The Libyan Journal of Agriculture: volume 3, 1974

Chemical and Mineralogical Properties of Kufra Sahara Soils

GILANI ABDELGAWAD, ALBERT PAGE, AND LANNY LUND[1]

ABSTRACT

Chemical, physical; and mineralogical properties of Sahara soils from the Kufra oasis in Libya are presented. The minerals present in the soils consist mainly of primary minerals. Sand size seperates make up 85–90% of the mass. The soils exhibit no profile development, and are classified according to the U.S.D.A. soil taxonomy as Torripsamments.

Sand lenses which occur within the root zone and restrict water movement and root penetration are not cemented but are due to particle size segregation.

INTRODUCTION

The Kufra oasis is located in the Sahara desert in the southeastern part of Libya at about 24°E longitude. Because of an abundant supply of excellent quality ground water in the region, it is currently under agricultural development. Ayers (2) made a preliminary study of the soils in the region.

The natural soils have a bulk density of approximately 1.8 g/cm^3, are very sandy, exhibit no profile development, are essentially devoid of organic matter, and very deficient in nitrogen and probably other macro- and micro-plant nutrients. Sand lenses in the root zone cause some restriction of water movement and root penetration.

The purpose of this study was to characterize the mineralogical and chemical properties of soils from the Kufra oasis in order to anticipate problems which may occur after the soils are brought under intensive, irrigated agriculture.

MATERIALS AND METHODS

Soil samples from three farms in the Kufra oasis were collected from 0–10 and 10–35 cm depths. The soils were sieved through a 2 mm sieve.

Undisturbed core samples were collected using a core sampler.

This work is a co-operation between Tripoli University, Department of Soil and Water, and University of California at Riverside, Department of Soil and Ag. Eng.

[1]*Lecturer at Tripoli University, Professor of soil chemistry and chemist, University of California, and Assistant Professor of Soil Morphology and Mineralogy, University of California, respectively.*

The cation exchange capacities (CEC) were determined by the NaOAC method and exchangeable cations were determined by leaching with 1 *N* NH_4OAc (3,4). Phosphorus sorption capacities were determined by equilibrating the soils overnight with graded amounts of P (as KH_2PO_4). Amounts of P sorbed were taken as equal to the difference between the amount added and that present in the supernatant. Phosphorus was determined colorimetrically by the chlorostaneous-reduced molybdophosphoric blue colour method (7). Calcium and magnesium were determined by atomic adsorption and sodium and potassium by emission flame photometry.

Thin sections prepared by the method outlined by Jackson (6) were examined under the petrographic microscope. Particle size analyses were determined by the pipette method (6). X-ray diffraction analyses were carried out after various treatments by using an X-ray diffractometer, equipped with a flow counter and recorder. Copper Kα radiation was employed with $\lambda = 1.5418$A.

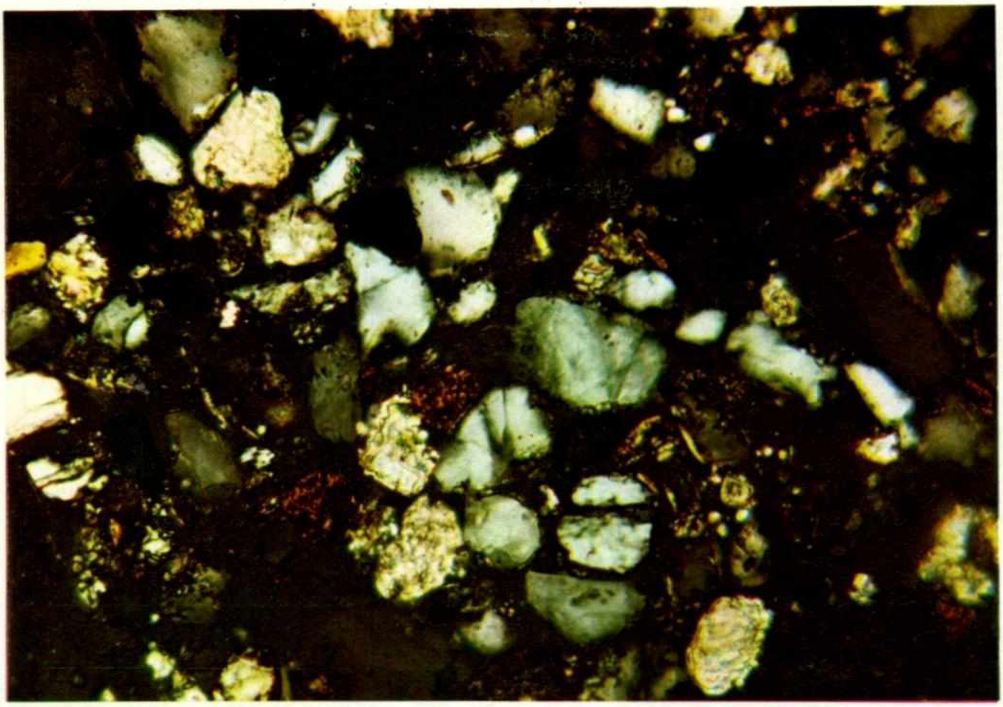
The samples were prepared for analyses as oriented aggregates of clay. The oriented aggregates were prepared by carefully depositing an aliquot of the suspension on a glass slide and evaporating. Clay samples were examined after the following treatments: Mg-saturation; Mg-saturation and glycol solvation; K-saturation, air dried; K-saturation, heated at 200°C; and K-saturation, heated at 600°C.

RESULTS AND DISCUSSION

Morphological and Mineralogical Properties:

The parent materials for the soils in the Kufra region are Niobian sandstone and some igneous rocks from the southern Chad mountains. The soils exhibit no profile development, are sandy throughout, and essentially devoid of organic matter. They are developed principally by wind action. According to the U.S.D.A. soil taxonomy (1), the soils would be classified as Torripsamments.

As mentioned in the introduction, soils in the Kufra area have lenses within the root zone which restrict water movement and root penetration. Thin sections from undisturbed cores were examined under the petrographic microscope to determine if these lenses were cemented. Prints of the thin sections showed quartz grains of medium size arranged in several rows with fine particles filling voids between the grains (Fig. 1). This arrangement probably occurred during the process of deposition with segregation of the medium size particles resulting from the velocity and direction of the prevailing winds. The petrographic study demonstrated that the lenses in the soil profile are not cemented but are a result of particle segregation. X-ray diffraction patterns, representative of the clay fraction of the Kufra soils, are presented in Fig. 2. Minerals identified in the clay fraction are all primary minerals. Spacings at 4.27, 3.37, 3.36, and 1.82A° demonstrated the presence of quartz. Orthoclase and plagioclase feldspars are associated with spacings of 3.27 and 2.14A°, respectively. Based upon peak height above background, quartz and orthoclase feldspar are the dominant minerals which occur in the clay fractions. Lesser amounts of kaolinite (7.19 and 3.57A°), dolomite (2.19A°) and plagioclase feldspar (2.14A°) occur. Peaks at 7.19 and 3.57A° disappeared when the specimens were heated to 600°C for 4 hours, which confirmed that these peaks are associated with kaolinite. The kaolinite in the clay fractions of the soil is probably inherited from the parent materials since the soils have not been intensely weathered. Other minerals identified in the clay fraction of the Kufra soils include: muscovite (10.1 and 1.50A°), chrysotite (3.64A°), hornblende (3.7 A°), apatite (2.83A°), goethite (2.42A°), calcite (2.29A°) and anatase (1.69A°).



Physical and Chemical Properties:

For the convenience of those working on the project, the results tabulated for the soils are identified according to the Kufra project farm designation.

Particle size analyses, presented in Table 1, reflect the uniformity of the soils in the Kufra oasis. The soils from the three farms sampled exhibit essentially the same particle size distribution. Sand percentages range from 85-91 %, while those of silt and clay range from 8–14 % and 1.1–3.0 %, respectively. Percentages of coarse sand in the surface are slightly greater than the medium, fine or very fine sand. This is probably related to the velocity of the wind and its capacity for carrying different particle size. Clay and silt concentrations are generally slightly greater in the surface horizons. This suggests more physical and chemical weathering at and near the surface.

The pH of the virgin soils in the Kufra region ranges between 7.5 and 8.2. Following a few years of cropping and irrigation, the pH range has decreased to 6.4–7.0. The use of ammonical nitrogen fertilizers, coupled with the low buffering capacity of the soils accounts for the rather rapid pH depression following cropping. Plants grown in the region commonly show symptoms typical of those described as zinc deficiency. Animals using forage from the region commonly exhibit copper deficiency symptoms. These observations suggest minor element fertilizers, in addition to nitrogen fertilizers, are needed for successful agricultural activities.

The CEC's of the soils range from 1.5 to 3.0 me/100 g and are only slightly influenced by pH in the range of pH 5 to pH 8.2 (Table 2). This is expected since the organic matter contents of the soils were below the limits of detectability (0.05 %) by the method used. The CEC's probably result in part from the presence of kaolinite and weathered muscovite. In subsurface soils (10–35 cm), CEC's are consistently slightly greater than those of the

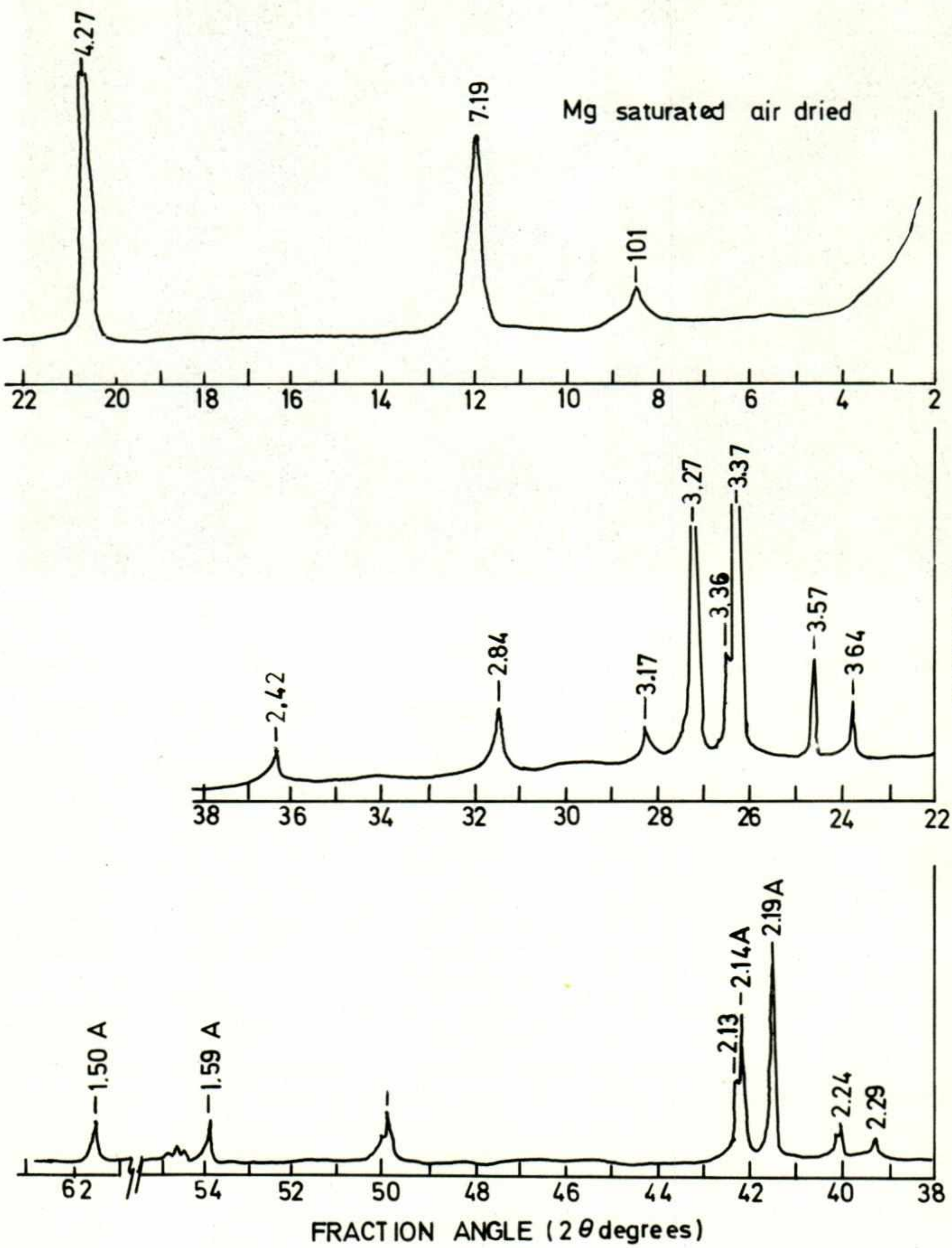


Fig. 2. Smoothed tracing of X-ray diffractogram for the $< 2\mu$ fraction of Kufra oasis soils.

Table 1 Particle size analysis of soil from three Kufra oasis farms.

Farm No.	Depth sampled (cm)	Percent Sand, Silt, and Clay: Sand[1] Coarse	Medium	Fine	Very fine	Silt[2] Coarse	Medium	Fine	Clay[3]
B_6W	0–10	38	12	16	21	3.8	1.4	4.7	3.0
	10–35	35	14	23	19	5.0	2.3	0.7	1.0
B_7W	0–10	40	10	19	18	4.0	3.7	4.6	2.2
	10–35	33	16	21	19	7.0	2.3	0.2	1.5
B_3W	0–10	48	11	10	18	5.0	3.7	4.6	1.2
	10–35	38	10	19	18	7.5	1.7	4.6	1.1

[1]Sand separates have the following size ranges (in mm): coarse (1.0–0.5), medium (0.5–0.25), fine (0.25–0.10), and very fine (0.1–0.05).
[2]Silt separates have the following size ranges (in mm): coarse (0.05–0.02), medium (0.02–0.005), fine (0.005–0.002).
[3]0.002 mm.

Table 2 Cation exchange capacities of Kufra oasis soils at various pH.

Farm No.[1]	Depth (cm)	CEC (me/100 g) at pH: 8.2	7.0	5.0
B_7W	0–10	1.8	1.6	1.4
	10–35	2.0	1.8	1.7
B_6W	0–10	2.4	2.2	2.0
	10–35	3.0	2.8	2.4
B_3W	0–10	1.6	1.6	1.5
	10–35	1.8	1.7	1.6

[1]Kufra oasis project designation.

surface soils (0–10 cm). This seems to contradict particle size analyses (Table 1) which shows greater concentrations of silt plus clay in the surface horizon. Possibly slightly greater concentrations of organic matter (although very low and 0.05%) in the subsurface horizons account for these apparent anomalous results.

Concentrations of exchangeable bases for the soils tested are presented in Table 3. The exchangeable bases for the soils from the three farms sampled show little variability and as with the other data presented, demonstrate that the properties of the soils from the

Table 3 Exchangeable bases for Kufra oasis soils.

Farm No.[1]	Depth (cm)	Exchangeable base (meq/100 g): Ca^{++}	Mg^{++}	K^{+}	Na^{+}
B_7W	0–10	0.80	0.30	0.25	0.12
	10–35	0.90	0.40	0.30	0.15
B_6W	0–10	1.20	0.50	0.40	0.10
	10–35	1.50	0.40	0.60	0.20
B_3W	0–10	1.20	0.30	0.54	0.12
	10–35	1.40	0.38	0.35	0.16

[1]Kufra oasis project designation.

Kufra oasis are quite uniform. Calcium is the predominant exchangeable base and accounts for 50–60 % of the total exchangeable bases. Generally, exchangeable Mg and K are approximately equal and account for 15–30 % of the total exchangeable bases. Compared to many agricultural soils of similar exchange capacities, the concentration of exchangeable K in the Kufra oasis soils is relatively high. The sources of this K are the K-feldspars and muscovite present in the parent material.

Embleton (5) had shown that high levels of soil K may bring on or aggravate Mg deficiencies of crops. This suggests that indiscriminate use of K fertilizers in the Kufra region may well induce Mg deficiencies.

Phosphorus sorption capacities for soils from farms in the Kufra region range between 160 and 250 g P/g soil and are independent of depth to 35 cm. Sorption of phosphorus by the soils is probably related to their concentrations of calcite and dolomite.

LITERATURE CITED

1. Anonymous. 1970. Soil Survey Staff. Selected chapters from soil taxonomy. U.S. Department of Agriculture, U.S. Government Printing Office, Washington, D.C.
2. Ayers, Robert. 1969. Primary study of Kufra Project. Technical Report Submitted to the Government of Libya Kufra Project Section.
3. Chapman, H. D. 1965. Cation exchange capacity. In: Black, C. A. (Editor-in-Chief). Methods of Soil Analysis, Part 2. Chemical and Microbiological Properties. Agronomy Monograph 9 : 891–901.
4. Chapman, H. D. 1965. Total exchangeable bases. In C. A. Black, (Editor-in-Chief), Methods of Soil Analysis, Part 2, Chemical and Microbiological Properties. Agronomy Monograph 9 : 902–912.
5. Embleton, T. 1966. Potassium. In Homer D. Chapman (Editor). Diagnostic Criteria for Plants and Soils. 2nd Printing, 1973. Quality Printing Co., Inc., Abilene, Texas.
6. Jackson, M. L. 1956. Soil chemical analysis. Advanced Course published by the Author, Department of Soil Science, University of Wisconsin.
7. Jackson, M. L. 1958. Soil chemical analysis. Prentice Hall, Inc., Englewood Cliffs, New Jersey.