SOIL ANALYSIS AND ITS RELATION TO LAND USE IN E-MARJ PLAIN, CYRENAICA

By Prof. Mukhtar Buru

Introduction

El-Marj Plain is known to Europeans as the Barce Plain. The plain is situated in the west of the Jebel Akhdar, on the area between the first and the second escarpment, known as the upper terrace (Fig. 1). At the south-western end of the terrace 'karst' erosion has predominated and has advanced so far as to create a series of inland drainage basins; these, with their thick deposits of Terra Rossa, form the fertile plains of El-Marj (Barce), Siline and El-Abiar (Fig. 2).

El-Marj Plain is a closed basin. The basin has a subvalley shape and it mainly extends south-west/north east. It is 42 kms. long and 12 kms. wide. The lowest point of the basin is 276 above sea-level, situated one kilometer to the north-east of Old El-Marj town, and occupied by an intermittent lake in the winter, known as El-Ghariq.

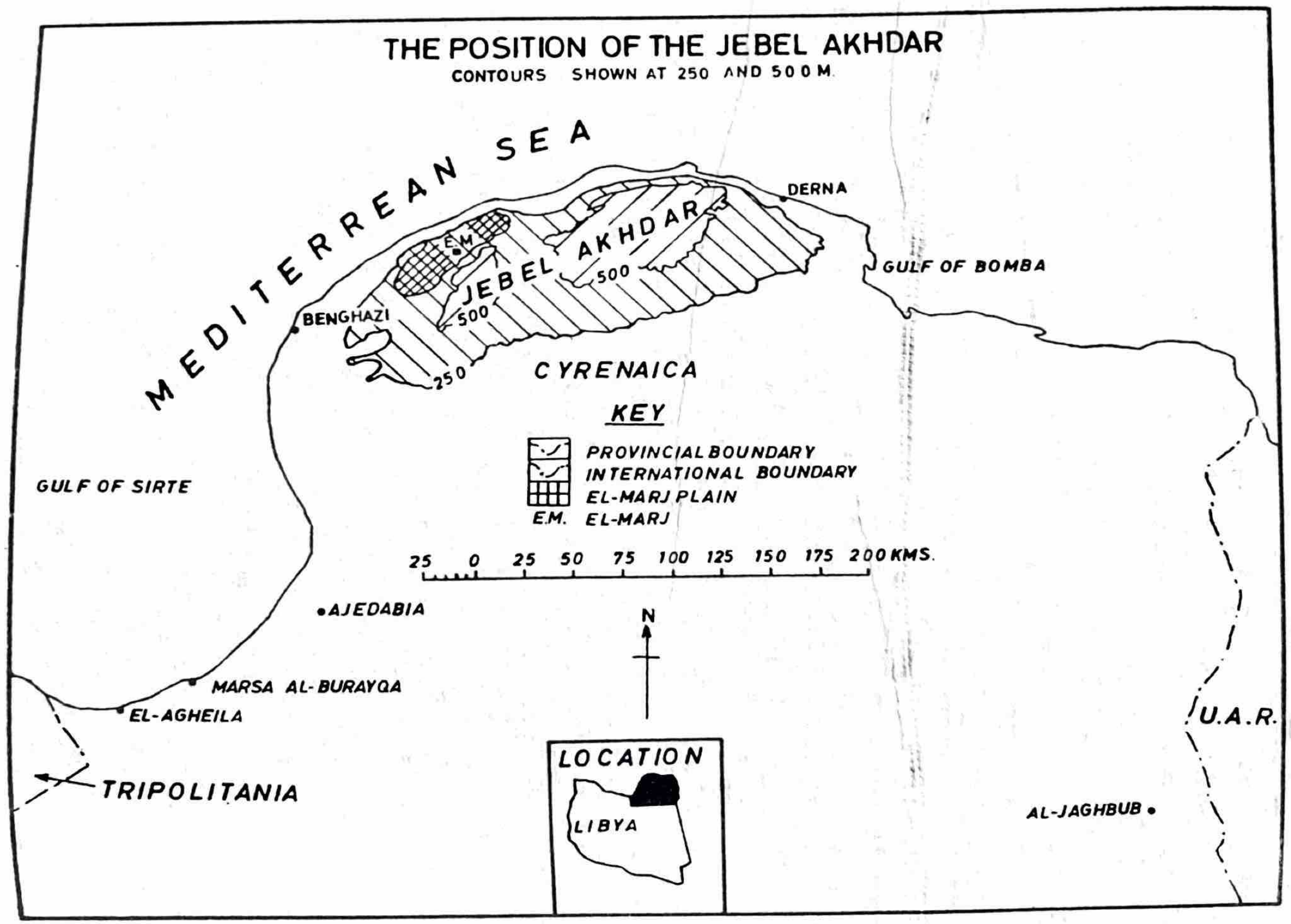
As far as the Jebel Akhdar is concerned, of the rocks exposed on the surface, all are of sedimentary origin and almost all are marine limestones. The greater part of northern Cyrenaica is covered by rocks of Miocene age, those of Middle Miocene being especially widespread. The most extensive strata in El-Marj Plain are of the Middle Eocene (Gregory's Derna Limestones).

The elements of relief of northern Cyrenaica are responsible for local variations in climate both in respect of thermal and precipitation conditions. Northern Cyrenaica is climatically divided by the influence of the Mediterranean Sea on the coast and altitude of the Jebel in the interior; these differentiate the two zones of continuous habitation from the desert. It is only along the Mediterranean coastline of northern Libya that the influence of the sea brings some rain and coolness and makes possible a zone of agricultural settlement and sustained agricultural production. Cyrenaica experiences extremely hot summers everywhere: on the coast winters are mild and in some parts frost has never been known. However, in northern Cyrenaica, the coastal plain is backed by the Jebel. The sea's moderating influence decreases southwards and temperatures increase. The effect of altitude is to reduce temperatures and in winter both factors combine to make the mean temperature about 2°C. colder than the coast. Variations in temperatures from place to place resulting from proximity to the sea and altitude can be illustrated by a comparison between Tulmeitha on the littoral and El-Marj some 18 kms. inland and about 285m. above sea-level. On the coastal plain the annual mean temperature is 19.9°C. at Tulmeitha, while on the upper terrace the mean is 17.7°C. at El-Marj.

Along the coastal plain, the daily range of temperature is moderated by the cooling influence of the Mediterranean during the day and the relative warmth of the sea during the night, though as might be expected the daily range is higher on the Jebel and further inland. Mean daily ranges of temperature at the coastal averaged between 7.2°C. at Tulmeitha for a period of ten years, 7.0°C. to 10.4°C. at Tocra for eleven-year period, and 8.5°C. to 10.4°C. at Benghazi for a period of thirty one years.

Figures for the Jebel show that the highest mean daily range on the Jebel at El-Marj averaged between 10.7°C and 17.5°C., i.e. twice that of the coastal stations. The range of temperature in Libya is a product of the high temperature during the day rather than the low night temperatures.

The rainfall starts in autumn with a rapid increase in Decem-


THE POSITION OF THE JEBEL AKHDAR
CONTOURS SHOWN AT 250 AND 500 M.
MEDITERREAN SEA
DERNA
GULF OF BOMBA
E.M.
JEBEL AKHDAR
500
500
250
BENGHAZI
CYRENAICA
KEY
PROVINCIAL BOUNDARY
INTERNATIONAL BOUNDARY
EL-MARJ PLAIN
E.M. EL-MARJ
GULF OF SIRTE
25 0 25 50 75 100 125 150 175 200 KMS.
AJEDABIA
N
MARSA AL-BURAYQA
EL-AGHEILA
LOCATION
LIBYA
TRIPOLITANIA
U.A.R.
AL-JAGHBUB

ber and January, and then decreases quickly in the successive months. The peak of rainfall is in December and January. The dry half of the year extends from May to September, but the rainfall may start earlier in September and be prolonged until April, and sometimes even May, especially on the Jebel Akhdar. The rainy half of the year (October-March) received between 90 and 95% of the total annual rainfall.

On the coastal plain rainfall ranges from only 200 to 250 mm. and increases south to north. At Benghazi rainfall amounts to 265.8 mm. Rainfall increases in the extreme north of the coastal plain where it is 311.0 mm. at Tocra and 350 mm. at Tulmeitha, whilst rainfall exceeding 300 mm. is found beyond the first escarpment from which point on it increases to 484.7 mm. at El-Marj. The highest rainfall (500-600 mm.) is found on the northern part of the Jebel Akhdar in the vicinity of Cyrene. This favoured sector, however, is of limited extent, and to the south, south-west and south-east, rainfall declines sharply.

As pointed out, most of Cyrenaica is dominated by desert climate conditions, except for northern Cyrenaica which enjoys a more humid climate especially the Jebel Akhdar where the Mediterranean climate predominates. Consequently the floral life on El-Marj Plain is related to the Maghreb and southern Europe rather than to the rest of Libya.

Dry farming is practised in the whole of El-Marj plain. All the agricultural production is subject to a considerable risk with regard to yields. The main crops are wheat and barley, chickpeas, broad beans, oats and fenugreek are grown in small quantities. As regards the growing of fruit trees, good stocks of peach, fig, pear, apple olive and almond trees still exist on the former Italian Ente farms. In a number of privately-owned farms there are high yields of olives, almonds and vines. The amount of vegetable growing, apart from potatoes, tomatoes and melons in El-Ghariq, is negligible.

A conservative estimate of total cultivated land in El-Marj Plain may be made at 28,000 hectares.

Soils of El-Marj Plain.

Soils of El-Marj Plain show a diversity of origin, properties and land use capabilities which is perhaps best explained by reference to the factors of soil formation. Following the initial work of Dakuchaieve (1898)(1) and Jenny (1941),(2) it is convenient to consider this diversity in(1) climate,(2) vegetation,(3) parent material or parent rocks,(4) topography,(5) time and(6) human influences. Within El-Marj Plain it soon became apparent that climate and parent material are perhaps the dominant determinent of the soil character.

This super-imposition of Mediterranean climate on calcareous parent material has dominated the processes of soil formation, and by far the most important soil type which is found in El-Marj Plain and on the surrounding scarps and the upland areas is the classical Terra Rossa. Much has been written about this soil and its distribution throughout the whole of the Mediterranean region, but relatively little work has been published on its Libyan habitat. The reconnaissance observation of Ferrara (1933) (3) and Principi(4) (1936 and 1947) are useful, as are parallel findings of Reifenberg(5) in Palestine, but that research carried out on this soil group in North Africa would seem to exist in unpublished form.

The original work of Reifenberg on the Terra Rossa soil is still the standard reference for the properties and definition of this soil type, and it seems convenient to consider here some of the main points which are contained within Reifenberg's original concept. For him:

"Terra Rossa develops on limestone under the conditions of the Mediterranean climate. In comparison with its parent material, the limestone, it has been greatly enriched in sesquioxides and in silica. In comparison with the soils of humid climate it contains large quantities of salf of the alkaklis and alkaline earths. The high iron content together with low humus content are responsible for the red colour and which often is brilliant. They are mostly soils with an alkaline reaction and ferruginous concretions."(6)

This view of Reifenberg is in many ways the most composed and impressive statement on the origin and nature of Terra Rossa which has been attempted by any pedologist. Certainly the thesis that Terra Rossa is a contemporary phenomenon resulting from the interplay of a Mediterranean climate regime and a calcareous parent material is widely held in soil science circles.

However, whilst a discussion of the pedological controversy surrounding Terra Rossa is beyond the scope of this present paper, it should also be noted that Kubiena (1953) and others would regard Terra Rossa as a fossil feature found under more humid sub-tropical conditions and therefore essentially a soil parent material rather than a modern soil.

The work presented in this paper does not aim at presenting any definite origin of this soil and its association, but rather to study specific Terra Rossa profiles in Cyrenaica and to analyse particularly their agricultural properties.

Detailed soil analysis: In order to supplement the general accounts of the soil types and their distribution within El-Marj Plain and the surroundings it was decided to carry out a more detailed analysis of the soils of the area using standard field and laboratory investigation techniques. A field survey of the soils was carried out and a reconnaissance was made of natural soil sections and soils occurring in the main agricultural areas. From this reconnaissance survey it was possible to decide upon the main soil types occurring in the plain and also to locate eleven soil profile pits which would give a representative picture of the pedological pattern.

Each of these pits was described in the field and each was sampled at two main depths, i.e. at the surface and at a depth of 25cm. The samples were analysed at Sidi Mesri Experimental Station. Details of the chemical analyses are given in the appendix 1. The main site characteristics of the soil profiles are also presented in Table 1. A schematic classification of the soils is given in Table 2, and the location of soil pits is further shown on figure No. 3.

Profile I — Is a good example of a relatively thin terra fusca which has developed directly from the underlying Lower Eocene limestone beds. The soil is quite thin, passing into parent rock at 50 cms., and is one of the stoniest profiles examined due to high content of limestone fragments from the parent rock. The mechanical analysis of the samples shows a high content of sand and also of clay, whilst the silt fraction is relatively low. The soil is dominantly a sandy clay with a very slight increase of the sand fraction with depth.

The figures for the total carbonates reflect the large proportion of limestone fragments in the soil material. The figures for the surface horizons is 10% higher than that at 25 cm. which would seem to suggest movement of lime towards the surface and some concentration there. The Ph. figures of 6.5 and 7.6 respectively were in fact the highest recorded in the whole region. The figures for the total acid soluble material again show the high lime content and were the highest over the whole survey area. The conductivity of the soils too were amongst the highest recorded. These figures again show a tendency for the soil solution to move upwards to the surface.

TABLE 1 : Locations of the Soils Sites

Profile No.	Situation	Grid Ref.	Height in Metres	Parent Rock	Topographic Situation	Land Use
1	3 kms. S.W. of Tulmeitha	400/750	5	Lower Eocene Limestone	Flat coastal plain	Dry farming barley
2	South of the village of El-Hemda	100/450	326	Middle Eocene Limestone	Level	Dry farming wheat
3	3 kms. N. of Sidi Rahuma	275/760	280	Middle Eocene Limestone	Gentle southerly slope	Dry farming wheat
4	4 kms. S.E. of El-Marj	185/755	295	Middle Eocene Limestone	Gentle northerly slope	Dry farming wheat
5	14 kms. N.E of El-Marj	350/800	350	Middle Eocene Limestone	Gentle south-westerly slope	Dry farming wheat
6	El-Ghariq Lake	230/740	278	Middle Eocene Limestone	Flat	Seasonal flooding
7	7 kms.W. of El-Marj	195/645	340	Middle Eocene Limestone	Gentle easterly slope	Dry farming wheat
8	3 kms.W. of Batta	370/885	380	Wadi alluvium over Middle Eocene Limestone	Wadi bottom	Dry farming barley
9	Zorda Exp. Station	165/705	310	Middle Eocene Limestone	Flat	Dry farming wheat
10	South of Farzugha	190/540	333	Middle Eocene Limestone	Flat	Dry farming wheat
11	8 kms. W. of Batta	365/840	400	Wadi alluvium over Middle Eocene Limestone	Wadi bottom	Uncultivated scrub

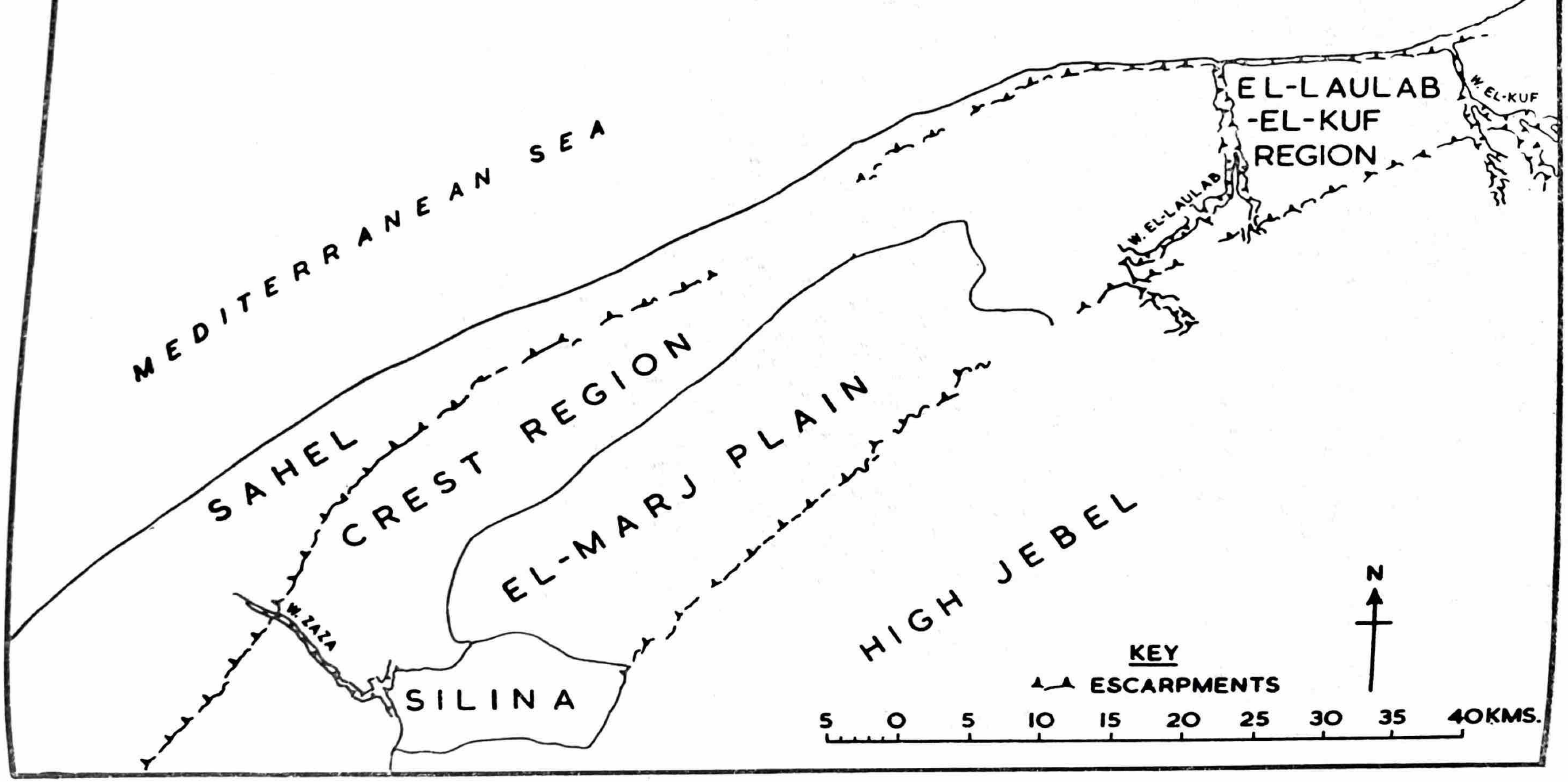
TABLE 2 : Classification of the soils

Parent material	Profile Drainage	Major Soil Type	Profile Number
Terra Rossa Material over Limestone	Free	i) Red Terra Rossa soils-deep phase	9,4,3,2
		ii) Red Terra Rossa soils - shallow phase	10
		iii) Dark Red Terra Rossa soils	7,5
		iv) Terra Fusca soils	
	Impeded	v) Hydromorphic Saline soils	6
Wadi Alluvium over Limestone	Free	vi) Yellowish Brown Alluvium Soils	8
		vii) Dark Brown Alluvium Soils	11

The exchangable cation data show that the catonic exchange capacity is relatively low but is dominated by calcium and magnesium. The figures for both sodium and potassium are much lower. The figures for available nutrient show that nitrogen is extremely low and likely to be a major obstacle to adequate plant growth. The figures for phosphate and potash too are low and again would be likely to prove limiting to any intensive land use.

Profile 2 — Represents a well developed red Terra Rossa soil 2 metres deep over Middle Eocene limestone. Its texture is similar to profile one, but figures for soil carbonates fail to show any accumulation of lime and profile. This would seem to suggest that soil drainage has been adequate to leech out much of the calcium material from which the soil was ultimately derived. Ph. figures show that the soil is only slightly alkaline. The figures for the total analyses show accumulation of iron and aluminium

PHYSIOGRAPHIC REGIONS OF EL-MARJ PLAIN
AND THE ADJACENT AREAS



in the soil. This is as one would expect from Terra Rossa. The conductivity of the profile is similar to Profile 1, again showing a slight accumulation of salt. The cation exchange capacity is relatively high and due probably to the higher content of iron and aluminium oxides. Calcium and magnesium again dominate the exchange complex.

The data for the nutrient elements of this Terra Rossa present some interesting contrast with Profile 1. Figures for total nitrogen again show the very deficient content of this important plant food. This is quite characteristic for the whole region. The figures for phosphate, however, are extremely low and point to the fact that many of those soils do not contain adequate phosphorus. This is no doubt a reflection of the long period of chemical leeching and degradation which the soil has undergone. The relatively low figures for the acid soluble material would seem to support this view.

Profile 3 — Has been classified into the same soil grouping as Profile 2, namely Red Terra Rossa soil of a deep phase and indeed the analytical figures of this soil show many resemblances. From a point of view of texture this profile is slightly heavier, being classed as a clay soil rather than a sandy clay. The figures for clay content are some 5% higher than Profile 2 and the sand percentage is correspondingly lower. The silt percentages are still the same. The soil reaction is slightly lower than Profile 2, and in fact the surface shows slight salinity. This may in fact be due to agricultural practices; at 25 cm. in fact the Ph. rise to 7.2 which corresponds to the general Ph. level of the Terra Rossa material.

Rather surprisingly the figures for the cation exchange capacity are amongst some of the lowest recorded in the area. This may be due to a lack of organic matter or to the type of clay mineral involved. Calcium and magnesium are again the dominant ions and this is reflected in the figures for soil conductivity, which vary from 1.10 millimhos/cm. at the surface to 0.75 millimhos/cm. at 25 cm. depth. This points to a slight seasonal upward movement of soluble salt. The carbonate figures show an almost complete removal of lime as in Profile 2, with again a slight increase at the surface. The figures for available nutrients are amongst some of the lowest recorded in the survey. Nitrogen varies from 0.10% at the surface to 0.12% at 25 cm.; this seems to be a direct result of the poor organic matter status of this profile. The plant food would seem to be a limiting factor in the plant growth. The figure for available potash is quite high in the mineral function evidently much of the potash in a form which is not available to the plant root.

Profile 4 : — Is similarly classed as deep Rossa soil but is much more similar to Profile 2 rather than to Profile 3. The general texture is on the transitional boundary between sandy clay and sandy clay loam, mainly resulting from slight increase in the sand content. The clay percentage is 29.6 at the surface falling to 28.0 at 25 cm. The data for the cationic exchange capacity is also similar to Profile 2 ranging from 24.12 m. 1/100 gms. of the soil at the surface to 26.75 m. 1/100 gms. at 25 cm. Calcium and magnesium are again the dominant cations on the exchange complex. The Ph. varies from 7.45 at the surface to 7.20 at 25 cms. which is again similar to Profile 2, and the Profile shows a corresponding lack of total carbonates Figures for available nitrogen show an increase on those for Profile 3, and the available potash is also much higher. Phosphate, however, is still extremely low.

A brief comparison of Profiles 2, 3 and 4, all of which are designated as deep red Terra soil, shows that there is some analytical variation within this general grouping. This is only to be expected when one considers differences of situation and soil history which these sites probably have undergone. This particular aspect will be treated more fully in the next section.

Profile 5 — Represents slight difference from the last three profiles in that it has been designated as a dark red Terra Rossa soil largely on the basis of a field appearance. A study of the analytical data, however, fails to reveal any real significant contrast. The only figure which would seem to be important in this respect is that for the moisture content. The dark red Terra Rossa has a moisture percentage of over 5 whereas a red Terra Rossa has generally figures between 2 and 3. The texture of this soil shows a difference between the surface and 25 cm. The surface layer is a sandy clay whereas a little lower down the texture changes to sandy clay loam/sandy loam. This is mainly due to decreasing clay percentages from 29.4 to 20 and an increase in sand function from 56.4 to 72.2. The figures for silt function show a very striking decrease with depth dropping 14.2% at the surface to 7.4% at 25 cm. This decrease of silt and clay function within such a short distance would seem to suggest that the upper horizons are in fact receiving finer material which is being washed in from surrounding slopes.

The Ph. of this soil and the total carbonates are very similar to Profile 3, as also the figures for cationic exchange capacity. Calcium and magnesium are again the dominant ions, and the figures for conductivity of the soil are very low despite this high moisture content. Figures for available nutrients show the same low values, although the availability of phosphate is slightly higher than the previous three profiles.

Profile 6 — Is an extremely interesting profile as it is the only profile study which shows the effects of impeded drainage on the soil profile. The profile pit was located on the northern edge of El-Ghariq depression which is an area of accumulation of moisture from surrounding areas. El-Ghariq depression is in fact an intermittent lake each winter and usually remains flooded until it is dissipated by evaporation in late May. The dominant feature of the soils therefore is extremely waterlogged conditions for much of the year. The high water table thus produced has very detrimental effects on plant growth.

The mechanical analysis shows that the soils may be classified as sandy clay which is very important from a point of view of soil permeability. The soils are relatively impermeable, a factor which makes even worse the effects of a large seasonal influx of moisture. Despite the poor drainage, however, alkalinity has not developed and the Ph. is only 7.1. The figures for total carbonate also show no accumulation of lime. By far the most interesting analytical figure is that which refers to soil salinity. The figure for the conductivity figure is that which refers to soil salinity. The figure for the conductivity of the soil reaches the very high level of 18.5 millimhos/cm. at the surface but it drops quickly to 3.25 millimhos/cm. at 50 cm. The figures for cation exchange capacity similarly reflect the saline conditions of this soil. The percentage of sodium on exchange complex does in fact exceed the figure for calcium and magnesium combined and would seem to suggest that there is a very high sodium hazard in this soil. This is further reinforced by the figure of the Sodium Absorption Ration which is 12.32 at the surface. The fact that alkalinity has not developed under the high sodium figure may, in fact, be due to the high iron content of the soil. The figures for available nutrients show the usual lack of nitrogen and phosphate but it is noticeable that the figure for available potash is extremely high. In fact the figures of 1067 p.p.m. of potash is more than double the figure recorded in the other profiles. This is almost certainly due to the fact that potassium is being washed in the area by seepage water.

The saline nature of this profile appears very puzzling when compared to the good crop yields which this area supports. Whether the salinity is closely restricted to the surface and hence does not affect the main root zone, or whether the soluble salts are of a nature which does not inhibit plant growth is a question which needs further investigation.

Profile 7 — Is another example of a dark red Terra Rossa soil and therefore it may be convenient to discuss its analytical data in comparison with that of Profile 5 at the village of Batta. From a point of view of texture Profile 7 represents a clay soil rather than sandy clay. The figures for clay at the surface and at 25 cm., 35.4% and 33.0% respectively. This relatively heavy texture is only exceeded by red Terra Rossa soil at Profile 9. It is also worth noting that the silt function of this soil is quite high, reaching a figure of 20.6% at 25 cms. It is also noticeable that this profile is very slightly acidic showing Ph. s which never rise above 6.9. The saturation percentage is also higher than profiles considered previously, a fact which is resultant upon the finer texture of the soil. The figures for soil carbonates are again quite low.

The figures for cationic exchange capacity range from 20.5 m/100 gms. at the surface to 24.5 m. 1/100 gms. at 25 cms. Calcium and magnesium are again the dominant ions, and this fact together with the low figures of soil conductivity would seem to suggest that sodium is easily removed from the soil profile.

From the point of view of total analysis iron and aluminium are again dominant. The data for the available nutrients show that nitrogen is only sparingly present whereas phosphate was much more abundant than in any other profile studies. This is probably due to the richness of the soil in phosphate bearing minerals rather than to any addition by fertilisation. The figures for potash are average for the region.

Profile 8 — Is a soil with a completely different pedological history, compared with those profiles described earlier. It represents essentially an alluvial soil which is developed in the alluvium of a wadi bottom and it has been designated as yellowish brown alluvial soil on account of its dominant colour.

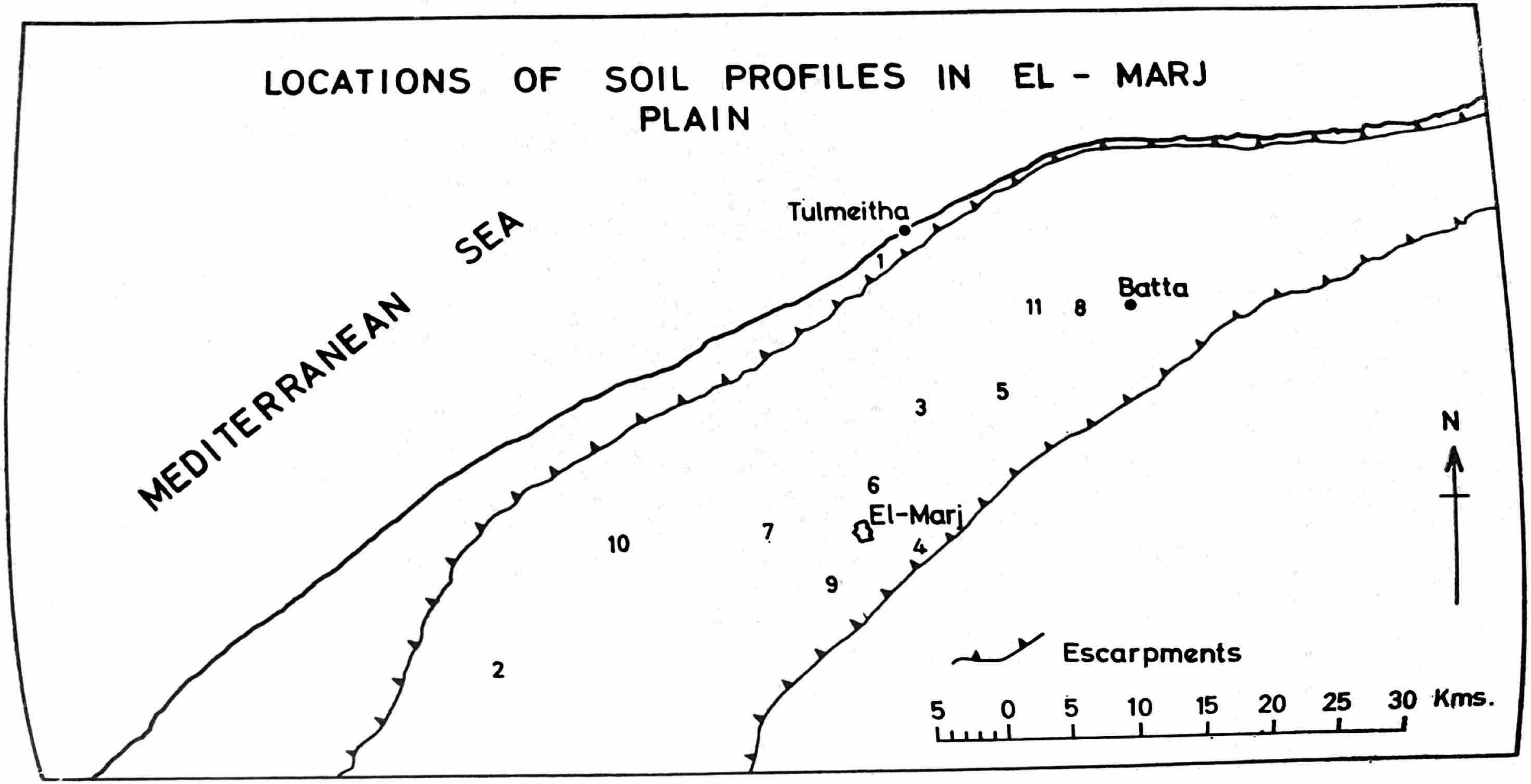
The analytical data shows several interesting comparisons compared with Terra Rossa soils. This is by far the lightest soil according to texture which was met in the field study. The sand function is as high as 67% at the surface and 66.4% at 25 cms., thus giving the designation of sandy loam. The figures for total carbonate are also high being 30% at the surface and 24% at 25 cms. The fact that these high figures are found in such light textured soil would seem to indicate that there is quite a large influx of lime from the surrounding Jebel. The Ph. is still slightly alkaline at 7.3. Rather surprisingly the figures for cationic exchange capacity are the highest so far met in the area, being 42.25 m. 1/100 grms. at the surface and 38.5 m. 1/100 grms. at 25 cms. This is probably due to the slightly higher organic matter status of this soil. Calcium and magnesium dominate the exchange complex much more than in the Terra Rossa soils and this is again reflective in the very low figures for the soil conductivity.

From the point of view of plant food elements the figures for total nitrogen are the highest recorded during the investigation. It is still low however, being 0.24% at surface and 0.12% at 25 cms. The figures for phosphates are higher than average, but those for potash are relatively low. This is rather surprising on account of the influx of moisture which must occur.

Profile 9 — is the fourth example of a deep red Terra Rossa soil and shows many similarities to those previously considered. The soil is sandy clay in texture and in its upper horizon as with other Terra Rossa is almost completely decalcified with a Ph. 7.4. The data for the cation exchange capacity is also very similar to Profile 2, and again calcium and magnesium are by far the dominant ions on the complex. Indeed, the conductivity of this soil shows that it has the lowest content of salts of all the red Terra Rossa. The conductivity is 0.77 millimhos/cm. at the surface and 0.63 millimhos at 25 cm. The total chemical analysis again shows the importance of iron and aluminium in the soil. From a point of view of available nutrients the figures 0.2 show the striking deficiency in nitrogen and phosphate already referred to, but the potash status is quite high for a Terra Rossa soil. This is probably due to the relatively high content of potassium bearing minerals in the sand function.

Profile 10 — is the only example for which analytical data have been gained of the shallow phase of the red Terra Rossa gro up. It consists of one metre of Terra Rossa material which has been accumulated on the Middle Eocene limestone. Again the soil texture can be classed as sandy clay and again the soil material has been relatively declassified. The Ph. of both the surface and 25 cms. is 7.1. Rather interestingly this profile shows a higher saturation percentage. The cation exchange values are similar to those deep Terra Rossas. Calcium and magnesium are again the dominant ions. The conductivity of the soil is 0.84 millimhos/cm. at the surface and 0.6 millimhos/cm. at 25 cm. The sodium absorption ratio is again quite low.

From a point of view of available nutrients, a similar picture


LOCATIONS OF SOIL PROFILES IN EL - MARJ PLAIN
MEDITERRANEAN SEA
Tulmeitha
Batta
El-Marj
1
2
3
4
5
6
7
8
9
10
11
Escarpments
5 0 5 10 15 20 25 30 Kms.
N

is given compared to the Terra Rossa soils. Nitrogen and phosphate are low and available potash is average. It seems therefore from this examination of these chemical analyses that within the top 25 cm. there is very little significant chemical distinction which can be made between the deep and the shallow phases of the Terra Rossa group. It is likely that differences would occur at depth, but unfortunately no analytical data are available.

Profile 11 — Is an example of dark brown alluvium soil which is developed in a wadi bottom 8 kms. west of Batta. It is a sandy clay at the surface in texture and a clay at 25 cms. and it is likely that this profile shows a wide textural heterogeneity. It is noticeably true too that the silt function shows quite startling variations in the top 25 cms. being 12% at the surface and 24% lower down. It is also interesting that this profile has lost all its lime content, a very interesting contrast with the alluvia soil of Profile 8. The Ph. however is still slightly alkaline.

Calcium and magnesium are again the dominant ions on the exchange complex, and it is noticeable that this profile shows the lowest conductivity so far examined; these are 0.62 and 0.85 millimhos/cm. at the surface and 25 cm. respectively.

The most interesting aspect of the analytical data, however, is that which refers to the available nutrient status. It is worth noting that this is the only profile which was not taken from a cultivated area and it is the profile which shows the most complete and serious deficiency in plant food. At the surface there were recorded 0.095% nitrogen, 2.7 ppm for phosphate and 187 ppm of potash, at 25 cms. the figures were 0.084% nitrogen, 3.9 ppm. phosphate and 121 ppm of potash. These figures illustrate the extreme poverty of the soil as a medium for plant growth.

Soil-Land Use Relationships.

From a point of view of agricultural potential indicated by a soil profile and soil analytical data, a number of characteristic properties of the soils can be listed and a brief statement made on

PEDO-AGRONOMIC ANALYSIS OF SOILS IN EL-MARJ PLAIN AND SURROUNDING AREAS

MECHANICAL ANALYSIS
by Bouyoucous Method

PHYSICAL AND CHEMICAL ANALYSIS

Lab. No.		Reference No.		Sand %	Silt %	Clay %	pH Paste	Carbonates Total 2s $CaCo_3$	Nutrient Elements		
									Total Nitrogen $^o/_{oo}$	$P_4 O_5$ ppm	$K_2 O$ ppm
608	1	TULMEITHA	Sect. A	60.2	7.8	32.0	7.65	55.15	1.25	87.9	168
609		"	" B	63.2	9.2	27.6	7.60	45.20	1.04	111.5	384
610	2	EL-HEMDA	Sect. A	66.2	6.8	27.0	7.15	0.25	1.65	10.3	842
620		"	" B	57.0	12.2	30.8	7.10	0.30	1.24	6.2	449
624	3	N. of SIDI RAHUMA	Sect. A	47.4	16.2	36.4	6.75	0.35	1.07	7.5	374
611		" " " "	" B	59.2	8.2	32.6	7.20	0.20	1.15	4.1	299
612	4	S. of EL-MARJ PLAIN	Sect. A	63.2	7.2	29.6	7.45	0.20	1.43	10.3	795
629		" " " "	Sect B	61.4	10.6	28.0	7.20	0.40	1.24	6.2	589
627	5	N.E. EL-MARJ 14 KM BATTA	Sect. A	56.4	14.2	29.4	6.55	0.25	1.56	16.5	617
613		" " " " " "	" B	72.2	7.4	20.4	7.40	0.30	1.12	10.3	898
614	6	EL GHARIQ	Sect. A	65.2	7.0	27.8	7.15	0.10	1.61	14.2	1067
615		" "	" B	58.0	13.8	28.2	7.10	0.20	1.15	8.2	861
617	7	W. of EL-MARJ KM 7	Sect. A	51.4	13.2	35.4	6.90	0.15	1.46	224.3	486
616		" " " " "	" B	46.4	20.6	33.0	6.90	0.15	1.25	73.3	299
620	8	W. of BATTA KM 3	Sect. A	67.0	10.6	22.4	7.30	29.75	2.37	175.9	571
618		" " " " "	B	66.4	14.4	19.2	7.35	34.05	1.15	58.2	505
630	9	ZORDA	Sect. A	53.0	10.6	36.4	7.30	0.45	1.16	6.1	870
619		"	" B	50.4	12.6	37.0	7.50	0.25	0.85	4.8	505
623	10	FARZUGHA	Sect. A	53.4	12.2	34.4	7.10	0.15	1.29	7.5	571
621		"	" B	50.0	15.6	34.4	7.10	0.25	1.28	3.4	440
622	11	W. of BATTA KM 8	Sect. A	54.0	12.0	34.0	7.40	1.05	0.95	2.7	187
628		" " " " "	" B	42.0	24.5	33.5	7.15	0.65	0.84	3.9	121

CHEMISTRY OF THE SOILS

Lab. No.	Moisture %	Total Solub. in HCL %	Total ins. %	Fe_2O_3 %	Al_2O_3 %	Ca O %	Mg O %	Na_2O %	K_2O %	SO_3 %	P_2O_5 %	le %
608)	2.64	73.39	27.61	3.83	3.19	30.24	0.56	0.395	0.492	0.105	0.022	0.015
609)	3.57	68.56	31.44	4.67	4.37	25.62	1.00	0.364	0.614	0.163	0.026	0.012
610)	2.65	30.47	69.53	8.82	3.48	1.41	0.82	0.053	0.405	0.134	0.023	0.014
626)	2.95	33.23	67.77	10.45	10.19	1.42	1.27	0.102	0.514	0.192	0.025	0.014
624)	2.54	21.31	78.69	7.98	5.02	0.80	0.24	0.154	1.092	0.693	0.025	0.010
611)	2.69	22.75	77.25	7.98	5.28	0.46	0.47	0.153	1.041	0.094	0.031	0.015
612)	5.10	25.91	64.09	11.18	8.61	0. 92	0.88	0.155	1.102	0.591	0.054	0.022
629)	3.12	33.85	66.15	17.24	3.98	1.88	0.18	0.093	1.217	0.274	0.045	0.015
627)	5.15	34.12	65.88	10.69	8.15	1.30	0.41	0.134	1.123	0.185	0.061	0.025
613)	5.18	37.89	62.11	11.88	10.20	0.96	0.08	0.136	1.174	0.334	0.052	0.024
614)	5.22	42.94	57.06	12.45	12.15	11.64	0.61	0.347	1.419	1.046	0.062	0.382
615)	5.10	40.21	59.79	11.88	13.26	0.88	0.80	0.196	1.456	0.561	0.051	0.055
617)	2.48	32.32	67.67	9.26	9.66	1.36	0.33	0.195	0.818	0.373	0.043	0.015
616)	3.83	41.84	58.16	12.44	14.20	0.96	0.52	0.193	1.343	0.159	0.027	0.015
620)	4.09	60.84	39.16	6.95	12.17	15.04	1.06	0.312	0.948	0.147	0.063	0.015
618)	5.17	63.00	37.00	7.02	2.38	24.12	0.06	0.341	0.754	0.243	0.046	0.025
630)	2.75	32.03	67.97	9.42	9.98	1.46	0.18	0.124	1.240	0.481	0.016	0.015
619)	3.74	35.47	64.53	11.02	9.54	1.32	0.95	0.225	1.151	0.212	0.017	0.014
623)	2.87	32.52	67.48	9.50	10.09	0.48	0.55	0.196	0.972	0.273	0.030	0.013
621)	3.77	36.83	63.70	10.46	10.90	0.64	0.80	0.154	1.053	0.355	0.025	0.014
622)	3.53	37.53	62.47	9.34	12.06	2.40	0.42	0.142	0.734	0.887	0.012	0.014
628)	3.27	38.22	61.78	11.81	12.35	1.36	0.658	0.123	0.701	0.268	0.015	0.014

Lab. No.	Conductivity Water Extract Millimhos at 25°C	ANALYSIS ON SATURATION EXTRACT — SATURATION EXTRACT DETERMINATIONS				CATION EXCHANGE CAPACITY	EXCHANGEABLE CATIONS — EXCHANGEABLE CATIONS			EXCHANGEABLE CATION PERCENTAGE			S.A.R.
		Na meg/l	K meg/l	Ca+Mg meg/l	Total meg/l		Na meg/100gr	K meg/100gr	Ca+Mg meg/100gr	Na	K	Ca+Mg	
608)	1.39	5.30	.655	7.50	13.45	17.75	1.056	.976	5.575	5.9	5.7	32.8	2.74
609)	.75	4.35	.435	3.70	8.48	18.50	1.449	1.733	4.711	7.8	9.4	25.5	3.19
610)	1.22	3.15	.800	10.00	13.95	28.12	.893	.573	3.407	3.2	2.1	12.1	1.41
626)	.67	1.55	.250	4.80	6.60	26.75	.578	1.364	2.932	2.1	5.1	10.9	.97
624)	1.10	3.60	.490	5.80	9.89	15.00	.460	.781	1.235	3.1	5.2	8.2	2.11
611)	.75	3.30	.515	4.70	8.51	14.50	.736	1.783	1.380	5.1	12.3	9.5	2.16
612)	..96	2.30	.775	6.70	9.77	24.12	.900	1.741	2.706	3.7	7.2	11.2	1.26
629)	.87	1,85	.420	5.60	7.87	26.75	.587	1.780	2.733	2.2	6.6	10.2	1.11
627)	.74	1.40	.410	5.00	6.81	25.75	.533	2.131	2.260	2.1	8.3	8.7	.89
613)	.55	1.55	.510	4.00	6.06	26.25	.875	2.500	2.846	3.3	9.5	10.8	1.10
614)	18.50	88.55	3.125	93.50	185.10	27.25	2.473	2.049	2.201	9.1	7.5	8.1	12.32
615)	3.25	13.00	1.125	14.00	28.10	25.75	2.412	.797	2.171	9.4	3.1	8.4	4.93
617)	.96	2.70	.500	7.00	10.20	20.25	.916	1.100	1.621	4.5	5.4	8.0	1.44
616)	.53	1.80	.190	3.00	4.99	24.50	.961	.940	2.000	3.9	3.8	8.2	1.43
620)	.85	1.25	.295	6.30	7.84	42.25	1.151	1.483	7.158	2.7	3.5	16.9	;71
618)	.50	1.00	.200	3.60	4.80	38.50	1.246	11113	7.087	3.2	2.9	18.4	.75
630)	.77	1.60	.355	5.00	6.95	29.50	.572	1.732	3.222	1.9	5.8	10.9	1.01
619)	.63	1.85	.215	4.00	6.06	30.50	1.105	1.389	2,919	3.6	4.5	9.6	1.31
623)	.84	2.15	.410	5.20	7.76	23.35	1.048	1.131	2.065	4.5	4.8	8.9	1.33
621)	;69	1.80	.330	7.60	9.73	26.75	1.086	1.059	2.187	4.1	3.9	8.2	.93
622)	.62	1.40	.140	4.80	6.34	26.25	1.150	.493	4.909	4.4	1.9	17.9	.91
623)	.85	3.30	.100	4.40	3.30	30.25	1.140	.495	2.843	3.8	1.6	9.4	2.55

their effects on plant growth. From a point of view of the physical properties of the soils it has been already noted that the soils in Cyrenaica have a moderately heavy texture varying from a range of clay, sandy clay, and sandy clay loam. The clay contents are fairly high, i.e. up to 36% of the total mineral function, but these relatively high figures are generally adequately balanced by a much higher sand content. Thus, the textures of the soils are relatively good from the agricultural point of view, and under favoured methods of cultivation would be able to support quite intensive land use.

In addition with these moderately high contents and given the relatively high contents of aluminium and iron content, the structure of the soil also has inherent favourable qualities. However, under the prevailing intense Mediterranean climate there is a strong tendency for extremely hard and compact structures to form during the intense period of dessication. The high content of colloids and sesquioxides is likely to be highly affected by the climate regime during the wet absorbent season and the soils are likely to be absorbent in moisture and very sticky whilst during the summer drought they tend to break up into extremely hard clods and soil pans with very obvious signs of soil cracking. With this annual unfavourable change in soil structural characteristics it can be imagined that the problems posed for soil practices are very great. In particular the nature and timing of ploughing operation is critical for the production of a proper seed bed. If the land is worked when the moisture content is high the ground is likely to be compressed and there will be a tendency for large clods to be formed. On the other hand it is mechanically impossible to plough many of these soils during the dry season when the soil is compact and extremely indurated. Working the land at this time of the year only produces very strong blocky units of an irregular size. The important point to emphasise here is that under the prevailing climatic regime the soil structures are extremely unfavourable to agricultural management, and under the prevailing agricultural technique there is always a strong tendency towards a structural degradation. This unfortunate condition as regards physical fertility is very widespread in the arid zones of the Middle East and deserves much more attention in soil conservation.

One point that has to be remembered in this region as in most of the Middle East is that most soils have been utilised for milennia and the processes of degradation, especially those associated with the reduction of organic matter and the consequent effect on soil structure and texture, have had extreme results. It is, therefore, more difficult to discover suitable tillage techniques and cultivation periods than in apparently analagous regions of, for instance, North America where conservation techniques are being applied at a much earlier stage in degradation.

The behaviour of moisture in the soils is, of course, of major importance in climatically marginal areas like Cyrenaica, but unfortunately very little data are available to give an accurate quantitative picture of the soil moisture situation in the area under study although the work of Micheli (7) in Benghazi Plain does provide some preliminary statement to be made. The hydrological cycle is perhaps one of the major fields of investigation which should be carried out in the future of Cyrenaica.

However, from field observation and simple laboratory tests it is possible to outline the major feature of the soil moisture regime in the area. Undoubtedly a high percentage of the rainfall on Cyrenaica does not penetrate very deeply on account of impermeable layers and is readily lost by high evaporation in the summer.

From a physical point of view the soils under study have a very high capacity for absorbing moisture and in fact the saturation percentages are quite high ranging from 34 to 39.2%. Ultimately this means that the wilting percentages too are quite high and in fact Micheli(8) estimates that water in the soil becomes unavailable at a percentage moisture of 8.5%. This is very high percentage and points to the fact that much of the moisture in the soil is unavailable for plant growth .

In addition to the basic problem of the availability of moisture for plant growth, the water regime of the soils also presents problems in the realm of soil structure and land management. The fact that some of the semi-arid areas do provide such great difficulties in the maintenance of good soil structure is a very well known theme and one which is receiving a very great attention at the present time. Aubert(9) has underlined the advances and also the work to be done in this field.

From a point of view of chemical fertility of the soils, in particular the ability of the soils to provide necessary nutrients for plant growth, the picture is more straight-forward. The overwhelming fact which must be borne in mind in this regard is the extremely low organic matter in the soils. The organic function at the surface ranges from 0.95% organic matter in profile 11 to 2.4% in profile 8. In addition to the unfavourable effects on soil structure which these low figures here indicate, the main effect of this is the inability of the soils to provide enough nitrogen for intensive plant growth. This is a very common problem in semi-arid lands and points to the need for improved management practices with greater emphasis on chemical fertilisation and the introduction of a leguminous crop in the farming rotation.

The laboratory analysis of available nutrients also indicates that phosphate is poorly available for plant growth. The figures for available phosphate are consistently less than 13 ppm except for Profiles 1, 7 and 8 where larger amounts were recorded. The fact that phosphate is so unavailable is most probably related to the high content of iron and aluminium in the soils. With a high content of iron, aluminium oxides, much of the phosphate will be fixed into unavailable iron and aluminium phosphate. The fact that Profile 1 has a higher phosphate status can probably be explained in terms of its lower content of sesquioxides, but the relatively high phosphate in profiles 7 and 8 are more difficult to explain. In the absence of any addition of fertilizers by farmers it is probably related to the minerological make up of the soils. Unfortunately this could not be verified by the laboratory analysis.

To summarise the fertility aspect of the soils under study it may be pointed out that such basic limitations as soil depth and stoniness which are often found in the Middle East do not present a serious problem in El-Marj Plain. The Terra Rossa soils are quite deep and provide an adequate rooting medium for plants and the limitations found are much more related to the system of management. In particular such physical characteristics as soil moisture regime and the soil structure conditions point to the need for careful and adequately planned management system, whilst the lack of the organic matter nitrogen and phosphate in the soil can again be remedied by rational management practices. There is no pedological reason to suppose that under a good management system the soils of El-Marj Plain should not prove particularly fertile.

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