.75	12.45	8.31
	13	0-20	5.45	-	3.40	18.00	31.97	10.00	9.27	33.28	0.82	10.85	8.13
		20-60	3.99	-	2.00	11.00	27.07	13.00	7.13	19.60	0.34	6.20	8.05
		60-80	6.06	-	4.20	11.00	44.37	24.50	8.19	26.40	0.48	6.53	8.05
K4	16	0-25	6.58	-	3.20	25.00	37.12	16.50	9.94	38.00	0.88	9.04	7.85
		25-70	3.52	-	2.40	11.00	20.72	7.00	5.50	21.20	0.42	8.64	8.03
		70-125	4.96	-	2.40	14.00	32.16	7.50	5.40	35.20	0.46	13.82	7.73
	17	0-25	7.85	-	3.20	48.00	27.10	30.80	16.86	30.00	0.64	10.89	7.44
		25-60	4.45	-	2.80	13.00	28.18	10.50	3.44	29.60	0.44	11.20	7.89
		60-150	4.78	-	3.00	11.00	32.40	9.00	5.90	31.20	0.30	11.43	7.98
Y1	8	0-25	2.43	-	3.20	12.02	8.53	6.50	2.63	12.80	1.82	5.99	8.30
		25-50	2.11	-	2.40	4.00	13.68	5.00	2.60	12.00	0.48	6.16	8.35
		50-120	3.06	-	2.80	4.00	22.23	8.50	4.00	16.80	0.53	6.72	8.40
	9	0-30	5.51	-	3.20	19.00	32.58	19.50	8.90	24.50	1.88	6.50	8.00
		30-55	5.78	-	2.80	10.00	43.84	29.50	4.20	22.50	0.44	6.50	7.80
		55-90	6.73	-	2.80	14.00	48.42	29.50	8.90	26.50	0.32	6.05	7.40
	10	0-30	4.83	-	3.80	10.00	34.36	20.00	7.90	19.60	0.66	5.25	7.74
		30-65	6.30	-	2.80	11.00	48.98	29.50	9.90	23.00	0.38	5.18	7.67
		65-95	5.55	-	2.40	7.00	45.56	28.00	8.54	18.00	0.42	4.20	7.67
O1	15	0-25	5.03	-	3.00	13.00	33.59	19.50	3.00	26.30	0.73	8.00	8.13
		25-50	4.52	-	3.20	14.00	27.14	11.00	1.98	30.40	0.96	11.93	9.90
		50-150	5.19	-	2.40	17.00	33.31	9.50	9.75	32.80	0.66	10.57	7.85
O11	14	0-25	7.65	-	3.20	17.00	56.29	30.00	20.83	25.00	0.66	7.97	8.06
		25-65	6.67	-	2.40	11.40	51.99	19.50	8.38	36.80	1.06	9.86	80.27
		65-125	4.80	-	3.00	15.00	29.80	10.00	6.34	30.40	1.06	10.46	8.30

With respect to the cationic composition of the saturated soil paste extract, data indicate that Na^+, in general, is the dominant cation followed by Ca^{++} and Mg^{++} in most of the studied soil profiles, while K^+ is the least abundant cation in all soil profiles under consideration. The anionic composition usually follows the descending order of $SO_4^{--} > Cl^- > HCO_3^-$, with entire absence of CO_3^{--}.

4.3.2. Soil pH:

Values soil pH (Table, 7) are generally tending to be at slight or medium alkaline reaction (7.40-8.40). This is confirmed by the parallel trend of the SAR values which being in the range of 1.35 to 14.72.

The lowest value was found in the deepest layer of profile No.5 (K1, soil unit), while the highest one is detected in the surface layer of profiles Nos.15 and 17 (O1 and K4, soil units). In general, the SAR values are relatively low in most of the studied soil profiles.

4.3.3. Organic matter content:

Data in Table (8) show that the organic matter content was relatively low, with a range of 0.07- 0.63% for profile 15 (O1, soil unit) and profile 13 (K3, soil unit), respectively. This condition represents a natural characteristic of the soils in the arid and semiarid regions and their scanty vegetation. In general, the organic matter tends to decrease gradually with soil depth. The relatively high values are usually occurred in the surface

Table (8): Organic matter content, cation exchange capacity (CEC) and exchangeable cations of the studies profiles

Soil mapping unit	Profile No.	Depth (cm)	Organic matter %	CEC (me/100g soil)	Exchangeable cations (me/100g soil)				ESP
					Ca^{++}	Mg^{++}	Na^{+}	k^{+}	
K1	5	0-20	0.49	7.80	3.98	2.58	0.52	0.36	6.66
		20-60	0.27	8.60	5.00	2.04	0.75	0.71	8.72
		60-130	0.25	8.80	4.21	2.44	1.05	0.80	11.93
	6	0-25	0.40	7.30	3.23	2.53	0.76	0.58	10.41
		25-50	0.25	8.90	4.01	2.74	1.15	0.80	12.92
		50-150	0.17	9.70	5.11	2.80	0.92	0.77	9.48
K1S	3	0-20	0.40	6.60	3.70	1.70	0.69	0.31	10.45
		20-50	0.21	8.30	4.55	2.05	0.75	0.70	9.04
		50-100	0.08	9.20	5.20	2.04	0.69	0.90	7.50
	4	0-20	0.36	6.40	3.35	1.80	0.79	0.16	12.34
		20-55	0.14	8.80	4.21	2.50	0.95	0.70	10.79
		55-130	0.12	7.70	3.75	2.00	0.80	0.87	10.39
K11	7	0-25	0.44	11.90	6.50	3.60	1.02	0.60	8.57
		25-60	0.31	13.10	6.52	4.59	0.97	0.73	7.40
		60-150	0.19	14.00	7.60	4.25	1.01	1.02	7.21
	11	0-25	0.45	9.90	5.31	2.63	0.92	0.77	9.29
		25-55	0.28	13.30	7.30	4.00	0.85	0.80	6.39
		60-120	0.12	16.70	8.02	6.40	1.31	0.80	7.84
K2	1	0-25	0.52	6.50	3.57	1.74	0.56	0.28	8.51
		25-60	0.30	5.80	3.15	1.20	0.70	0.60	12.07
		60-100	0.28	10.80	5.54	2.85	1.15	0.90	10.65
	2	0-20	0.42	5.40	2.70	1.20	0.63	0.70	11.67
		20-50	0.25	7.29	3.30	1.80	0.89	0.93	12.21
		50-150	0.13	8.30	3.90	2.65	0.75	0.80	9.04

Table (8): **Cont.**

Soil mapping unit	Profile No.	Depth (cm)	Organic matter %	CEC (me/100g soil)	Exchangeable cations (me/100g soil)				ESP
					Ca^{++}	Mg^{++}	Na^{+}	k^{+}	
K3	12	0-20	0.47	11.20	6.26	3.25	0.89	0.60	7.95
		20-60	0.18	8.80	4.82	2.00	1.05	0.80	11.93
		60-80	0.11	17.70	8.46	5.98	1.50	0.96	8.47
	13	0-20	0.63	14.80	8.05	4.25	1.30	0.80	8.78
		20-60	0.34	13.70	7.10	4.30	0.85	0.90	6.20
		60-80	0.12	15.50	9.15	3.93	1.19	0.98	7.68
K4	16	0-25	0.56	14.10	7.43	4.25	1.31⁺	0.90	9.29
		25-70	0.24	15.70	7.60	5.63	1.19	0.98	6.24
		70-125	0.16	13.20	7.25	4.00	0.85⁺	0.70	6.44
	17	0-25	0.45	17.00	8.50	5.40	1.56⁺	1.26	9.18
		25-60	0.32	14.50	7.50	4.25	1.31	1.11	9.03
		60-150	0.21	15.10	9.00	3.63	1.19	0.98	7.88
Y1	8	0-25	0.43	9.50	4.22	2.93	1.09	0.85	11.47
		25-50	0.25	10.90	5.99	2.65	0.96	0.76	8.81
		50-120	0.09	11.10	4.90	4.60	0.65	0.55	5.86
	9	0-30	0.44	13.50	7.55	4.20	0.85	0.50	6.29
		30-55	0.16	12.90	6.68	3.86	1.35	0.99	10.45
		55-90	0.08	11.30	4.76	3.80	1.52	0.99	13.45
	10	0-30	0.49	10.00	5.03	3.15	0.96	0.56	9.60
		30-65	0.40	11.30	5.26	3.83	1.02	0.99	8.76
		65-95	0.11	9.10	4.05	2.66	1.09	1.05	11.98
O1	15	0-25	0.15	11.50	4.96	3.70	1.52	0.99	13.22
		25-50	0.13	17.50	8.06	5.98	1.86	1.26	10.63
		50-150	0.07	13.70	6.80	5.00	0.85	0.70	6.20
O11	14	0-25	0.44	16.20	8.25	5.88	0.88	0.74	5.43
		25-65	0.32	14.00	7.30	4.25	1.31	0.91	9.36
		65-125	0.21	15.90	9.85	3.63	1.19	1.08	7.48

Layers, probably due to intensive cultivation processes and soil management practices, especially organic maturing (**Erian *et al.*, 1991**).

4.3.4. Cation exchange capacity (CEC):

CEC values vary widely from 5.40 (profile No.2, K2) to 17.70 me/100 g. soil (profile No. 12, K3), Table (8). The differences in the CEC values are coincided very well with the soil texture variations, particularly in regard to the clay content, Table (5). However, the CEC values show an irregular distribution pattern with soil depth throughout the studied soil profiles, may be due to the distribution pattern of organic and inorganic colloids.

Regarding the distribution of the exchangeable cations, data in Table (8) reveal that it follows a descending order of $Ca^{++} > Mg^{++} > Na^{+} > K^{+}$. Moreover, the exchangeable sodium percentage is less than 15 in all the studied soil profiles, indicating no sodicity hazard in the investigated soils (**Gobran, 1990**).

4.4. Plant nutrients as related to soil characteristics:

4.4.1. Available macronutrients:

Available N, P and K were determined to throw some light on fertility aspects, which are mainly controlling the productivity status of the studied soils.

In general, the values of available nitrogen were relatively moderate tended to decrease from topsoil towards the subsurface

Table (9): Available contents of some macro and micronutrients in the studied soils

Soil mapping unit	Profile No.	Depth (cm)	Available contents (mg kg^{-1})						
			N	P	K	Fe	Mn	Zn	Cu
K1	5	0-20	49.90	7.47	174.62	5.78	4.26	0.66	1.52
		20-60	34.90	3.33	153.63	2.54	3.28	1.02	0.76
	6	0-25	38.00	6.89	187.20	4.86	4.49	2.21	0.63
		25-50	35.00	2.33	117.31	4.10	2.62	1.21	1.06
K1s	3	0-20	50.00	4.63	187.90	4.32	3.01	1.45	1.06
		20-50	41.00	1.67	147.39	5.38	4.10	1.75	1.32
	4	0-20	46.70	7.45	171.10	4.76	3.77	1.36	0.90
		20-55	33.40	1.49	148.64	5.24	2.55	1.66	0.46
K11	7	0-25	48.70	8.08	178.20	6.92	4.02	0.75	1.64
		25-60	31.30	6.55	115.56	5.62	1.84	1.21	0.69
	11	0-25	40.03	7.04	197.31	4.88	3.11	3.45	0.55
		25-60	38.30	2.36	151.13	2.89	2.43	1.28	1.52
K2	1	0-25	50.00	8.90	195.44	5.54	4.19	1.25	1.17
		25-60	33.40	7.32	124.30	6.08	2.07	0.78	1.83
	2	0-20	46.70	6.96	190.80	5.64	3.15	0.53	0.69
		20-50	28.40	3.18	144.89	4.98	2.63	0.33	0.43

Table (9) Cont.

Soil mapping unit	Profile No.	Depth (cm)	Available contents (mg kg^{-1})						
			N	P	K	Fe	Mn	Zn	Cu
K3	12	0-25	48.00	8.80	170.35	5.00	4.05	3.30	1.68
		25-60	26.70	1.43	134.16	4.12	3.19	1.18	1.32
	13	0-20	31.60	4.46	180.70	6.08	2.14	1.91	1.48
		20-55	26.70	1.88	102.97	5.34	1.11	2.12	1.46
K4	16	0-25	35.33	5.07	113.56	5.74	2.05	3.06	1.57
		25-70	23.00	3.55	102.02	4.50	0.87	1.37	0.87
	17	0-25	24.91	8.75	187.82	6.34	5.22	3.65	0.99
		25-60	10.80	7.86	130.41	5.92	1.39	2.59	0.41
Y1	8	0-25	40.03	10.47	171.68	6.06	4.04	1.77	1.63
		25-60	38.30	7.27	148.64	5.64	3.34	2.46	0.81
	9	0-30	46.40	7.50	174.46	4.50	5.76	1.76	1.53
		30-55	38.70	3.64	141.64	3.10	3.95	1.79	1.39
	10	0-30	59.70	7.02	148.64	4.64	3.87	3.18	1.11
		30-65	45.00	2.76	122.43	4.14	1.66	1.57	1.25
O1	15	0-25	36.70	4.25	181.12	5.16	2.38	1.20	1.77
		25-50	32.30	1.82	100.64	4.56	1.23	1.05	0.87
O11	14	0-25	50.00	4.79	195.68	6.36	4.08	3.60	1.53
		25-65	35.00	1.75	184.08	5.12	1.99	2.70	0.79

layers, Table(9). Available nitrogen in the uppermost layers ranges between 24.91 (profile No.17, K4) and 59.70 mg/Kg^{-1} (profile No.10, Y1) and from 10.80 to 45 mg/Kg^{-1} in the subsurface one of the same soil profiles.

The low nitrogen content is expected in the studied soils, since the investigated area is characterized by arid conditions and relatively high values of both $CaCO_3$ and soil pH, which resulted in a great loss of N due to volatilization, as well as, leaching takes place throughout the relatively coarse textured soil profiles, **(Olsen, 1971).**

Available soil phosphorus is generally low and tending to be decreased with soil depth. The uppermost layers had a wide range fluctuated between 4.46 (profile No.13, K3) and 10.47 mg Kg^{-1} (profile No.8,Y1) while, the subsurface ones, contain, as an average, 1.43 mg Kg^{-1} (profile No.12, K3) to 7.86 mg Kg^{-1} (profile No.17, K4). However, the relatively low phosphorus content in the investigated soils can be explained according to **Olsen (1971) and Lindsay and Norvell (1978)**, who reported that the solubility of phosphorus in calcareous soils is depressed due to formation of the insoluble P forms of tricalcium phosphate.

The values of soil available potassium are relatively low and varied from 113.56 to 197.3 mg Kg^{-1} in the uppermost layers and from 100.64 to 184.08 mg Kg^{-1} in the subsurface ones. These are mainly due to the studied soils, are characterized by a calcareous in nature, and hence are in their content poor of K-bearing minerals, **Ibrahim (2001).**

4.4.2. Available micronutrient:

Table (9) shows that the uppermost and subsurface layers have available content of Fe ranged from 4.32 (profile No.3, KIs) to 6.92 mg Kg^{-1} (profile No.7, K11) and from 2.54 profile No. 5, (K1 unit) to 6.08 mg Kg^{-1} profile No.1, (K2 unit), respectively. The highest value is recorded in the surface layer of profile No.7 (K11 unit), while the lowest one is associated with the subsurface layer of profile No. 5 (K1 unit), **Eisa (2001).**

Considering the vertical distribution of available Fe, data show that extractable Fe behaved an irregular distributed pattern throughout the studied soil profiles. It is evident that, according to **Follett and Lindsay (1970) as well as Metwally and *El-Damaty*, (1972)**, the surface layers of soil profiles Nos. 5, (K1 unit), 11 (K11 unit) and 9 (Y1 unit) are exhibiting a deficient level.

The amount of DTPA-extractable Mn in the studied profile layers are presented in Table (9). Data show that DTPA-extractable Mn varies from 2.05 (profile No. 16, K4) to 5.76 mg Kg^{-1} (profile No.9,Y1) in the uppermost layers and from 0.87 mg Kg^{-1} (profile No. 16,K4) to 4.10 mg Kg^{-1} (profile No.3, KIs) in the subsurface ones. That means the values of available Mn are found within a range of moderate-high in the topsoil, and low-moderate in the subsurface one **(Basyouny, 2001)**.

Table (9) shows that amount of DTPA-extractable Zn in the studied profiles layers, differs widely from 0.66 (profile No. 5,K1) to 3.65 mg Kg^{-1} (profile No. 17, K4) in the uppermost layers and from 0.33 (profile No.2, K2) to 2.29 mg Kg^{-1} (profile No.17,K4) in the subsurface ones. Considering the vertical distribution of available Zn, data show that DTPA-extractable Zn decreased with increasing soil depth. Comparing the amounts of DTPA-extractable Zn in the studied soil profiles with the critical levels postulated by **Lindsay and Norvell (1978),** it is found that the obtained values are lying within a wide range of high (>2 mg/Kg $^{-1}$) to low (<1 mg/Kg $^{-1}$) avelaible soil Zn level.

The DTPA-extractable copper in the studied profile layers are presented in Table (9). The data show that DTPA-extractable Cu varies widely and showing a range fluctuated from 0.55 (profile No.11,K11) to 1.83 mg Kg^{-1} (profile No. 15,O1) in the uppermost layers and from 0.41 (profile No.17, K4) to1.52 mg Kg^{-1} (profile 11, K11) in the subsurface ones. It is clear from the obtained values that all investigated soils have adequate amounts of available copper **(Abol roos et al., 1996)**.

From the discussion above mentioned values obtained for the micronutrient levels in the tested soils , it could be concluded that most of the studied soils are suffering from nutrients deficiency, especially in the subsurface layers. This is could mainly due to the relatively high activity of soil calcium carbonate , **(FAO, 1968).**

4.5. Mineralogy of the clay fraction:

The type of clay minerals and their content in soils are of importance, as they controlled most, if not all, the soil properties, i.e. shrinkage, swelling, plasticity, moisture holding properties, permeability, ion exchange capacity, adsorption phenomenon, fixation or realse of nutritive elements and soil weather ability.

The data of clay minerals are used as a criterion for differentiating the soils among the different geomorphic units under consideration.

The X-ray diffraction analysis is an essential tool for studying the clay mineralogy of soils. The X-ray diffraction characteristics for each clay species present in a given soil sample reveal its mineralogy. The intensity and sharpness of the peaks are affected by many factors, such as contents and fineness of crystals, crystal imperfection, degree of disordering, content of amorphous materials and the presence or absence of clay mineral mixture.

The x-ray diffractograms obtained from the diffractometer scans of oriented clay samples are shown in Figures (7-10). These figures were used for identifying the different minerals in the selected clay samples, using the diagnostic criteria of **Brown (1961), Black (1965), Dexon and Weed (1977) and Abdel-Aal *et al.*, (1979),** as follows:

1. The smectite minerals (the montmorillonite group)are identified by the expansion of the basal reflection (001)from 14 A ° in the Mg-saturated sample 18 A ° upon glycerol solvation, and its collapse to about 10A ° in the K-saturated sample, heated to 550 °C for four hours.
2. The kandite minerals (the kaolinite group) are identified by the presence of very sharp peaks at 7.18A° and 3.55 A ° in the Mg- saturated samples. These peaks are not affected by glycerol solution and they disappear upon heating to 550 °C for four hours.

3. The hydrous mica minerals are identified by the presence of the basal maximum 10 A ° peaks upon Mg-saturation, which remains constant throughout the different treatment.
4. Palygorskite mineral is identified from the basal reflection (001) of strong intensity at spacing ranges from 10.5 A ° pack in th Mg-saturated sample, which is not affected by the glycerol solvation. The presence of other diffraction peaks of moderate intensity at 6.44, 5.42, 4.50, 3.68, 3.24 and 2.15 A °
5. The vermiculite is identified by the presence of the 14 A°, which is contracted to 10 A° in the K-saturated sample heated to 550 °C for four hours.
6. The chlorites are identified by the presence of basal diffraction peaks at 13.6-14.3 A ° (first order) and 7.07-7.20 A ° (second order), which remain costant throughout the different treatments, the presence of the third order reflection at 4.7-7.8 further confirmed its presence.
7. The interstratified clay minerals are identified by their basal (001) diffraction peak, corresponding to the sum of the spacing of individual components in the different treatments. Randamly interstratified minerals give X-ray diffraction having peaks at positions intermediate between the peaks of individual components. For example randomly interstratified mica-chlorite is characterized by basal spacing intermediate between

10and 14 A°, which do not change during different treatments.

8. Quartz usually gives two fairly strong peaks at 3.35 and 4.26 A° , the former being over twice as intense as the latter.
9. The feldspars, calcite, dolomite and apatite are identified by their characteristic diffraction peaks at 3.1-3.25, 3.03, 2.88 and 2.77 A °, respectively.

Semi-quantitative determinations of clay fraction of the selected samples were estimated by measuring the area under the peaks according to **Gjems (1967),** and given in Table (10). The mineralogical compositions of the separated clay samples representing the different soil mapping units could be discussed in the following.

4.5.1. Soil mapping unit of K_I:

The mineralogical composition of the clay fraction separated from soil profile No. 5, which represented by the soils of K1 unit (Ganacils plain), are dominated by kaolinite, palygorskite and vermiculit, followed by interstratified minerals which are found in few amounts.on the other hand, illite, smectite (montmorillonite) and chlorite are found in minor amounts. The accessory minerals are characterized by the dominance of quartz followed by feldspars, dolomite and calcite, Table (10) & Fig. (7).

4.5.2. Soil mapping unit of Y1 :

The assemblage of clay minerals in soil profile No.10, which representing the soil unit of YI, reveal that kaolinite is the

Table (10): Semi-quantitative determinations of the clay fraction (<0.002m) separated from the different selected soil samples.

Mapping unit	Profile No.	Depth (cm)	Clay minerals							Accessory minerals			
			Montmo-rillonite	Kaolinite	Vermiculite	Illite	Inter-stratified	Chlorite	Playgorskite	Quartz	Feldspars	Calcite	Dolomite
K_1	5	20-60	4.51	32.78	9.83	3.50	5.4	3.30	27.78	8.16	2.56	0.77	1.41
Y_1	10	30-65	1.58	28.21	10.90	4.04	6.24	2.20	24.76	17.54	2.41	0.47	1.71
K_3	13	20-55	2.3	36.92	7.50	3.75	6.20	5.60	22.48	10.70	1.86	1.74	0.95
K_4	17	25-60	3.53	29.59	8.75	2.04	4.80	6.20	22.33	19.80	1.32	0.79	0.85

> 40% Dominate 25-40% Common 15-25% Moderate 5-15% Few < 5 Absent

dominant clay mineral followed by palygorskite, while interstratified minerals and vermiculite are detected in few amounts. Illite, smectite (montomorillonite) and chlorite are found in traceable amounts. Non clay minerals (accessory minerals) are dominated by quartz followed by feldspars, dolomite and calcite, as shown in Table (10) and Fig. (8).

4.5.3. Soil mapping unit of K3:

The X-ray diffraction patterns of the clay fraction seperated from the fine-textured layers of profile No.13, representing the soils of K3 unit, are shown in Table (10) and Fig. (9). These diffraction patterns reveal that the clay fraction of these soils are dominated by kaolinite followed by palygroskite minerals. Insterstratified mierals, vermiculite, cholorite, illite and smectite (montmorillonite) are detected in minor amounts. The accessory minerals are mainly dominated by quartz, while feldspars, calcite and dolomite are found in traceable amounts.

4.5.4. Soil mapping unit of K4 :

This geomorphic unite is represented by 25-60cm layer of profile No.17. The assemblage and frequency of clay minerals are shown in Table (10) and Fig. (10). The data obtained show that kaolinite is the dominant clay mineral in the representative soil sample followed by palygorskite, vermiculite, chlorite and interstratified minerals. While, illite, smectite (montmorillonite) are found in treaceable amounts. Accessory minerals are characterized by a relatively high content of quartz, while feldspars, dolomite and calcite are found in traceable amounts.

From the above-mentioned discussion, it can be concluded that:

1- Kaolinte is the predominant clay mineral in the soils of the different studied soil units. This result is in agreement with those obtained by **Eisa (2001).** The occurrence of a relatively high content of this mineral is confirmed by the prevailing aridity conditions. At the sametime, it confirms the hydromorphic condition of soils propably inherited from the parent material during the drastic leaching of soil in the past humid times.

2- Palygorskite is most probably inherited from sediments rich in salts and $CaCO_3$, and in turn the presence of palygroskite in the studied soils is not only related to the soil formation processes, but also to a geogenic origin.

3- The presence of vermiculite, hydrous mica (illit) and chlorite is explained on the premise that Mg-affected conditions stimulate their formation either through digenesis or neogensis.

4- The low content of vermiculite represents a transitional stage between non-expanding mica and fully expanding montmorillonite. It is expected that they are mostly inherited from the parent material, from which the studied soils are derived.

5- The presence of interstratified minerals occurring in the natural media reveal that they are formed under the moist action in a pre-wet climatic condition. These minerals are considered as a transitional stage between clay mineral and formed primarily by hydrothermal alternation or by weathering involving partial removal of interplanar K from mica or removal of hydroxide interlayers from chlorite.

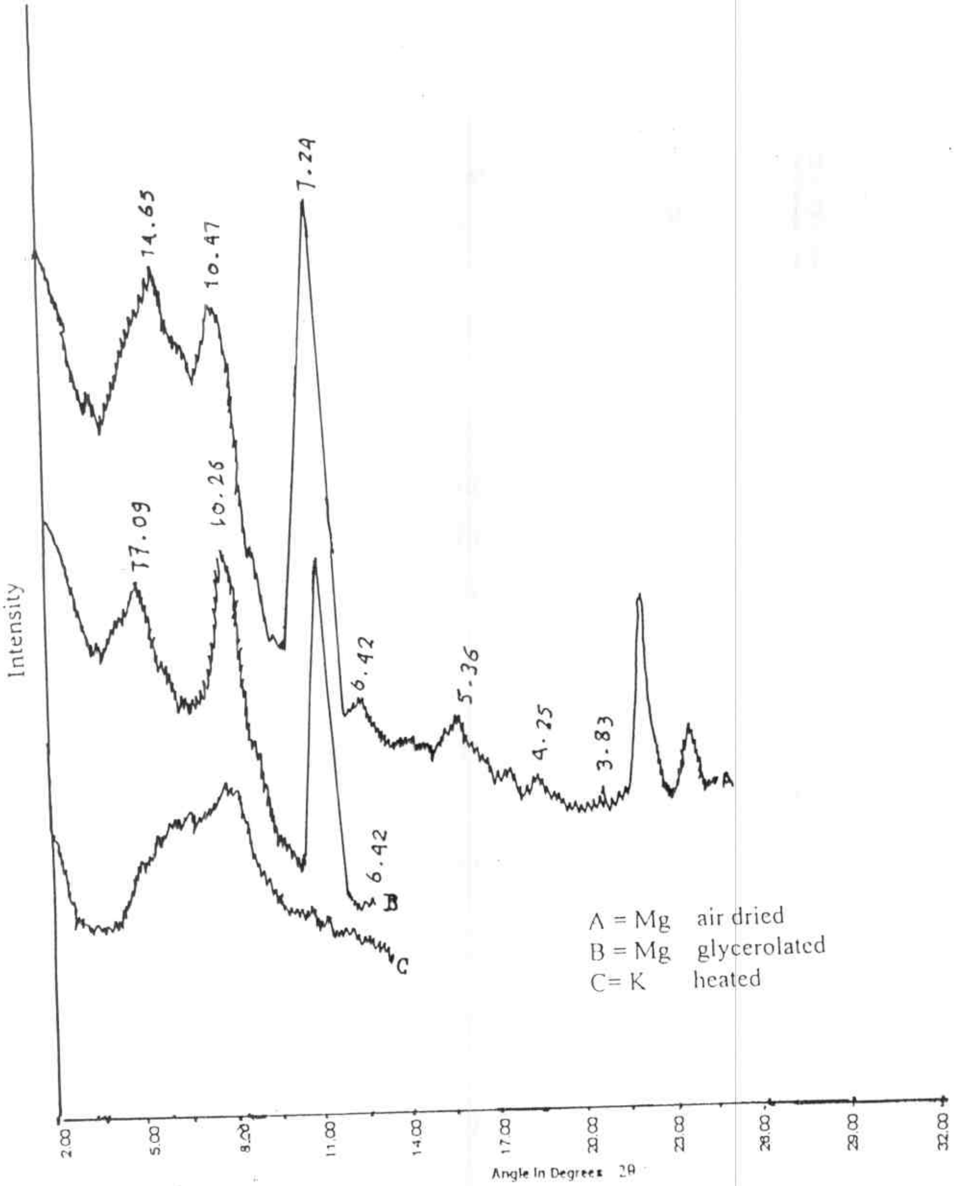


Fig (7) X- ray diffraction pattern of the clay fraction separated from the 20 - 60 cm layer of profile (5)

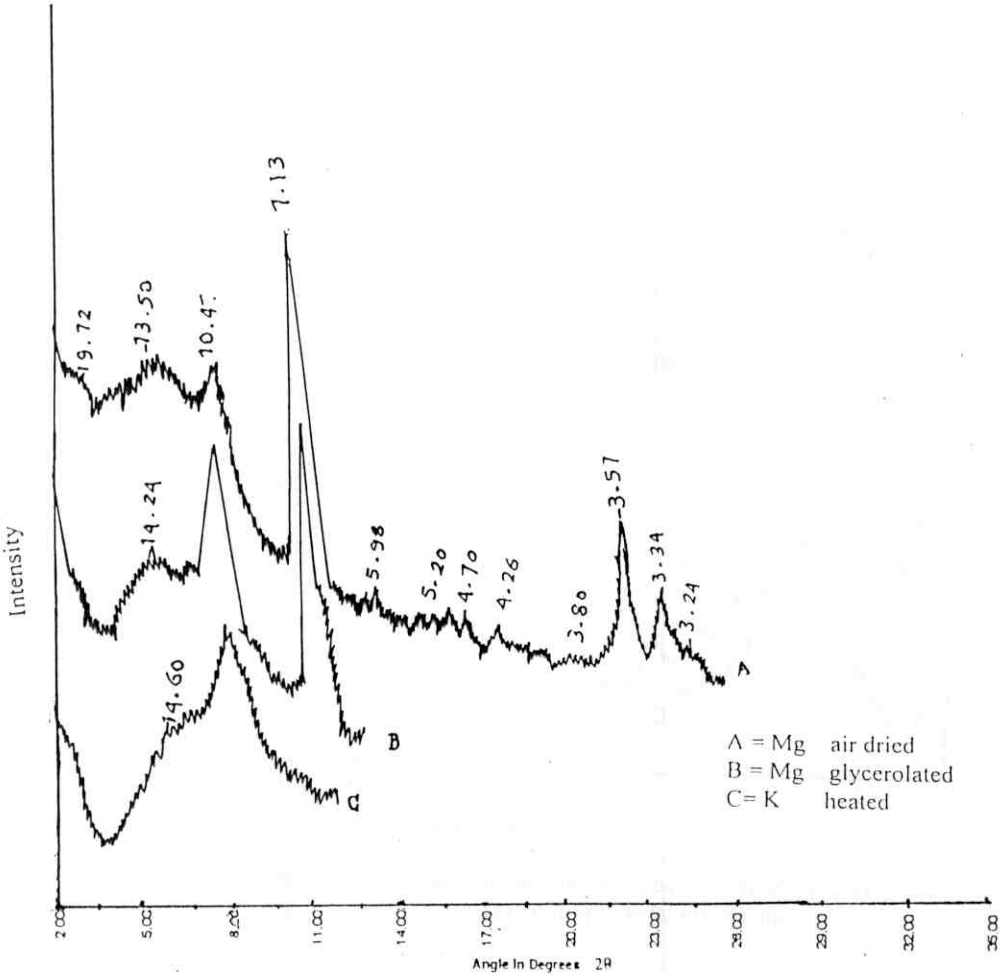


Fig (8) X- ray diffraction pattern of the clay fraction separated from the 30-65 cm layer of profile (10)

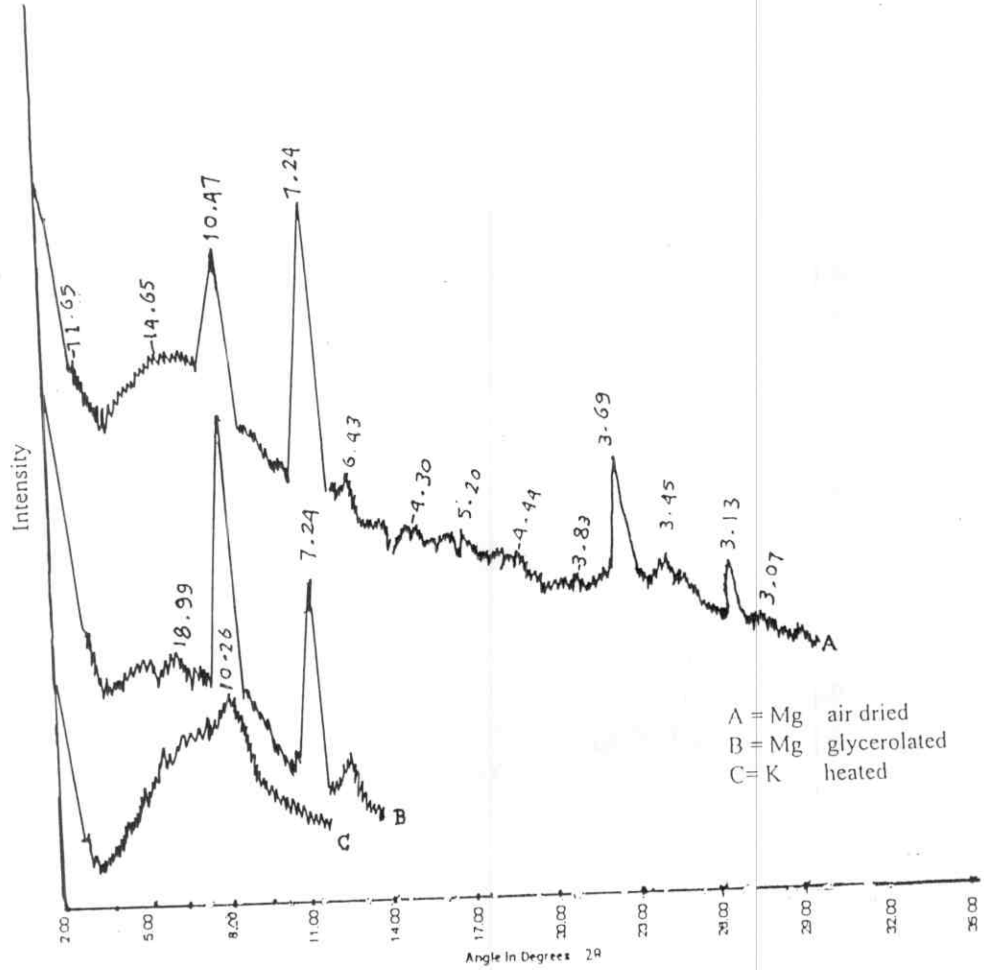


Fig (9) X- ray diffraction pattern of the clay fraction separated from the 20-55 cm layer of profile (13)

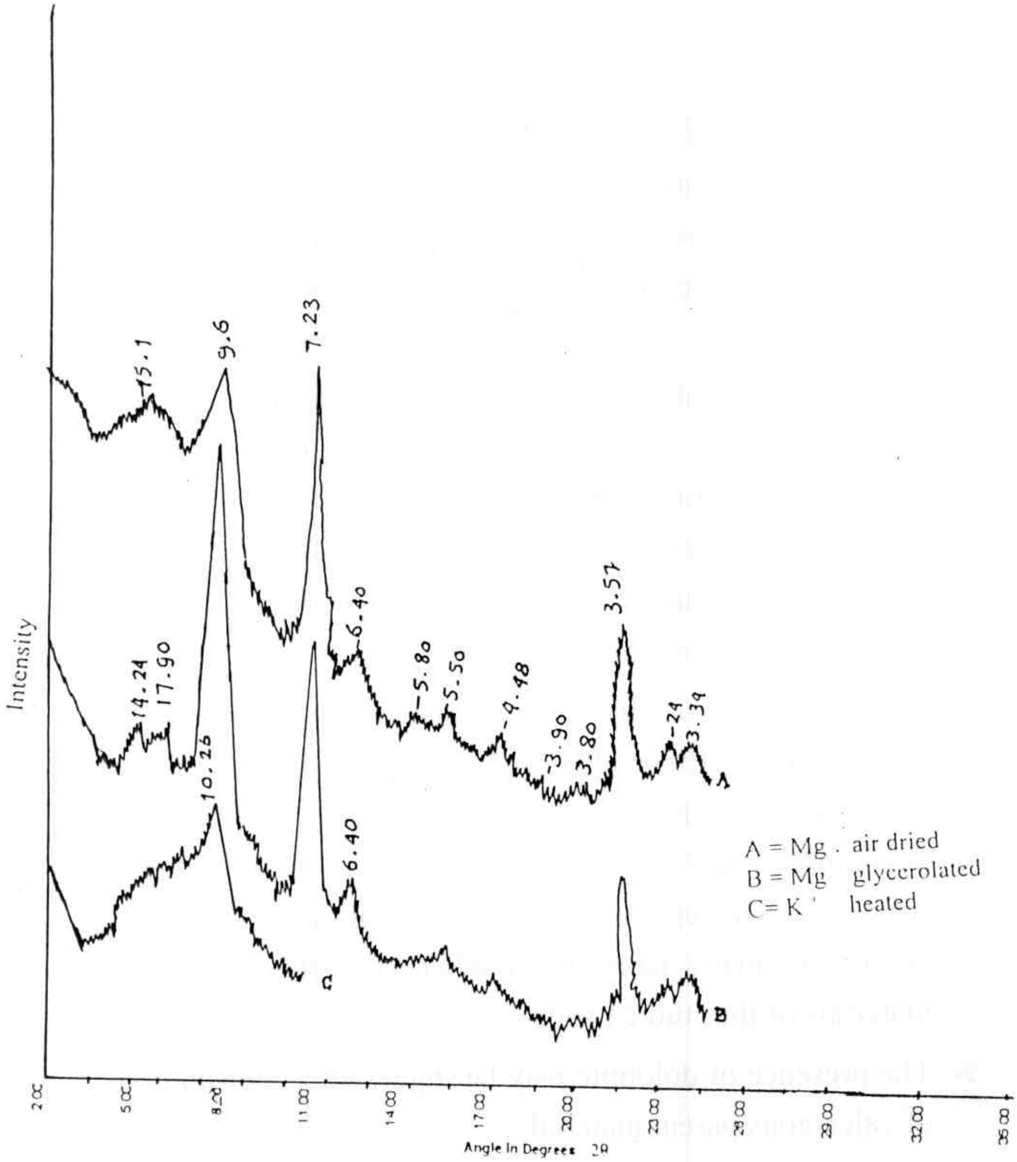


Fig. (10) X- ray diffraction pattern of the clay fraction separated from the 25-60 -cm layer of profile (17)

6- The presence of a relatively high portion of quartz as accessory minerals is a true reflection of the physical weathering of sand stone. Quartz persists due to its high stability or at least in part, being transported through aeolain action.

7- The presence of a pronounced content of feldspars indicate that the studied soils are pedologically young. Feldspars are mostly inherited from the parent material and their persistence in the studied soil profiles serve as an explanation that weathering causes no drastic measure to fulfill their complete decay.

8- Calcite is one of the major constituents of accessory minerals in all the studied soils. The presence of calcite reflect either a direct effect of the aridity conditions or alternation of dry and wet periods of the semi-arid region, which encouragement the formation of such minerals. Beside, in many cases, it is inherited from the parent materials of the studied soils.

9- The presence of dolomite may be suggested a contribution of calcareous parent material.

4.6. Land evaluation:

The objective of land evaluation is to judge the value of an area for defined purposes. The evaluation need not be limited to assessment of environmental characteristics, but the exercise can be extended to the point where the economic viability, the social consequences and the environmental impact of the proposal are also analysed. The parallel and the two-stage approaches are the possible strategies of land evaluation

(FAO, 1976). In the first approach, the analysis of the land and land use relationships proceeds concurrently with economic and social analysis. In the two-stage approach, an economic and social analysis may follow on from a qualitative land ssification. Land use suitability (capability) assessment is an example of the first stage incorporated into planning decisions. Alternatively, the results of a suitability assessment can be subjected to an economic and social analysis to provide a quantitative land classification which can be applied to planning.

The trend towards assessment procedure geared to particular land use is further demonstrated by the FAO Framework for Land Evaluation **(FAO, 1976)** in which the starting point is the land use. The FAO Framework provides a structure by which land can be evaluated for any defined purpose as long as the land use requirements are known and the necessary data about land are available.

4.6.1. Land suitability for irrigation:

The simple approach, propsed by **Sys and Verheye (1978)** was selected for land suitability evaluation of the study area, since it is valid for irrigation purposes in arid and semi arid regions. By this approach, the classification was processed according to the FAO Framework **(FAO, 1976)**. The aim of this system was to provide a method that permits a suitable evaluation for irrigation purposes based on the standared physio-chemical characteristics of the soil profiles. The land characteristics used are topography (t), wetness (w), soil texture including stoniness (s1), soil depth (s2), calcium carbonate status (s3), gypsum status (s4), and salinity & alkalinity (n). these characteristics could be achieved in a relative limitation scale where five levels are used in the following order:

Symbol	Intensity of limitation	Rating
0	No	95-100
1	Slight	85-95
2	Moderate	60-85
3	Severe	45-60
4	Very severe	< 45

Based on the intensity of limitations, the system suggested definations of suitability orders and classes. The suitability index for irrigation (Ci) is calculated as follows:

$Ci = t \times w / 100 \times s_1 / 100 \times s_2 / 100 \times s_3 / 100 \times s_4 / 100 \times n / 100$

In light of the calculated Ci values, the orders and classes of lands can be distinguished as follows:

Order S: Suitable land for irrigation (Ci is more than 25)

- Class S1 : Ci is more than 75.
- Class S2 : Ci is between 50 and 75.
- Class S3 : Ci is between 25 and 50.

Order N : Not suitable (Ci is less than 25).

- Class N1 : with limitations can be corrected.
- Class N2 : with limitations can not be corrected.

Based on the system of **FAO (1976)**, the land suitability units as a subdivision of the subclasses level is applied to specify the kinds of limitations and the minor differences in required management.

According to the above described system, the intensity of limitations and suitability categories in the studied soils were calculated (Table,11).

4.6.1.1. Intensity of soil limitations:

Applying the land classification system suggested by **Sys and Verheye (1978)**, data in Table (11) indicate that land quality of majority of the soils under study is slightly influenced by many constrains, i.e. topography (t) wetness (w), soil texture (s1, skeletal nature, low water holding capacity, poor fertility and low response for fertilization), calcium carbonate content (s3, less available nutrient supply for plant), gypsum (s4) and soil salinity hazard (n).

On the other hand, soils of K2 and K4 are moderately influenced by soil texture as well as $CaCO_3$ content for soils of K3 and K4 unit.

Moreover, the previous results, Table (11), indicate that soil suitability classes seems to reflect actually degree of soil suitability, where the Ci values could be appropriate in a quantitative classification as follows:

a) Class S1 (highly suitable): This class, which covers about 4662 feddans (20.99% of total area), is represented by soil mapping units of K11 (profiles Nos. 7 & 11) and O1 (profile 15).

b) Class S2 (moderately suitable): This class, which covers about 15040 feddans (67.74% of total area), is represented by the soil mapping units K2 (profiles Nos. 1 & 2), K_{IS} (profiles Nos. 3 & 4), K1 (profiles Nos. 5 & 6), Y1 (profiles Nos.8 & 9, 10), K3 (profiles Nos.12 & 13) and O_{11} (profile No. 14).

c) Class S3 (marginally suitable: This class, which covers about 2500 feddans (11.26% of total area), is represented by soil mapping unit K4 (profiles Nos. 16 & 17).

4.6.1.2. Land suitability units:

The land suitability classes units as a subdivision of the subclass level is applied to specify the rest of limitations based on the system of **FAO (1976),** which is considered as a base for **Sys and Verheye approach (1978).** The different suitability units of the studied area are shown in Table (11).Fig(11) and are described as follows:

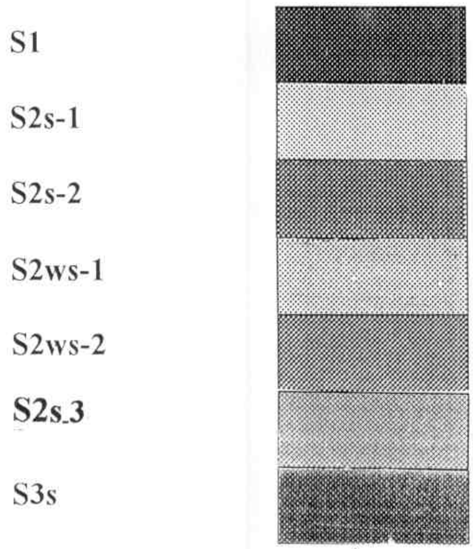
- **S1**

This unit is represented by soils of K11 and O1 units, which are highly suitable (S1), (suitability indices of (75.54 to 76.20) and slightly affected by soil wetness and calcium carbonate limitations.

- **S2s-1 :**

This unit is represented by soils of K_I unit, which are moderately suitable (S2, Ci , indices 68.17 to 69.98). The subclass S2s had moderately intensity of texture and calcium carbonate limitation. It has slight intensity of soil wetness, limitation.

Legend of land suitability units.



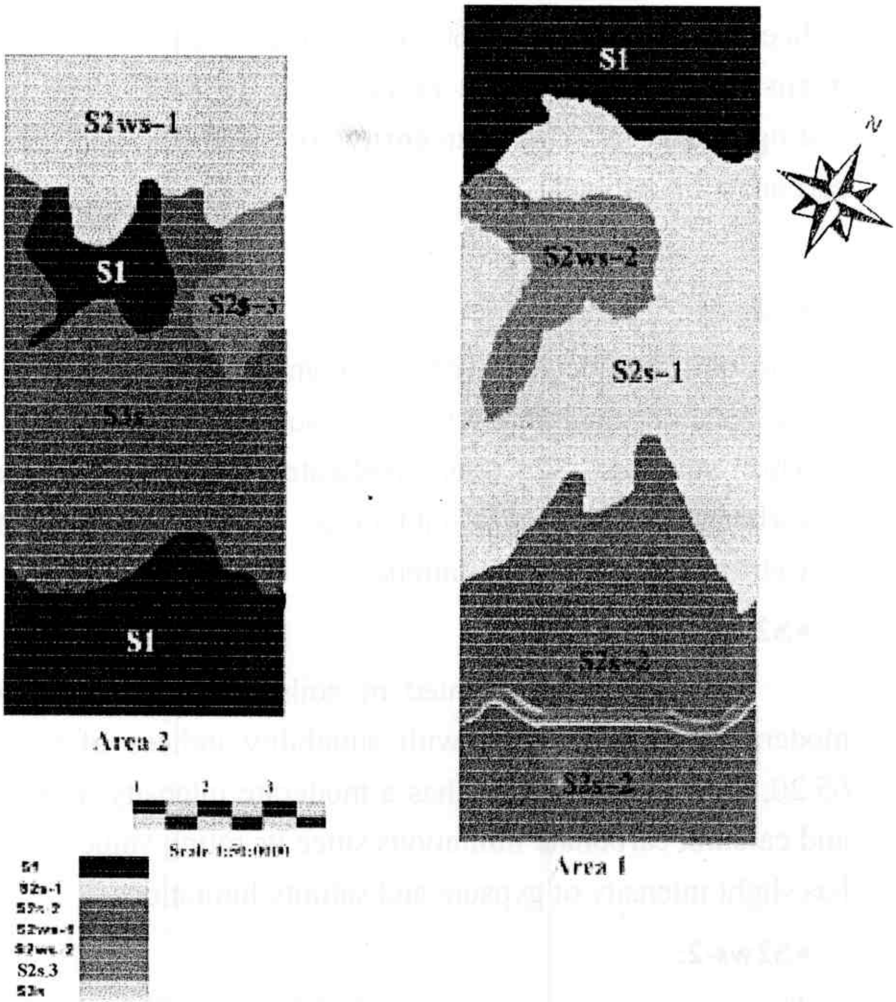


Fig. 11, Land suitability units of the studied area according to Sys and Verheye, 1978,

- **S2s-2 :**

This unit is associated with the geomorphic units of KIs and K2, where the soils are moderately (S2) with suitability indices of 53.35 and 62.60, its subclass S2s has moderately intensity of texture with a rating of 65 to 85.25. The unit is distinguished by slight intensity of wetness and calcium carbonate limitations.

- **S2s-3:**

This unit is associated with the geomorphic unit of OII, where the soils are moderately (S2 with suitability indices of 65.6). This subclass S2s has moderate intensity of calcium carbonate, and gypsum limitations. It has slight intensity of wetness and salinity limitations

- **S2ws-1:**

This unit is represented by soils of K3 unit, which are moderately suitable (S2), with suitability indices of 61.17 to 65.20, the subclass (S2ws) has a moderate intensity of wetness, and calcium carbonate limitations since its rating value is 85.0. It has slight intensity of gypsum and salinity limitations

- **S2ws-2:**

This unit represents soils of Y1 unit. This land is moderately suitable (S2), with suitability indices of 62.01 to 65.39. This subclass S2ws has a moderate intensity of

Table (11): Intensity of limitations and suitability classes of the studied soils (according to **Sys & Verheye, 1978)**

Soil mapping unit	Profiles No.	Area (fed.)	t	w	S				n	Ci	Suitability class	Suitability subclass	Unit
					S_1	S_2	S_3	S_4					
K1	5	4110	100	90	88.3	100	90	100	96	68.7	**S2**	S2s	S2s-1
	6	2000	100	95	87	100	90	98	96	69.98	**S2**	S2s	
K1s	3	700	100	85	85.25	100	90	100	96	62.6	**S2**	S2s	S2s-2
	4	1310	100	90	74.2	100	90	98	96	56.54	**S2**	S2s	
K11	7	1110	100	90	98	100	90	100	96	76.2	**S1**	S1	S1
	11	3000	100	90	98	100	92	95	98	75.5	**S1**	S1	
K2	1	930	100	90	65	100	95	100	96	53.35	**S2**	S2s	S2s-2
	2	900	100	90	68	100	95	100	96	55.81	**S2**	S2s	
K3	12	1250	100	85	96	100	85	90	98	61.17	**S2**	S2ws	S2ws-1
	13	2500	100	85	100	100	85	95	95	65.2	**S2**	S2ws	
K4	16	1200	100	85	75	100	80	95	100	48.45	**S3**	S3s	S3s
	17	1300	100	85	80	100	80	93	98	49.58	**S3**	S3s	
Y1	8	210	100	85	88.8	100	95	95	96	65.39	**S2**	S2ws	S2ws-2
	9	400	100	80	93.5	100	100	95	90	63.95	**S2**	S2ws	
	10	400	100	80	95	100	100	85	96	62.01	**S2**	S2ws	
O1	15	550	100	90	95	100	95	95	98	75.6	**S1**	S1	S1
O11	14	330	100	90	100	100	90	90	90	65.6	**S2**	S2s	S2s-3

t = Topography
w = Wetess
n = Salinity and alkalinity

s_1 = Te xtural
s_2 = Depth
s_3 = Calcium carbonate status
s_4 = Gypsum status

wetness limitation since its rating value is 80.0 to 85.0. It has slight intensity of texture, gypsum and salinity limitations.

- **S3s :**

This unit represents soils of K4 unit, a marginally suitable (S3 with suitability indices of 48.45 to 49.58). The subclass S3s has a moderate intensity of texture and calcium carbonate (with a rating value of 75 and 80 , respectively. It has slight intensity of wetness and gypsum limitations.

4.6.2. Land suitability for certain crops:

The land suitability for irrigation, shown in Table (11) and Fig.(12), characterized and appraises land development units from a general point of view without mentioning the specific kind of use. The obtained results may be very useful, but as a same soil may be suitable for a specific crop and unsuitable for another.

The requirements with regard to landscape and soil condition for a wide range of crops were suggested by **Sys et al. (1993).** In this system, the crop requirements are summarized in separate tables which indicate four limitation levels with corresponding land classes and, also, rating values for the parametric approach. For certain crops the tables have been elaborated on the basis of available literature data and technical reports; for other crops they have been adapted to

Table (12): Suitability classification of the studied soils for certain crops.

Soil mapping unit	Profiles No.	Field crops														Vegetables				Fruits					
		Wheat		Barley		Maize		Sorghum		Alfalfa		Sun-flower		Soybean		Tomato		Cabbage		Olives		Citrus		Mango	
		S_I	S_C	S_I	S_C	S_I	S_C	S_I	S_C	S_I	S_C	S_I	S_C	S_I	S_C	S_I	S_C	S_I	S_C	S_I	S_C	S_I	S_C	S_I	S_C
K_I	5	48.5	S_3	48	S_3	43.4	S_3	68.6	S_2	46	S_3	39	S_3	19	N	39.12	S_3	50	S_2	85	S_1	29	S_3	32	S_3
	6	50.1	S_2	53	S_2	40.2	S_3	71.4	S_2	40	S_3	32	S_3	24	N	35.1	S_3	31	S_3	83	S_1	25	S_3	27	S_3
K_{IS}	3	51.4	S_2	48.8	S_3	41.2	S_3	72.7	S_2	41	S_3	27.6	S_3	27	S_3	30.52	S_3	32	S_3	76	S_1	20	N	48.5	S_3
	4	50.4	S_2	53	S_2	40.4	S_3	67.8	S_2	40	S_3	27	S_3	25	S_3	29.31	S_3	30	S_3	75.3	S_1	19	N	30	S_3
K_{II}	7	65.2	S_2	58.3	S_2	46.0	S_3	65.8	S_2	51	S_2	32.5	S_3	25	S_3	37.1	S_3	36	S_3	75	S_1	20	N	41	S_3
	11	48	S_3	45	S_3	46.3	S_3	59	S_2	46	S_3	35	S_3	26	S_3	35.21	S_3	43	S_3	86	S_1	16	N	25	S_3
K_2	1	51.4	S_2	51.4	S_2	58.3	S_2	72.8	S_2	65	S_2	52.6	S_2	29	S_3	41.42	S_3	62	S_2	85	S_1	31	S_3	41	S_3
	2	51.4	S_2	48.9	S_3	58.3	S_2	72.8	S_2	65	S_2	55.4	S_2	29	S_3	41.42	S_3	62	S_2	85	S_1	30	S_3	48.5	S_3
K_3	12	42	S_3	37.3	S_3	27.5	S_3	57	S_2	28	S_3	35	S_3	21	N	19.95	N	29	S_3	73	S_2	23	N	27	S_3
	13	46	S_3	48.7	S_3	27.5	S_3	54	S_2	31	S_3	41	S_3	18	N	21.47	N	25	S_3	69	S_2	22	N	35	S_3
K_4	16	39	S_3	43.0	S_3	31.0	S_3	36	S_3	32	S_3	31	S_3	23	N	15.64	N	26	S_3	51	S_2	21	N	23	N
	17	35	S_3	43.0	S_3	25.5	S_3	32	S_3	27.2	S_3	25	S_3	21	N	16.26	N	25	S_3	51	S_2	23	N	21	N
Y	8	50.1	S_2	45	S_3	40.0	S_3	75	S_1	65	S_2	38	S_3	45	S_3	28.1	S_3	45	S_3	85	S_1	30	S_3	37.5	S_3
	9	55	S_2	59	S_2	55.2	S_2	79	S_1	73	S_2	44	S_3	37	S_3	33.93	S_3	60	S_2	86	S_1	34	S_3	31	S_3
	10	48	S_3	46	S_3	52.5	S_2	63.7	S_2	70	S_2	32	S_3	45	S_3	31.59	S_3	57	S_2	73	S_2	30	S_3	28	S_3
O_I	15	62	S_2	65.2	S_2	58	S_2	77	S_1	62	S_2	44	S_3	46	S_3	35	S_3	49	S_3	77	S_1	26	S_3	29	S_3
O_{II}	14	72.6	S_2	85	S_1	69	S_2	89	S_1	69	S_2	39	S_3	44	S_3	37	S_3	51	S_2	73	S_2	28	S_3	27	S_3

SI = Suitability Index SC = Suitability Class specific site conditions using regional experience **Sys et al. (1993).**

Accordingly, the suitability indices (Si) and classes of the studied soils for twelve different crops (seven filed crops, two vegetables and three fruits) are calculated and given in Table (12). The suitability classes for the tested crops are varied and could be arranged, generally, as follows:

Field crops: Sorghum (S1/S2) followed by barley, wheat and alfalfa (S2/S3) followed by maize (S3/S2) followed by sunflower (S3) followed by soybean (S3/N1).

Vegetables and fruits: Olives (S1/S2) followed by cabbage (S3/S2) followed by mango and tomato (S3) followed by citrus (N1/S3).

In addition, the suitability indices of the tested crops were arranged in descending order within soil mapping units. Then, the optimum, marginal and not suitable land use could be identified as given in Table (13). The optimum land use includes crops that having (Si) of 50 or more, while the marginal that lies between 50 and 25. From the obtained order, the soil mapping units in the studied area were regrouped into five land classified units as follows:

Table (13): Optimum, marginal and not suitable land utilization for the tested crops in the studied soils .

Soil mapping units					Land utility class
O1,O11	K2,Y	K1,K1s,K11	K3	K4	
Sorghum (83)	Olives (83.5)	Olives (78.4)	Olives (71)	Olives (51)	Optimum
Barley (75.1)	Sorghum (72.7)	Sorghum (67.6)	Sorghum (55.5)	Barley (43)	
Olives (75)	Alfalfa (67.2)	Wheat (52.3)	Wheat (44)	Wheat (37)	
Wheat (67.3)	Cabbage (58)	Barley (51)	Barley (43)	Sorghum (34)	
Alfalfa (65.5)	Maize (53.8)	Alfalfa (44)	Sunflower (38)	Alfalfa (29.6)	Marginal
Maize (63.5)	Wheat (51.2)	Maize (42.9)	Mango (31)	Maize (28.3)	
Cabbage (50)	Barley (50.1)	Cabbage (37)	Alfalfa (29.5)	Sunflower (28)	
Soybean (45)	Sunflower (46)	Tomato (34.4)	Maize (27.5)	Cabbage (25.5)	
Sunflower (41.5)	Mango (38.5)	Mango (33.9)	Cabbage (27)	Mango (22)	
Tomato (36)	Tomato (36.3)	Sunflower (32.2)	Citrus (22.5)	Citrus (22)	Not suitable
Mango (28)	Soybean (35.7)	Soybean (24.3)	Tomato (20.8)	Soybean (22)	
Citrus (27)	Citrus (30.9)	Citrus (21.5)	Soybean (19.5)	Tomato (15.9)	

(....) Mean of suitability indices (Si) values

a) O1 and O11 soil units:

The soils of this group, that represent most of the Abu Mina valley, indicate the relatively highest Si values of the tested crops. It showed highly suitable for sorghum, barley and olives, while the moderately suitable were detected for wheat, alfalfa, maize and cabbage. The rest of the tested crops indicated as suitable ones.

b) K2 and Y soil units:

This group represents part of both the gentel slopes of Mariut Table – land and Gianaclis plain. It indicates almost similar results as O1and O11 soil units but with relatively low Si values for the tested grain crops (maize, wheat and barley).

c) K1, K1s and K11 soil units:

This group represents most of Gianaclis plain and parts of the gentel slopes of Mariut Table – land. It showed highly suitable for olives and moderately suitable for sorghum, wheat and barley. The moderately suitable were detected for the rest of the tested crops, except soybean and citrus which exihibted not suitable.

d) K3 soil unit:

The soils of this unit represent parts of the gentel slopes of Mariut Table – land that characterized by relatively high lime content. It showed marginaly suitable for most of tested crops

,except the moderately suitable for olives and sorghum ,and not suitable for citrus ,tomato and soybean.

e) K4 soil unit:

The soils of this unit represent part of the gentle slops of Mariut Table-land that characterized by highest contents of both lime and coarse fragments.

It indicates almost similar trend of K3 soil unit, but in relatively low values of Si for all crops.

It should be mentioned that the tables of **Sys et al. (1993)** have to be considered as a guideline so that the limitation levels for the different characteristics should be critically reviewed and possibly adapted to local conditions and sometimes to varieties of the same crop

The land utilization types, as Km^2 and % of the total area, which resulted from the requirements of the investigated crops (field crops, vegetables and fruits) are given in Table (13). In general, data obtained indicate that the identified land suitability classes (S1, S2, S3 and N1) reflect the degree at suitability for each crop under investigation. A quantitative classification showed that all crops under study could be grown in about 86% of the total area.

As for a more detailed survey, results show that some of the investigated field crops exhibited a highly suitable class for either a relative big area, i.e., olives (60.88 km^2) or few scattered ones, i.e., barley (1.32 km^2), sorghum (5.96 km^2). However, Table (14): Areas (km^2 & %) of the land suitability classes for the investigated crops in the area under consideration.

Investigated crops	**S_1**		**S_2**		**S_3**		**N**	
	km^2	%	km^2	%	km^2	%	km^2	%
Wheat	-	-	33.76	38.02	55.04	61.98	-	-
Barley	1.32	1.48	25.2	28.38	62.28	70.13	-	-
Maize	-	-	14.04	15.81	74.76	84.19	-	-
Sorghum	5.96	6.71	72.84	82.03	10.00	11.26	-	-
Alfalfa	-	-	19.32	21.75	65.48	78.24	-	-
Sunflower	-	-	7.32	8.24	81.48	91.75	-	-
Soybean	-	-	-	-	39.36	44.32	49.44	55.67
Tomato	-	-	-	-	63.80	71.84	25.00	28.15
Cabbage	-	-	28.28	31.85	60.52	68.15	-	-
Olives	60.88	68.55	27.92	31.44	-	-	-	-
Citrus	-	-	-	-	39.32	44.28	49.48	55.72
Mango	-	-	-	-	78.80	88.74	10.00	11.26

most of soils of the studied area are moderate to marginal uitable for wheat (88.8 Km^2, barely (87.48 km^2), maize (88.8 km^2), sorghum (82.84 km^2), alfalfa (88.8 km^2), sunflower (88.8 km^2) soybean (39.63 km^2), tomato (63.8 km^2), cabage (88.8 km^2), olives (27.92 km^2), citrus (39.52 km^2) and mango (78.8 km^2).

Locally non suitable areas for cultivation are occurred in some of the studied, soils for some of the crops under consideration, i.e., soybean (49.44 km^2), tomato (25.00 km^2), citrus (49.48 km^2) and mango (10.00km^2).