Physical Characterization of Some Libyan Soils in Sidi El Mesri Area in the Jaffara Plain

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INTRODUCTION

The rapid progress in Libya during the past few years has been directed towards the expansion of Agricultural land, and the utilization of all resources for the increase in production required to produce enough food for the needs of the population. It is clearly understood that the characterization of soils is an important and integral part of Agricultural planning and development. Since little information about Libyan Soils is available in the literature, a full knowledge of the soil characteristics is regarded as of major importance for Agricultural development.

The objective of this study is to characterize physically the soils in Sidi El Misri area of the Jaffara Plain.

MATERIAL AND METHODS

I. Field Examination

A detailed study of the area of Sidi El Mesri in the Jaffara Plain was conducted. The area covered by this study is about 4 square kilometers; part of this area is the College of Agriculture Experimental Farm. A series of 25 profiles were dug to a depth of 150 cm. Profiles were located to represent the different soil types in the area. All the profiles were examined in the field and samples were collected for analysis. Soils are classified as:

1. Ridge or hilly soils These soils consist of a series of ridges or hills draffed and piled by wind. These ridges are made up of moderately- to strongly-sloping land.

2. Valley soils These soils lay between ridges. The Valley Soils are nearly level and represent about 70% of the area.

3. Sloping soils These soils consist of sloping land located between the Valley Soils and the Ridge Soils, in which the slope varies from moderate to strong.

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4. Calcipan soils The features of this soil resemble the Valley Soils except for the presence of a calich layer of cemented Ca CO_3. in the soil profile.

The area where this calcipan exists is the small area in the depression between the greenhouse of the Experimental Farm and the ridge facing the main high way to Fernag. The presence of this calcipan was not encountered in any other place examined in the area of study to 150 cm depth.

The soil is generally deep in valleys, ridge and sloping land. The depth of the soil profile is not a limiting factor for agricultural development. The soils are developed from alluvial material washed mainly from sandstone and sandy shales. This alluvial land consists of unconsolidated loose material, structureless, generally stratified and showing little variation with depth. This alluvial deposit is too recent for soil profile development. Small concretions of Ca CO_3 occur at different depths of the different profiles, especially in the profiles located in the Valley Soil. Because these valleys form depressions which are surrounded by hilly sloping land, it receives water runoff and during the movement of water in the profile it carries Ca CO_3 with it, which is deposited and accumulated in forms of small concretions at different depths in soil profile (3,2,5).

The subsoil except in locations with calcipan, is a little hard and compact when dry but becomes soft and easily penetrated with auger when moist. It is easily penetrated by roots and water.

II. Methods of Analysis

1. Total water soluble salts The ratio of soil to water adopted is one part of soil to one part of water. The total soluble satls are determined by measuring the electrical conductivity of the extract by means of a conductivity cell and a bridge (7).

2. Soil reaction pH in the soil paste is measured using a bench type glass electrode pH meter.

3. Calcium carbonate Calcium carbonate is estimated volumetrically by means of a calcimeter. The sample which was used in the analysis was 0.1 gm. of soil and the results are corrected to normal temperature and pressure (1).

4. Mechanical analysis The determination of silt and clay was carried out in all samples by the pipette method. Mechanical analysis by this method is precies but time consuming. The Bougoucus hydrometer method (2) was also used and a close correlation was found between the pipette and hydrometer method in such soils. The treatment of soil with HCl was omitted.

5. Bulk density and true density Bulk density was determined by taking a core sample of known volume from the field and the oven dry mass of this core was determined. True density was determined by the picnometer method. A vacuum was used during water displacement to determine exactly the volume of soil particles.

6. Soil water relations The saturation percentage of the samples was evaluated from the total pore space in undisturbed core samples. The moisture content retained by soil at suctions of 1/10, 1/3, 2, and 15 atmospheres was determined by taking undisturbed core samples from different depths in the soil profiles. A core sampler was used for taking the samples. These undisturbed cores were placed on porous plates in the pressure chamber and were saturated with deaerated water. The required pressure was applied and at equilibrium samples were taken out and the moisture retained in the soil was determined on a weight basis and on a volume basis.

RESULTS AND DISCUSSION

1. Description of selected soil profiles representing different types of soils in the area

a. Profile in the Valley Soils

0–35 cm	loose soil, sandy loam in texture, no structure, contains roots and some decayed organic matter; a slight amount of segregated lime occurs in thin veins or in small white mottles.
35–75 cm	little compact, sandy loam; when moist the soil is very friable, contains pebbles and a lot of concretions of Ca CO_3 which increase slightly with depth.
75–130 cm	compact, but not a hard pan, contains pebbles and concretions of Ca CO_3, loamy in texture. When crushed the soil breaks into small aggregates cemented by Ca CO_3. The high content of pebbles and concretions facilitates water movement and good drainage.

b. Profile in the Sloping Soils

0–30 cm	loose materials, sandy to sandy loam in texture, no structure.
30–90 cm	a zone calcarious in nature, rich with pebbles and concretions of Ca CO_3. When crushed, the clods break into loose materials, sandy loam to loam in texture.
90–150 cm	compact when dry, concretion content of this layer is greater than the above layer, the soil breaks into small aggregates cemented with carbonate. Occasionally the accumulation of Ca CO_3 takes the form of discrete thin sheets of calich type, but porous in nature which will not retard water movement.

c. Profile in the Ridge Soils

0–50 cm	loose soil penetrated with roots, sandy loam in texture, no structure; when moist this surface soil absorbs water almost instantly.
50–100 cm	less compacted than the above layer, sandy loam in texture, friable, no structure.
100–150 cm	more compact than the above layer, but soft when moist, sandy loam. There are little spots of Ca CO_3. The soil breaks into clods which form soft fine material when crushed. This profile is easily penetrated with roots and water.

d. Profile in Calcipan Soil

0–35 cm	loose soil sandy loam in nature.
30–65 cm	friable material which is cemented with Ca CO_3, more compact than the above layer, a lot of concretion of Ca CO_3 exists in this layer.
65 cm	rocky cemented calich layer, hard to dig in.

2. Mechanical composition Tables 1, 2, 3 and 4 show the results of the analysis of the different soils in the area. As shown in the tables the Ridge soils contain the lowest content of Ca CO_3 compared to the other soil types. The distribution of Ca CO_3 with depth in the Ridge Soils is uniform which indicates that the deposits in these ridge are of a recent nature and their development is limited. In both Valley Soil and Slope Soils the Ca CO_3 content is comparatively higher and there is some variation with depth. The subsoil contains a higher content of Ca CO_3.

In the Calcipan Soil the Ca CO_3 of the calich layer is very high, it reaches up to 60%. The Ca CO_3 is finely divided and intermixed with other mechanical components giving

Table 1 Soil analysis of profile representative of Valley Soils

Depth of sample cm	Ca CO_3 %	pH in soil paste	E.C. mmhos/cm	T.S.S. %	Mechanical analysis gm/100 gm soil			Texture Class	Bulk density gm/cm^3	True density gm/cm^3	Soil water relations					
					Sand	Silt	Slay				Saturation cm^3/cm^3	1/10 Atm. cm^3/cm^3	1/3 Atm. cm^3/cm^3	2 Atm. cm^3/cm^3	15 Atm. cm^3/cm^3	Available water cm^3/cm^3
0–35	7.44	7.5	0.45	.022	65.7	19.2	15.1	Sandy loam	1.42	2.48	42.5	15.44	8.95	5.61	3.94	5.01
35–70	13.05	7.2	0.55	.027	60.1	19.9	20.0	Sandy loam	1.45	2.63	45.1	24.81	11.40	7.68	4.96	6.44
70–100	10.77	7.6	0.61	.029	59.0	19.7	21.3	Sandy loam	1.47	2.62	44.0	21.80	10.39	7.05	4.90	5.49
100–130	9.96	7.4	0.48	.024	59.8	19.1	21.1	Sandy loam	1.6	2.64	40.0	20.34	11.50	6.91	4.80	6.70

N.B. — T.S.S.: total soluble salts
E.C.: electrical conductivity mmhos/cm
1/10 atm.: water retained at tension equal to 1/10 atmosphere

Table 2 Soil analysis of profile representative of Slope Soils

Depth of sample cm	Ca Co^3 %	pH in soil paste	E.C mmhos/cm	T.S.S. %	Mechanical analysis gm/100 gm soil			Texture Class	Bulk density gm/cm^3	True density gm/cm^3	Soil water relations					
					Sand	Silt	Clay				Saturation cm^3/cm^3	1/10 Atm. cm^3/cm^3	1/3 Atm. cm^3/cm^3	2 Atm. cm^3/cm^3	15 Atm. cm^3/cm^3	Available water cm^3/cm^3
0–30	6.77	7.65	0.515	0.025	74.5	12.4	13.1	Sandy loam	1.43	2.50	42.7	13.9	7.44	5.43	3.1	4.34
30–60	13.38	7.55	0–615	0–030	60.2	17.8	22.0	Sandy loam	1.41	2.62	46.2	20.38	10.58	7.14	4.89	5.69
60–90	11.13	7.60	0.560	0.028	59.9	19.9	20.2	Sandy loam	1.51	2.40	37.0	22.11	10.24	7.20	4.90	5.34
90–120	8.99	7.40	0.600	0.029	56.8	13.9	19.3	Sandy loam	1.47	2.64	44.5	20.24	9.91	6.93	4.85	5.06

Table 3 Soil analysis of profile representative of Ridge Soil

Depth of sample cm.	Ca CO³ %	pH in soil paste	E.C. mmhos/cm	T.S.S. %	Mechanical analysis gm/100 gm soil			Texture Class	Bulk density gm/cm³	True density gm/cm³	Soil water relations					
					Sand	Silt	Clay				Saturation cm³/cm³	1/10 Atm. cm³/cm³	1/3 Atm. cm³/cm³	2Atm. cm³/cm³	15Atm. cm³/cm³	Available Water cm³/cm³
0–30	6.54	7.6	0.370	0.015	73.5	11.1	15.4	Sandy loam	1.44	2.73	47.5	10.92	7.38	4.25	3.00	4.38
30–60	5.60	7.5	0.500	0.025	72.9	12.3	14.8	Sandy loam	1.48	2.64	43.6	14.79	8.70	5.04	3.97	4.73
60–90	6.20	7.2	0.435	0.0225	75.9	8.2	16.1	Sandy loam	1.48	2.62	43.5	11.48	8.83	4.47	3.2	5.63
90–120	5.01	7.35	0.518	0.026	79.8	5.9	14.3	Sandy loam	1.43	2.64	46.0	11.51	7.32	4.50	3.3	4.02

Table 4 Soil analysis of profile representative of Calcipan Soil

Depth of sample cm	Ca CO_3 %	pH in soil paste	E.C. mmhos/%	T.S.S. %	Mechanical analysis gm/100 gm. soil			Texture Class	Bulk density gm/cm³	True density gm/cm³	Soil water relations					
					Sand	Silt	Clay				Saturation cm³/cm³	1/10 Atm. cm³/cm³	1/3 Atm. cm³/cm³	2Atm. cm³/cm³	15Atm. cm³/cm³	Available water cm³/cm³
0–30	8.49	7.4	0.580	0.0280	76.3	9.0	14.7	Sandy loam	1.39	2.61	47	15.9	8.67	6.10	3.64	5.03
30–65	25.01	7.6	0.705	0.030	58.0	17.5	24.5	Sandy clay loam	1.42	2.27	37.5	14.79	10.00	6.39	4.00	6.00
65–90	57.72	7.95	0.955	0.048	52.2	18.7	29.1	Sandy clay loam	1.42	2.61	46.0	33.99	16.60	12.18	7.81	8.79

a pseudo feeling regarding the presence of a high percentage of the finer fractions, i.e. silt and clay.

Regarding the other separates, i.e. sand, silt and clay it is clear from the tables that sand is the dominant fraction in all the soils in the area. The soil texture class is sandy loam except the calcipan layer where the texture is sandy clay loam. The texture class as obtained from the textural triangle is the same with depth, although there is a slight increase of the finer fraction of silt and clay with depth. Percent silt and clay is comparatively higher in the Valley Soils than in the Ridge Soils. The Valley Soil being located in the depressions, are subjected to the deposition of finer wind and waterborn material.

3. Soil reaction Determination of pH in the soil paste indicates a reaction that is neutral. In the soils with a calcipan in the sub-soil, the reaction of this calich layer is moderately alkaline. This is possibly due to the presence of a high percentage of Ca CO_3, and indicates the absence of real alkalinity.

4. Total water soluble salts The total soluble salts in all the soil types is very low, and it does not present any salinity problem in the area. However, in the soils with calcipan there is a slight increase in salt content with depth but the level of salt in this calcipan is too low to cause any salinity problem.

5. Bulk density and true density of soil The value for bulk density of soil in general is about 1.4 gm/cm^3, which does not indicate any compaction problem in the soil profiles in all the types examined. Even in the calcipan layer the bulk density is not high which indicates that precipitation of Ca CO_2 does not raise the bulk density in that layer, and the only hazard of that high Ca CO_3 in that calcipan layer is a cementing effect, not a compaction effect.

The true density value of soils in the area is about 2.6 gm/cm^3. This value is close to the average value for soils which is 2.65 gm/cm^3. The high content of sand in the soil in the area and the absence of heavy minerals in the soil is the reason for this value.

6. Soil water relations The percent of water at saturation on volume basis is obtained from the evaluation of the total pore space, by applying the values for both true density and bulk density. The saturation percent ranges from 40–45%. The percentage of moisture retained at 1/10 atmosphere suction on volume basis is low. In the soils in the Valley this represents 1/2 of the moisture at saturation, while in the Ridge Soils this value is about 1/3 of the value of saturation. This indicates the rapid release of water from these types of soils and the low energy with which this water is retained in soil. In the calcipan layer the value of water retention at 1/10 atmosphere suction is about 70% of the moisture at saturation; this is mainly due to the high content of Ca CO_3 in that layer. The higher the Ca CO_3 content the higher the moisture retention in these soils. This high content of Ca CO_3 makes the soil behave like fine texture soils in regard to pore size distribution and water retention by the soil. The difference between the saturation percentage and the moisture retained at 1/10 atmosphere is the aeration porosity of soil. This is the large size pores which are rapidly drained after irrigation or precipitation and allow for air passage for root respiration. Generally speaking the aeration porosity is excellent in all types of soils. However the aeration porosity in the calich layer is low but still favorable for growing plants and does not cause aeration problems.

The water retained at 1/3 atmosphere is considered the upper limit of the water which the soil holds in capillary pores against gravity pull; this is what is called field capacity. In general the retentivity power of the soils in the area is low. The amount of water retained at field capacity is equal to 1/5–1/4 of the water retained at saturation. There is a slight increase in water retained at field capacity in Valley Soils compared to Ridge Soils, even though the two soils fall in the same texture class. This indicates that the pore size distribution in Valley Soils is comparatively more favorable for retention of water for plant use. The calcipan layer retention of water at field capacity is high due to the high content of Ca CO_3. The Slope Soils follow the same trend as the Valley Soils as far as the retention of water at 1/3 atmosphere suction. In all types of soils the surface layer retains less water than the subsoil, even though the surface layer contains more organic matter in the form of decayed roots, but the sand content of this surface layer is comparatively higher than the subsoil.

The water retained at a 15 atmosphere tension is the amount of water which plants fail to get from the soil. If water continuous at that level without addition of water to soil plants will wilt. The amount of water in all soils in the area at wilting point is low. There seems to be a correlation between field capacity and wilting point in those soils. This relation is

$$\text{Field Capacity} = (2.1)\ (\text{Wilting Point})$$

The term 'available water' is used to designate the difference between moisture content at field capacity and moisture content at wilting point. It is presented in the tables as cm^3/cm^3 which indicates the volume of water as a ratio of the volume of soil. These values are easily usable for irrigation purposes because if we multiply the values presented in the tables by the thickness of the root zone of the growing plants, the product is equal to the depth of water in the root zone. For the soils studied, the available water is between 4 to 6 cm^3/cm^3. This means that for each 100 cm depth of soil the amount of water retained available for growing plants is only a 4 to 6 cm. depth. Again the Valley Soils have comparatively higher available water than the Ridge Soils.

These data indicate that management to increase the water holding capacity and the available water is needed in all types of soils.

It is interesting to notice as shown in tables that the water retained at a 2 atmosphere tension is not much higher than the amount of water retained at a 15 atmosphere tension, which indicates that the proportion of small size pores in these soils is very low.

SUMMARY

The soil types that are observed in Sidi El Mesri area of the Jaffara Plain have the following characteristics. (1) Ridge Soil occupies all the ridge and hilly areas. The soil in these ridges is deep loose soil, sandy loam in texture, with low content of Ca CO_3. The distribution of Ca CO_3 is more of less uniform with depth. (2) Valley Soil occupies all the nearly level area between ridges. This soil is more developed compared with Ridge Soil. Ca CO_3 content is higher, with more Ca CO_3 content in the subsoil in concretion form. Because these valleys form depressions which are surrounded by hilly sloping land, it receives water runoff. The soil is deep sandy loam in texture, and the subsoil is a little compact when dry but friable when moist. (3) Sloping Soil which is similar in character to Valley Soil except that it has a strongly to moderately sloping surface. Calcipan Soil, which contains zone of accumulation of Ca CO_3 in the subsoil. This layer is cemented and the Ca CO_3 content reaches up to 60%.

The soils in the area of study are developed from alluvial material washed mainly from sandstone and sand shales.

All types of soils are low in salt content and there is no trend of salt accumulation with depth except in the Calcipan Soil. The soil reaction is generally neutral, but slightly

alkaline in the calcipan horizon. The bulk density of soils does not indicate any compaction problem even in the zone of accumulation of Ca CO_3. The water is retained in soils with low potential and most of it is released from soil under low suction, which indicates that large size pores are dominant in the soil.

The water holding capacity of the soil is low. When the Ca CO_3 content is high as in the zone of accumulation of Ca CO_3, the water holding capacity is comparatively high. Generally speaking the water which is held in that soil at field capacity is about 10% on volume basis, and is approximately twice the water which is held in soil at wilting point.

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