PRELIMINARY SOIL SURVEY REPORT FOR THE BENI MAGDOUL AND EL HAMMAMI AREAS

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agency of the United States Government.

By

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INTRODUCTION

This is a preliminary report of the soil survey for the Beni Magdoul and El Hammami areas in Mansouria. The purpose of the report is to supply base data to assist in planning the adaptive research and development phases of the Project. As additional crop production, agricultural engineering and economic data become available, a more comprehensive soil classification will be developed.

The soils in the two pilot areas selected for the Water Use and Management Study in the Mansouria Irrigation District were surveyed during February and March, 1978. The Beni Magdoul area, in the southern part of the District, consisted of approximately 800 feddans and the El Hammami area in the northern part of about 2000 feddans. Fifty-seven profiles were examined and 150 samples were collected for chemical and physical analyses from Beni Magdoul and 88 profiles were examined and 130 soil samples were collected from El Hammami. Maps with a scale of 1:5000 were prepared on the basis of soil profile characteristics and on soil chemical and physical properties. These maps delineated the soil units on the level of soil series and phases of series. Also included is a preliminary evaluation of the effects of the physical and chemical properties of the soils on crop production.

MATERIALS AND METHODS

Field Procedures

The field survey was conducted in Beni Magdoul and El Hammami using cadastral maps of scale 1:2500 prepared by the Soil Survey Department.

Soil profiles representing an area of 10 to 15 feddans per profile were examined to a depth of approximately 150 cm. The morphological features of the profiles were carefully described using the system outlined in the USDA Soil Survey Manual (1951). These features are soil color, texture, structure, consistency in dry, moist and wet conditions, porosity, root distribution, lime and gypsum accumulations, and the horizon boundaries. Other characteristics of the site included crop, relief, topography, salt efflorescence, and depth to ground water table at the time of the survey. Soil samples were taken from each depth and ground water samples were removed from 8 profiles in Beni Magdoul and 22 profiles in El Hammami.

Laboratory Methods

The soil samples collected from the different horizons were air-dried, crushed and passed through a 2-mm sieve. A saturation paste was prepared and the saturation extract was analyzed for electrical conductivity and water soluble cations ($\overset{++}{Ca}$, $\overset{++}{Mg}$, $\overset{+}{K}$, $\overset{+}{Na}$) and anions ($\overset{-}{Cl}$, HCO_3^-, $\overset{-}{CO}_3$) (U.S. Salinity Laboratory Staff, 1954). Soil pH was determined on the saturation paste. Some samples were selected for the determination of cation exchange capacity and exchangeable sodium. Calcium carbonate was determined on all samples with the Collins calcimeter (Hesse, 1971). Particle size distribution was determined by the pipet method (Black, 1965). Total dissolved solids in the soils were determined gravimetrically after evaporation of the soil extract to dryness (Piper, 1950).

The sodium adsorption ration (SAR) was caluculated using the equation, $SAR = \frac{Na}{(Ca+Mg)^{1/2}}$, where Na and (Ca + Mg) refer to millimoles per liter of these ions in the saturation extract. The exchangeable

sodium percentage (ESP) was calculated for samples for which cation exchange capacity and exchangeable sodium has been determined using the equation:

$$ESP = \frac{\text{exchangeable sodium}}{\text{cation exchange capacity}} \times 100$$

The ground water samples were analyzed for soluble cations ($\overset{++}{Ca}$, $\overset{++}{Mg}$, $\overset{+}{Na}$, $\overset{+}{K}$), soluble anions ($\bar{C}l$, HCO_3^-), and electrical conductivity. Sulfate was calculated as the difference between the total cations and the sum of $\bar{C}l$ and HCO_3^-. Total soluble salts were calculated from the sum of the water soluble cations and anions using their respective molecular weights.

SOILS OF THE BENI MAGDOUL AREA

Soil Morphology

The morphological characteristics of the profiles and the chemical and the mechanical analyses of Beni Magdoul area revealed that most of these soils are Holecene alluvial deposits. These deposits were formed essentially from very dark grayish brown Nile suspended matter consisting of micaceous minerals and hydrated magnetite (Ball, 1952). The soils of the area are classified into the following series:

Series I This series occupies the larger portion of the Beni Magdoul area (Map 1B). The soil is dark to very dark grayish brown throughout, with the clay content generally ranging from 40 to 60% but occasionally with higher levels (Table A-1). The clay content in the topsoil of profiles adjacent to Mansouria canal was less than 40% because of the effect of the wind-blown sand from the near desert. The texture of these soils are classified as sandy clay. The soil is compact and has a strongly developed angular, blocky structure. Wide and deep cracking occurs when the soil dries. Slickensides are very clear in the subsoil to a depth of 60 cm. The lime content is relatively high, and

reaches from 2 to 12% in topsoil and decreases gradually with depth to 1 to 5% in the subsoil.

The soils of this series would be classified under the new American soil classification system "Soil Taxonomy" in the order Vertisols, suborder great group Torrerts, and the subgroup Typic Torrerts (Soil Survey Staff, 1967).

Series II This soil series occupies the area located west of Beni Magdoul Village between the canal and the drain. This series is represented on Map 1B by profiles 40, 41, 42, 43, 44. The soil is characterized by a brown to dark yellowish brown color, sandy loam to sandy clay loam, or even sandy clay to a depth of 80 to 150 cm or over. The clay fraction is less than 30%, and sand is the dominant fraction. The lime content is moderate and ranges from 1 to 3.5% and decreases gradually with depth.

This soil is classified under the American classification system in the order Entisols, suborder Fluvents, great group Torrifluvents, and subgroup Typic Torrifluvents (Soil Survey Staff, 1967).

Series III This soil is located in a small area in the corner between the Nahia drain and the Mansouria canal and is represented by profiles 3 and 6 (Map 1B). The soil has a sandy texture except for the topsoil which can be either a loamy sand or sandy clay.

The soil is almost structureless with single grains of pale brown to yellowish brown color. The lime content, which is relatively high, ranges from 3 to 6% and decreases gradually with depth. This soil series under the American System is in the order Entisols, suborder Psamments, great group Torripsamments, subgroup Typic Torripsamments (Soil Survey Staff, 1967).

Soil Salinity

The salinity and SAR levels of irrigated soils are dynamic properties and are related not only to soil properties but also to method and amount of water applied as well as to quality of the water. At the time of the survey surface soils of Beni Magdoul area generally were classed as non-saline when based on electric conductivity values under 4 mmhos (U.S. Salinity Laboratory Staff, 1954). Some scattered sites were moderate saline (4-8 mmhos) as shown for profiles 1, 4, 13, 14, 16, 26, 29, 30, 45, 48, 53 (Map 2B). Three soils were highly saline (8-16 mmhos) in the surface, profiles 12, 25, and profile 2 has an electrical conductivity of 20 mmhos (Table A-2).

The SAR of the surface soil generally was less than 10 and only in profile 2 was it greater than 15. The ESP of the few samples for which it was determined tended to be higher than that calculated from SAR as outlined by the U.S. Salinity Laboratory Staff, 1954.

Water-Table Status

The water table at the time of the survey generally was more than 150 cm below the soil surface. However, in some profiles, the water table ranged from 60 to 140 cm below the surface (profiles 6, 11, 13, 16, 25, 42, 44, 53) and signs of mottling occurred in the fluctuating water-table zone (Map 3B). It should be noted that the water table depth in these soils is not static but is related closely to the irrigation practices prior to measurement.

The analysis of 8 representative ground water samples shows that the total soluble salts ranged from 1060 to 7400 ppm, and reached 11,560 ppm in profile 13, where the soil was moderately affected by salinity (Table A-3). The dominant cation in the ground water of most profiles was sodium. Calcium and magnesium were dominant in the ground water of profiles 20 and 50.

SOILS OF THE EL HAMMAMI AREA

Soil Morphology

The morphological study of 88 soil profiles in Hammami area, together with the chemical and the mechanical analysis of representative soils revealed that: (1) the soil profiles of the entire area are quite uniform, of recent age and were formed from aeolean sand deposits blown from the near western desert; (2) the color of the subsoil ranges from yellow to yellowish brown. The topsoils are darker, being yellowish brown to dark yellowish brown and dark brown; and (3) soil texture generally is sandy throughout the profile. The topsoil in many cases is a loamy sand to depths of up to 30 cm (Table A-4) because of the addition of the suspended matter from previous Nile floods and also because of the application of manure composts during the past 30 years following reclamation. The soil ususally is loose or slightly compact in the topsoil without any developed structure. In addition it is porous and characterized by a high hydraulic conductivity because of the low content of clay and silt which generally does not exceed 10% in subsoils and/or 15 to 25% in topsoils. The lime content is low and ranges from 1 to 2% in the topsoils and less than 1% in subsoil. No gypsum accumulations were observed. Soils of this area according to the American soil classification system "The Soil Taxonomy" are in the order of Entisols, suborder Psamments, great group Torripsamments and subgroup Typic Torripsamments (Soil Survey Staff, 1967). These characteristics place the soils in the Hammami area under one series which is classified into two phases:

Phase I This is a very deep, coarse, sandy soil throughout. The color ranges from brownish yellow (10 YR 6/6) in the subsoil to yellowish

brown and dark yellowish brown in the topsoil (10 YR 5/3-5/4-4/4) in moist condition. The coarse sand is the dominant fraction which ranges from 50 to 78% and the silt and clay is less than 10%. The soil is structureless, consisting of loose, single grains. These soils occupy the central part of the area (Map 1A).

Phase II This soil phase is like Phase I, except for the topsoil which is slightly heavier in texture, and is a loamy sand or occasionally a sandy loam. The fine particles of the topsoil range from 15 to 25%. The consistence of the top layer is slightly compact and has a darker color, usually dark gray to dark grayish brown. The soils of this phase are located along the Mansouria canal and Kafr Hakim drain. These areas are considered to be the older cultivated lands in El Hammami (Map 1A).

Soil Salinity

The electrical conductivity of the soils in El Hammami at the time of the survey were usually less than 4 mmhos. Some scattered areas, however, were moderately saline (4 to 8 mmhos) and are represented by profiles 6, 31, 55, 60, 61, 62, 67, 76 and 99 (Map 2A). Some areas of high salinity (from 8 to 16 mmhos) are shown by profiles 12, 14, 47, 54 and 56. The saline areas were located mainly in the eastern part of the area and involved about 300 feddans. There appeared to be a shortage of irrigation water in this area of El Hammami.

Fifteen percent of the surface soils (14 sites) would be classed as sodic, i.e. with an SAR of 15 or greater. Another 7 percent of the soils (6 sites) had an SAR in the range of 10 to 15. Most of the surface soils would be classed as non-sodic (Table A-5).

Water-Table Status

At the time of the survey, water table depths were measured and found to be less than 100 cm from the surface in the entire area (Map 3A). In more than one-half of El Hammami area, water table levels reached 40 to 60 cm from the surface (47 profiles). Because of the presence of water table at shallow depths, mottling occurred in the fluctuation zone and occasionally gleyed layers appeared in the subsoils of many profiles.

The analysis of some water-table samples (22 samples) showed that the total soluble salts usually ranged from 1000 to 2000 ppm (Table A-6). The maximum ground water salinity (3970 ppm) was in profile 47 where the soil was affected by salinity. The lowest total soluble salts in the ground water was in profile 1 (630 ppm) which was adjacent to to Mansouria canal (Table A-6).

PRELIMINARY EVALUATION FOR CROP PRODUCTION

Soil texture, the mineral content of the soil and the cation exchange capacity are fundamental soil properties that are essentially static during man's lifetime. Other properties such as soil salinity, soil sodicity and soil fertility are dynamic properties that change with the farmers' management practices. Thus, in the interpretation of soil analysis, the static or dynamic nature of the parameter must be considered when evaluating management in terms of crop growth. The farmer can modify his cultural practices that influence the dynamic properties, but he must work within the limitations of the fundamental or static soil properties.

Beni Magdoul

Soil texture The principle series described for the area (Series I) s a heavy-textured soil containing from 40 to 60% clay. Soils with

this content of clay require good management practices if crop production is to be maintained at high levels. Problems associated with heavy-textured soils are characterized by a) poor aeration during a period of time following irrigation, particularly where a high water table is present, b) difficulty in cultivation or other soil manipulation practices when either too wet or too dry, and c) seedling emergence may be impaired by crusting and cracking.

The soils composing Series I are capable of producing crops from medium to high yield levels with good management systems. Soils composing Series II and III should have medium yield potentials. In all cases, the soils of Beni Magdoul require management practices that encourage good soil-particle aggregation, and careful irrigation is required to prevent poor soil aeration or temporary water-logging in the root zone.

pH and lime The pH of the soils ranged from 7.4 to 8.4 and is that expected in soils containing 2 to 12% lime. These are non-sodic, calcareous soil systems and the pH is determined mainly by the combination of soluble calcium salts and the CO_2 pressure as shown by the following equation (after Cole, 1957):

$$pH = 4.85 + 1/2\ pCa - 1/2\ \log\ pCO_2$$

The pH of the soils are in a favorable range for the nutrition of most crop plants. Few micronutrient deficiencies would be expected, except possibly Fe and Zn for certain crops in areas where soil organic matter is low and where no animal manures or plant residues are returned to the soil.

Saturation percentage (SP) and cation exchange capacity (CEC) The SP of Series I soils averaged 68% in the 0 to 20 or 0 to 30 cm depths and increased to 73% at intermediate depths (30 to 50 cm) and to

77% at 50 to 150 cm depths. The CEC for 9 samples ranged from a minimum of 10 to a maximum of 38. Using the limited data for CEC the following regression equation was developed to calculate the CEC from SP:

$$CEC = 0.80 = 0.45(SP)$$

The equation may be used to estimate the CEC of other soils in Beni Magdoul.

The SP was determined on disturbed soil samples and is not suitable as a single value for soils of these textures to evaluate soil aeration characteristics in the field. With the combination of bulk density and field moisture capacity measurements in the field, good estimates of the aeration characteristics of the soil can be obtained.

Electrical conductivity (EC) The EC of the saturation extract of the 57 surface soils from Beni Magdoul were grouped into 3 categories depending upon the degree of salinity:

a. Non-saline (0-4 mmhos)-only the more sensitive plants are affected.

b. Moderately saline (4-8 mmhos)-growth of most crop plants show reduction in growth. Salt sensitive plants show a considerable reduction in growth while salt insensitive plants show little reduction.

c. Strongly saline (> 8 mmhos)-there is marked reduction in growth of nearly all crop plants.

Electrical conductivity is not a fundamental soil property, but is one that depends largely on soil and water management and on quality of the irrigation water.

Of the 57 soils evaluated, 25% had EC values that were sufficiently high to have an adverse effect on the growth of most crop plants. Only

Salinity scale	No. of soils	% of soils	Average EC per category
Non-saline < 4 mmhos	43	75	2.1
Moderately saline 4 - 8 mmhos	11	19	5.7
Strongly saline > 8 mmhos	3	6	13.9

3 of the soil profiles were classified as strongly saline. With judicious management of irrigation water and possibly with the improvement of drainage and the leaching of excess salts followed by the addition of manure, the salinity problem in these areas could be reduced to the point where reductions in crop yields could be eliminated. The strongly saline areas which encompass only 6% of the total areas were located randomly in the Beni Magdoul (Map 2B).

Soil sodicity Both the exchangeable sodium percentage (ESP) or sodium adsorption ratio (SAR) of the saturation extract are used to characterize the sodicity of a soil. Because of the ease of determination, SAR is most often used. The SAR value is approximately equal to the ESP for values of ESP to about 30 (U.S. Salinity Laboratory Staff, 1954).

The SAR value of 56 surface soil samples are summarized in the following table according to a) low SAR (<10) b) medium SAR (10-15) and c) high SAR (>15).

SAR	No. of soils	% in category	Average per category
Low, <10	52	91	5.6
Medium, 10 - 15	4	7	12.7
High, >15	1	2	23.0

As with EC, if the irrigation water is of good quality the SAR is an indication of the type of soil and water management on the farm. With continued poor management, potential problems could be expected in 4 of the 57 soils (7%), and one soil now has a sodic problem. The combination of high quality irrigation water and high irrigation rates probably are the main factors maintaining the low SAR and salinity values of these soils. Leaching of excess salts from the soil profile, providing adequate drainage exists, and then followed by the applications of gypsum and manure would preclude the development of sodic conditions.

Ionic composition and the saturation extract Certain ionic ratios in the saturation extract can give insights to potential nutritional problems. The SAR values summarized in the preceding section indicate no calcium nutrition problems at the present time. Should the SAR of profile site 2 continue to increase (SAR = 23), nutritional problems could develop although detrimental soil physical conditions probably would appear first.

The Ca/Mg and SO_4/Cl ratios were calculated for the saturation extracts of the surface soils. The average Ca/Mg ration was 1.9 $\pm$ 0.5 and the average SO_4/Cl ratio was 1.6 $\pm$ 0.5. The value for the Ca/Mg ratio is satisfactory and a Ca/Mg imbalance would not be expected unless the ratio becomes very high or very low. The SO_4/Cl ratio indicates that it is a sulfate dominated system in most profiles. This is desirable because at comparable electrical conductivity levels in the soil, salinity effects on plant growth generally are less severe in sulfate systems.

Groundwater analysis Groundwater samples were analyzed from under 8 soil profiles and are summarized in the following table.

Factor	Average	Range
Electrical conductivity, mmhos	5.9	1.4 to 13.7
Sodium adsorption ratio	10.1	5.7 to 14.9
Total soluble salts, ppm.	4690	1065 to 11,100
SO_4/Cl ratio	0.84	0.6 to 4.0
Ca/Mg ratio	0.81	0.5 to 1.1

Six of the water samples had conductivity levels of greater than 4. None of the water samples had SAR values that exceeded 15, but one-half fell in the range of 10 to 15. Sodium chloride is the predominate salt in most of the ground water samples.

In general, the ground water samples indicate that problems could be encountered in crop production if irrigation practices allowed continued upward movement of salts from the ground water. This could be quite serious, particularly in areas where a high water table and high rates of evaporation occur simultaneously.

El Hammami

Soil texture The soils are largely loamy sands in the surface and sands in the subsoil. They have very low water holding capacities and low cation exchange capacities. Problems associated with light textured soils such as these are a) droughtiness, b) low fertility, and c) subject to severe leaching of nutrients. These soils should have no aeration problems but careful management of irrigation and fertilization will be required. In contrast to the heavier soils in Beni Magdoul, a relatively high water table may be advantageous if salinity can be controlled. Deeper rooted crops, such as tree crops, should be well suited in this area as the intervals between irrigations would be

lengthened thus reducing the build up of the water table and reducing the loss of plant nutrients by leaching.

pH The pH of the soils in El Hammami ranged from 7.9 to 8.8 and most of the soils were non-sodic. Some of the pH values of 8.4 or so were not as high as might be expected for SAR values in excess of 15. The soil pH values of the surface soils generally were in a favorable range for the growth of most crop plants, but micronutrient deficiencies could be expected, particularly with Fe or Zn for certain crops because of the combination light texture and low organic matter content of these soils.

Saturation percentage (SP) and cation exchange capacity (CEC) The SP percentages averaged 25.5% for the surface areas and 22.9 for the subsurface. This indicated a low water holding capacity of these soils. The field moisture capacity of most soils was 12 to 15 percent. With bulk density measurements reasonably good estimates of cover soil aeration, under field conditions can be calculated for these light textured soils.

Cation exchange capacity levels were also quite low as surface soils (0 to 20 and 0 to 30 cm) had values of 6.8 while subsurface soil layers (30 to 150 cm) averaged about 4.6 meq. per 100 g. The available water holding capacity estimated from SP indicates that the soils in El Hammami are not well suited for maintaining good soil moisture without frequent irrigation or subsurface water supplies. The low CEC values indicate the possibility of extensive leaching when the soils are heavily irrigated. Excellent management of both water and fertilizer is of prime importance in these soils so that adequate moisture can be maintained without excessive leaching of plant nutrients.

Soil salinity The electrical conductivity of the saturation extract samples that were sampled were grouped into 3 categories.

Salinity Scale	No. of Soils	% of Soils	Avg. EC per category
Non-saline, <4 mmhos	71	83	1.8
Moderately saline, 4 - 8 mmhos	9	10	5.6
Strongly saline, >8 mmhos	6	7	11.4

Of the 86 samples evaluated , 19% had EC values that were sufficiently high to have an adverse effect on crop production. This was in contrast to the 25% of the soils in the same category in the Beni Magdoul area. Only 6 sampled areas were classed as strongly saline. With proper use of water to facilitate the removal of excess salts from the root zone, the salinity of these areas could be controlled so that there are no detrimental effects on crop growth.

Soil sodicity The sodium absorption ratios (SAR) of 86 surface soil samples are summarized into 3 categories in the following table:

SAR	No. of Soils	% in Category	Avg. per Category
Low, <10	66	77	3.6
Medium, 10 - 15	7	8	12.5
High, >15	13	15	31.1

Potentially serious problems can be expected in 8 percent of the soils where SAR values range from 10 to 15, particularly if present farm management practices continue. Sodic problems have already developed in 15 percent of the area where SAR values are now above 15. Judicious irrigation practices combined with the addition of gypsum and animal manure will help remedy the salt-affected areas. The growing of tree crops in these areas should be encouraged.

Ionic composition of the saturation extract The Ca/Mg and SO_4/Cl ratios were calculated for the saturation extracts of the surface soils. The Ca/Mg ratio averaged 1.8 and the SO_4/Cl ratio averaged 2.0. Both ratios are satisfactory and no nutritional problems normally would be expected.

Groundwater analysis Groundwater samples were analyzed from under 22 soil profiles and the major factors are summarized in the following table.

Factor	Average	Range
Electrical conductivity, mmhos	2.05	0.7 to 4.5
Sodium Absorption ratio	5.85	1.0 to 15.84
Total Soluble salts, ppm.	1658	630 to 3970

Only one of the samples (No. 47) had a conductivity level over 4 and it also had the highest total soluble salt content. One sample had an SAR value that exceeded 15 and 4 other samples fell into the range between 10 and 13. The levels of salt in El Hammami groundwater samples generally were not excessively high, but if water table levels continued to rise, some surface soils could become saline or sodic if proper irrigation practices are not followed.

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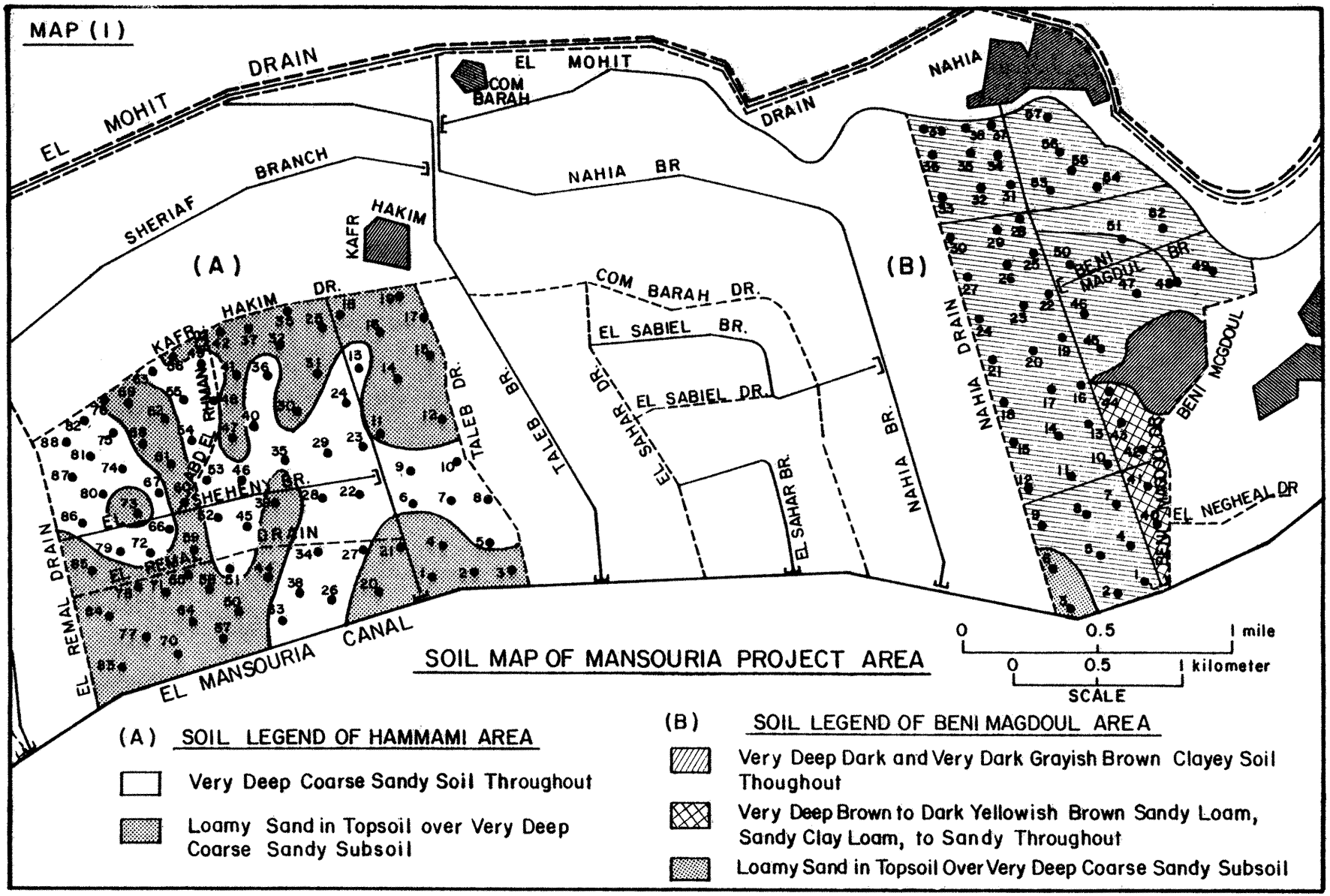
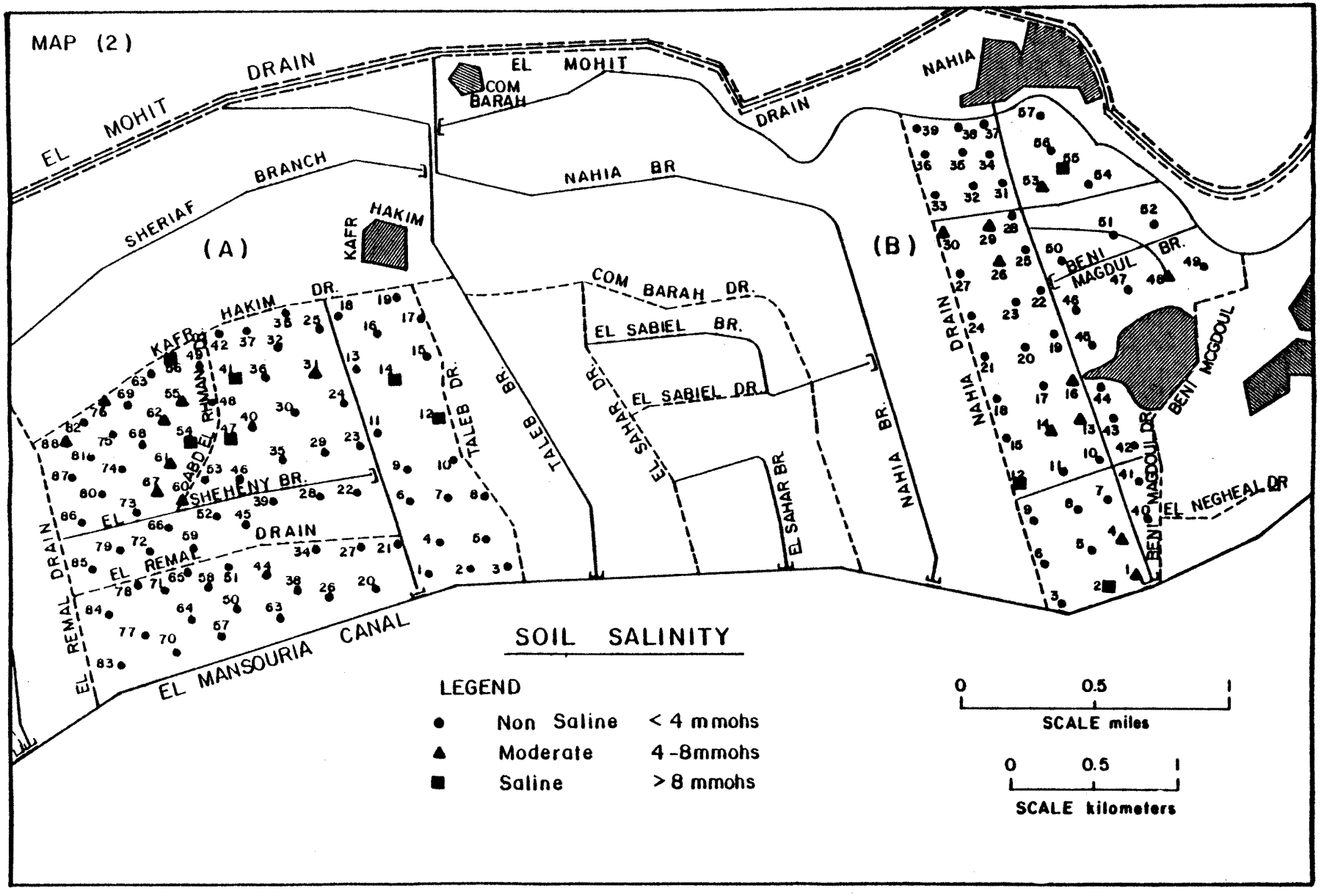
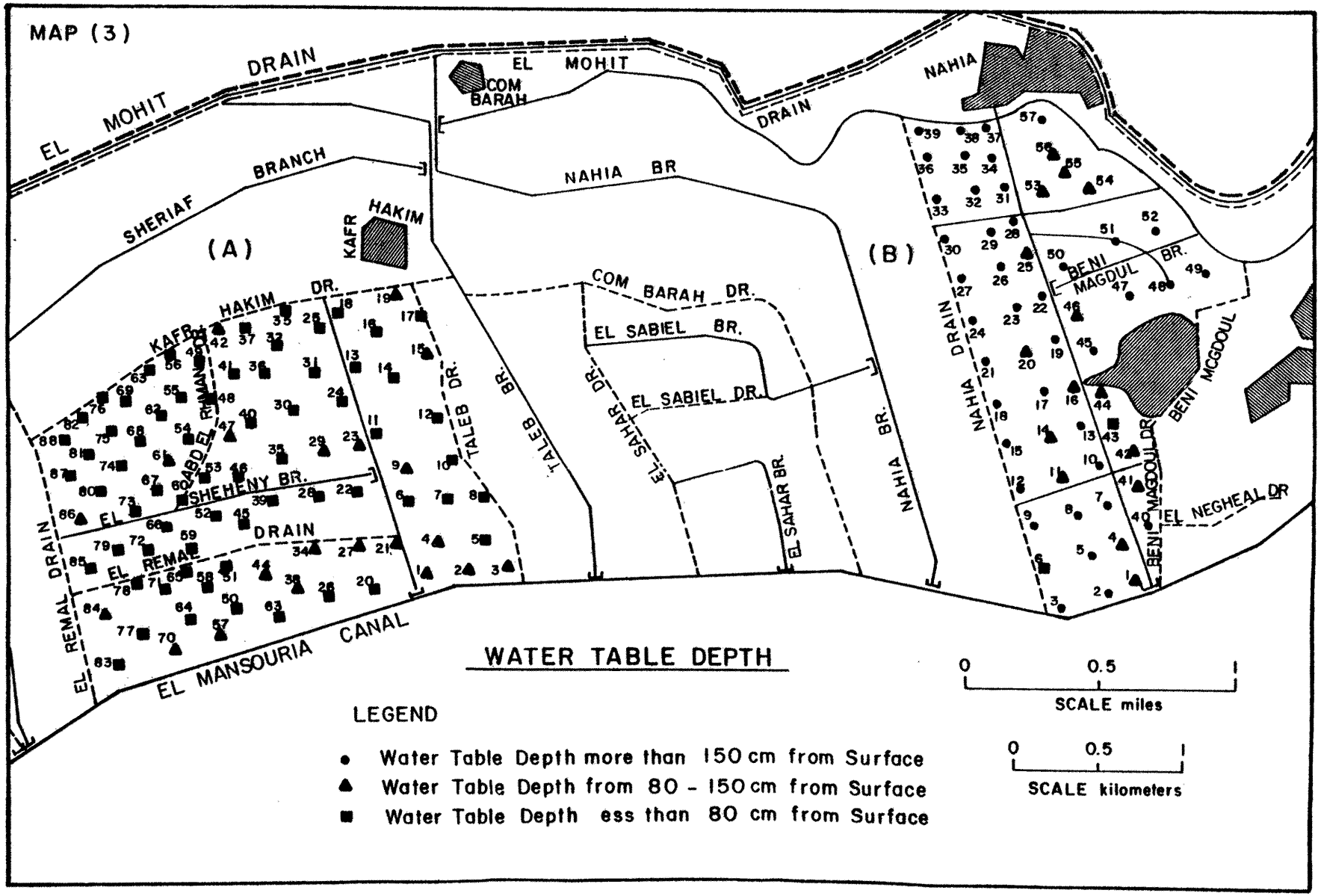
Appendix A


MAP (I)
EL MOHIT DRAIN
EL MOHIT
COM BARAH
NAHIA
DRAIN
NAHIA BR
SHERIAF BRANCH
KAFR HAKIM
(A)
(B)
COM BARAH DR.
EL SABIEL BR.
EL SABIEL DR.
EL SAHAR DR.
EL SAHAR BR.
NAHIA BR.
TALEB BR.
TALEB DR.
KAFR HAKIM DR.
RAMAN
SHEHENY BR.
EL REMAL DRAIN
EL REMAL
DRAIN
EL MANSOURIA CANAL
BENI MAGDOUL BR.
BENI MAGDOUL
NAHIA DRAIN
EL NEGHEAL DR
0 0.5 1 mile
0 0.5 1 kilometer
SCALE
SOIL MAP OF MANSOURIA PROJECT AREA
(A) SOIL LEGEND OF HAMMAMI AREA
Very Deep Coarse Sandy Soil Throughout
Loamy Sand in Topsoil over Very Deep Coarse Sandy Subsoil
(B) SOIL LEGEND OF BENI MAGDOUL AREA
Very Deep Dark and Very Dark Grayish Brown Clayey Soil Thoughout
Very Deep Brown to Dark Yellowish Brown Sandy Loam, Sandy Clay Loam, to Sandy Throughout
Loamy Sand in Topsoil Over Very Deep Coarse Sandy Subsoil


MAP (2)
EL MOHIT DRAIN
EL MOHIT
COM BARAH
NAHIA
DRAIN
SHERIAF BRANCH
NAHIA BR
KAFR HAKIM
(A)
(B)
COM BARAH DR.
EL SABIEL BR.
EL SABIEL DR.
EL SAHAR DR.
EL SAHAR BR.
NAHIA BR.
TALEB BR.
TALEB DR.
KAFR HAKIM DR.
ABD EL RAHMAN
SHEHENY BR.
EL REMAL DRAIN
EL REMAL DRAIN
NAHIA DRAIN
BENI MAGDOUL BR.
BENI MAGDOUL DR.
BENI MCGDOUL
EL NEGHEAL DR
EL MANSOURIA CANAL
SOIL SALINITY
LEGEND
Non Saline < 4 mmohs
Moderate 4 -8mmohs
Saline > 8 mmohs
0 0.5
SCALE miles
0 0.5
SCALE kilometers


MAP (3)
EL MOHIT DRAIN
EL MOHIT
COM BARAH
NAHIA
DRAIN
SHERIAF BRANCH
NAHIA BR
KAFR HAKIM
(A)
(B)
KAFR HAKIM DR.
COM BARAH DR.
EL SABIEL BR.
EL SABIEL DR.
ABD EL RHMAN
TALEB DR.
TALEB BR.
SAHAR DR.
EL SAHAR BR.
NAHIA BR.
NAHIA DRAIN
BENI MAGDOUL BR.
BENI MAGDOUL DR.
SHEHENY BR.
EL REMAL DRAIN
EL REMAL DRAIN
EL NEGHEAL DR
EL MANSOURIA CANAL
WATER TABLE DEPTH
0 0.5
SCALE miles
LEGEND
Water Table Depth more than 150 cm from Surface
Water Table Depth from 80 - 150 cm from Surface
Water Table Depth ess than 80 cm from Surface
0 0.5
SCALE kilometers

Appendix B

Table A-1. Particle Size Distribution Calcium Carbonate Content and Total Soluble Solids of Selected Soil Profiles (Beni Magdoul Location)

		Particle size distribution [1]				Percentage of Total Soil		
Profile No.	Depth cm.	Clay %	Silt %	Fine Sand %	Coarse Sand %	$CaCO_3$	T.D.S.[2]	Texture
1	0-17	35.0	7.2	27.9	28.0	8.1	0.7	Sandy clay
	17-60	44.8	9.2	26.1	20.0	8.0	0.4	Clay
	60-150	54.6	10.7	23.1	11.6	6.2	0.4	Clay
3	0-25	6.9	5.8	17.8	69.5	5.0	0.2	Loamy sand
	25-135	4.8	7.0	15.3	72.8	6.1	0.1	Sand
5	0-15	43.0	15.5	11.1	30.3	6.4	0.3	Clay
	15-50	63.6	12.3	10.8	13.6	6.0	0.4	Clay
	50-90	59.4	7.9	20.1	12.6	4.0	0.9	Clay
	90-150	50.3	19.3	20.3	10.2	3.1	0.8	Clay
6	0-15	30.0	14.4	12.0	43.6	8.0	0.3	Sandy clay
	15-50	22.4	10.9	19.3	47.4	3.6	0.3	Sandy clay
	50-130	4.6	5.5	21.1	68.8	2.8	0.2	Sand
12	0-15	49.8	8.4	22.9	18.9	4.8	0.9	Clay
	15-50	55.7	15.8	12.8	15.8	4.2	0.6	Clay
	50-150	51.3	7.4	28.2	13.1	2.7	0.9	Clay
16	0-25	53.5	10.5	32.8	3.1	4.2	0.5	Clay
	25-75	44.1	10.3	43.5	2.2	2.0	0.5	Clay
	75-130	56.0	22.4	16.0	5.6	1.2	0.6	Clay
18	0-15	44.2	9.8	45.7	0.3	3.7	0.2	Clay
	15-150	61.8	14.5	18.0	5.7	3.4	0.3	Clay
23	0-25	66.0	15.6	13.9	4.5	3.4	0.4	Clay
	25-50	58.5	23.1	15.2	3.2	2.2	0.4	Clay
30	0-30	49.0	12.4	37.3	1.2	4.4	0.6	Clay
	30-150	44.9	19.0	34.0	2.1	1.2	0.8	Clay
37	0-25	39.8	24.1	33.3	2.8	4.2	0.2	Clay
	25-80	57.5	23.9	17.9	0.6	1.6	0.2	Clay
	80-150	50.7	30.4	18.2	0.7	1.2	0.2	Clay
40	0-30	16.5	12.7	13.4	57.3	3.2	0.1	Sandy loam
	30-100	18.5	9.7	12.6	59.2	2.4	0.1	Sandy loam
	100-150	2.1	1.0	18.1	78.8	2.8	0.1	Sand
41	0-60	18.2	7.8	10.9	63.1	3.6	0.1	Sandy loam
	60-70	1.0	0.5	2.7	95.7	3.5	0.1	Sand
	70-100	15.8	8.2	16.8	59.2	2.0	0.1	Sandy loam
	100-150	3.1	2.6	0.9	93.4	3.0	0.1	Sand

Table A-1. Particle Size Distribution Calcium Carbonate Content and Total Soluble Solids of Selected Soil Profiles (Beni Magdoul Location)

		Particle size distribution 1/				Percentage of Total Soil		
Profile No.	Depth cm.	Clay %	Silt %	Fine Sand %	Coarse Sand %	$CaCO_3$	T.D.S.2/	Texture
42	0-30	26.3	13.8	4.1	55.7	3.0	0.1	Sandy clay
	30-60	10.6	5.0	9.1	75.3	1.6	0.1	Loamy sand
	60-110	5.6	5.6	7.1	81.7	1.7	0.1	Sand
43	0-25	23.9	14.3	8.4	53.4	5.5	0.2	Sandy clay loam
	25-75	12.0	18.2	12.5	57.4	3.7	0.1	Sandy loam
44	0-20	32.5	9.8	15.7	42.0	3.0	0.2	Sandy clay
	20-80	50.1	8.7	17.4	23.8	2.0	0.2	Clay
	80-110	8.7	5.4	16.3	69.7	1.7	0.1	Loamy sand
48	0-20	47.0	18.2	21.5	13.3	3.4	0.4	Clay
	20-75	45.7	21.4	21.3	11.5	1.0	0.5	Clay
	75-150	52.0	23.8	19.7	4.4	0.9	0.2	Clay
50	0-20	40.0	20.3	18.1	21.6	3.6	0.2	Clay
	20-75	44.7	25.6	23.1	6.6	1.6	0.3	Clay
	75-130	43.7	17.8	32.9	5.6	1.3	0.3	Clay
54	0-15	43.7	29.1	14.4	12.8	3.8	0.1	Clay
	15-100	40.5	28.1	20.5	10.9	2.4	0.1	Clay
	100-150	42.3	27.8	26.0	3.9	0.8	0.1	Clay
57	0-30	42.7	21.9	29.1	6.3	3.8	0.1	Clay
	30-85	47.6	25.3	21.3	5.9	1.1	0.1	Clay

1/Based on lime-free soil.
2/Total dissolved solids determined gravimetrically.

Table A-2. Chemical characteristics of soil profiles sampled - Beni Magdoul Area.

Profile No.	Depth cm	pH[1/]	SP[2/]	E.C. mmhos cm^{-1} 25° C	Composition of the saturation extract, meq/l							SAR[3/]	CEC[4/]	ESP[5/]
					Ca	Mg	Na	K	CO_3	HCO_3	Cl			
1	0-17	7.8	59	7.5	23.1	13.3	56.5	0.95	0.0	2.0	52	13.2	--	--
	17-60	7.8	67	5.4	15.5	11.7	42.5	0.8	0.0	2.5	32	11.5	--	--
	60-150	7.8	75	4.5	10.7	11.8	34.3	0.4	0.0	2.0	26	10.2	--	--
2	0-15	7.5	51	20.3	48.6	62.7	171.2	1.4	0.0	2.5	202	23.0	--	--
	15-65	7.6	55	15.7	41.4	51.7	171.2	1.4	0.0	2.0	142	25.1	--	--
	65-150	7.5	61	13.5	43.0	42.6	103.7	1.1	0.0	1.5	124	15.9	--	--
3	0-25	7.8	30	3.5	16.2	12.7	18.0	1.1	0.0	4.0	12	4.7	--	--
	25-130	7.9	26	2.9	12.3	6.5	14.1	0.55	0.0	4.0	13	4.6	--	--
4	0-15	7.7	62	6.7	20.2	18.8	50	0.8	0.0	3.5	46	11.3	--	--
	15-90	7.7	80	6.5	15.7	11.0	53	0.55	0.0	3.0	34	14.5	--	--
	90-150	7.7	95	7.5	19.0	16.8	55	0.55	0.0	2.0	34	13.0	--	--
5	0-15	7.6	62	3.8	13.4	9.1	26.5	0.4	0.0	3.0	20	7.9	--	--
	15-50	7.7	70	4.8	16.4	10.3	35.2	0.4	0.0	3.0	22	9.6	--	--
	50-90	7.4	76	6.8	26.3	23.9	47.0	0.55	0.0	2.5	24	9.4	--	--
	90-150	7.5	75	8.0	30.2	29.9	51.5	0.45	0.0	2.5	38	9.4	--	--
6	0-15	7.8	46	3.8	9.2	10.1	25.0	0.65	0.0	3.0	16	8.0	18.0	14.0
	15-50	7.9	47	4.5	8.5	9.8	36.2	0.3	0.0	3.5	22	12.0	18.0	14.0
	50-130	8.0	25	5.1	12.3	11.4	37.2	0.45	0.0	3.0	26	10.8	10.0	10.0
7	0-17	7.8	62	3.4	10.1	9.6	19.2	0.20	0.0	3.0	14	6.1	--	--
	17-150	7.8	75	3.5	5.6	6.9	25.0	0.20	0.0	3.0	18	9.1	--	--
8	0-17	7.7	63	1.5	5.6	3.0	7.8	0.40	0.0	3.0	7	3.8	--	--
	17-150	7.7	79	3.2	5.6	6.8	24.2	0.15	0.0	3.0	18	9.7	--	--

Table A-2. Chemical characteristics of soil profiles sampled - Beni Magdoul Area (continued).

Profile No.	Depth cm	pH[1/]	SP[2/]	E.C. mmhos cm^{-1} 25°C	Composition of the saturation extract, meq/l							SAR[3/]	CEC[4/]	ESP[5/]
					Ca	Mg	Na	K	CO_3	HCO_3	Cl			
9	0-17	7.7	65	3.3	8.4	7.6	20.0	0.20	0.0	3.0	17	3.8	--	--
	17-50	7.7	61	3.1	5.6	6.1	23.0	0.20	0.0	2.5	14	9.5	--	--
	50-120	7.5	69	4.6	12.6	10.7	32.2	0.20	0.0	2.0	30	9.4	--	--
10	0-20	7.6	68	2.2	6.7	6.2	10.6	0.10	0.0	3.5	10	4.2	--	--
	20-150	7.5	85	4.4	12.9	9.4	35.2	0.10	0.0	2.0	11	10.5	--	--
11	0-30	7.6	73	3.9	10.6	9.7	28.2	0.20	0.0	4.5	19	8.9	--	--
	30-120	7.4	83	5.0	15.1	12.3	37.2	0.25	0.0	2.0	34	10.1	--	--
12	0-15	7.5	69	10.5	36.9	21.9	80.5	0.25	0.0	3.0	78	14.8	32.0	18.0
	15-50	7.4	79	5.9	16.8	13.8	47.7	0.20	0.0	2.0	45	12.2	35.0	15.0
	50-150	7.4	86	7.5	24.6	22.8	45.5	0.25	0.0	2.0	42	9.4	36.0	15.0
13	0-15	7.6	64	5.9	17.9	15.3	40.0	0.80	0.0	3.5	41	9.8	--	--
	15-130	7.5	69	6.8	17.4	21.1	45.5	0.55	0.0	2.0	37	10.4	--	--
14	0-30	7.5	60	6.0	19.6	17.2	40.0	0.80	0.0	3.0	43	9.3	--	--
	30-150	7.6	85	4.8	14.0	13.4	36.2	0.45	0.0	2.0	31	9.8	--	--
15	0-10	7.7	65	2.0	5.0	4.1	12.0	0.25	0.0	4.0	9	5.6	--	--
	10-150	7.5	75	5.8	15.7	15.5	43.3	0.20	0.0	2.0	27	11.6	--	--
16	0-25	7.6	69	4.1	11.7	9.7	23.0	0.45	0.0	2.5	18	7.0	--	--
	25-75	7.5	72	4.9	12.9	13.8	36.2	0.10	0.0	2.5	19	9.9	--	--
	75-130	7.4	79	5.8	16.8	15.3	41.5	0.55	0.0	3.0	32	10.4	--	--
17	0-20	7.5	68	2.2	5.6	5.6	14.6	0.20	0.0	3.5	8	6.2	--	--
	20-90	7.4	81	5.8	16.8	15.3	45.0	0.55	0.0	2.2	24	11.2	--	--
	90-150	7.4	73	5.8	14.6	13.2	42.5	0.40	0.0	2.2	28	11.4	--	--

Table A-2. Chemical characteristics of soil profiles sampled - Beni Magdoul Area (continued).

Profile No.	Depth cm	pH[1/]	SP[2/]	E.C. mmhos cm^{-1} 25°C	Composition of the saturation extract, meq/l							SAR[3/]	CEC[4/]	ESP[5/]
					Ca	Mg	Na	K	CO_3	HCO_3	Cl			
18	0-15	7.6	68	1.9	7.8	4.5	10.6	0.28	0.0	3.0	7	4.3	--	--
	15-150	7.6	84	2.3	5.5	3.1	17.6	0.20	0.0	2.5	10	8.5	--	--
19	0-30	7.6	67	2.2	7.8	5.6	12.1	0.30	0.0	3.5	8	4.7	--	--
	30-150	7.6	87	4.1	8.3	8.1	32.0	0.30	0.0	3.0	16	11.2	--	--
20	0-25	7.6	69	2.2	6.7	5.1	14.0	0.2	0.0	3.0	10	5.8	--	--
	25-80	7.6	79	3.3	7.3	8.2	24.2	0.4	0.0	3.0	11	8.7	--	--
	80-150	7.5	83	4.7	12.9	13.8	31.2	0.4	0.0	3.0	21	8.5	--	--
21	0-20	7.6	62	2.0	7.3	5.0	11.2	0.4	0.0	3.5	10	4.5	--	--
	20-75	7.6	79	2.6	5.6	4.0	21.2	0.4	0.0	3.0	8	9.5	--	--
	75-150	7.6	79	2.6	3.9	4.1	20.7	0.4	0.0	3.0	10	10.4	--	--
22	0-30	7.6	63	1.7	5.0	3.0	11.7	0.4	0.0	3.5	5.0	5.9	--	--
	30-150	7.6	78	2.7	4.5	4.1	20.7	0.4	0.0	3.5	12	10.0	--	--
23	0-25	7.6	74	3.8	12.3	9.1	23.7	0.45	0.0	3.5	22	7.2	--	--
	25-150	7.4	80	5.5	16.8	13.2	37.2	0.4	0.0	3.0	36	9.6	--	--
24	0-15	7.6	70	2.2	7.8	6.6	10.9	0.4	0.0	3.0	10	4.1	--	--
	15-150	7.6	79	2.7	10.1	9.2	11.4	0.4	0.0	3.0	14	3.7	--	--
25	0-25	7.6	69	3.7	15.6	7.4	22.2	0.45	0.0	3.5	26	6.5	--	--
	25-130	7.5	78	3.7	10.1	6.5	26.5	0.45	0.0	3.0	18	8.9	--	--
26	0-30	7.7	72	4.3	15.6	11.7	28.2	0.45	0.0	3.5	28	7.6	--	--
	30-150	7.6	84	4.7	18.4	10.5	40.2	0.4	0.0	2.5	28	10.6	--	--

Table A-2. Chemical characteristics of soil profiles sampled - Beni Magdoul Area (continued).

Profile No.	Depth cm	pH[1/]	SP[2/]	E.C. mmhos cm^{-1} 25°C	Composition of the saturation extract, meq/l							SAR[3/]	CEC[4/]	ESP[5/]
					Ca	Mg	Na	K	CO_3	HCO_3	Cl			
27	0-30	7.8	104	1.3	6.1	2.5	7.05	0.30	0.0	3.5	4	3.4	--	--
	30-90	7.7	80	1.3	2.8	2.5	10.0	0.15	0.0	3.0	3	6.1	--	--
	90-150	7.8	72	3.1	7.3	6.1	25.0	0.40	0.0	3.0	14	9.7	--	--
28	0-25	7.5	64	2.6	14.0	5.8	11.7	0.45	0.0	4.0	11	3.7	--	--
	25-80	7.8	74	1.9	6.1	2.5	13.2	0.25	0.0	3.5	6	6.4	--	--
	80-150	7.7	75	2.2	3.9	3.6	18.5	0.25	0.0	3.0	7	9.6	--	--
29	0-30	7.8	74	4.8	15.6	13.3	31.2	0.45	0.0	3.5	27	8.2	--	--
	30-75	7.6	75	5.9	15.1	11.1	39.2	0.40	0.0	3.0	31	10.8	--	--
	75-150	7.6	78	6.9	20.1	18.9	42.5	0.95	0.0	2.5	41	9.5	--	--
30	0-30	7.6	75	7.4	26.3	18.1	41.5	0.95	0.0	3.5	51	8.8	--	--
	30-150	7.7	70	8.0	30.7	21.2	48.5	0.80	0.0	2.5	45	9.5	--	--
31	0-30	7.8	72	1.5	6.1	3.5	9.2	0.40	0.0	3.5	5	4.2	--	--
	30-85	7.9	73	1.3	4.5	3.5	8.5	0.25	0.0	3.0	6	4.3	--	--
	85-150	7.9	75	1.3	2.8	2.0	10.0	0.45	0.0	3.0	7	6.5	--	--
32	0-35	7.8	80	3.8	9.5	8.7	28.2	0.55	0.0	4.0	14	9.3	--	--
	35-80	7.9	78	3.5	9.0	8.6	22.0	0.40	0.0	3.5	15	7.4	--	--
	80-150	7.7	78	3.2	8.4	7.6	22.7	0.40	0.0	2.0	14	8.0	--	--
33	0-25	7.6	64	3.0	14.0	6.3	11.7	0.45	0.0	4.0	8	3.7	--	--
	25-80	7.7	70	1.5	3.9	5.1	7.9	0.15	0.0	2.5	3	3.7	--	--
	80-190	7.9	78	2.3	3.7	3.8	18.5	0.40	0.0	3.0	4	9.6	--	--
34	0-25	7.6	70	2.3	7.8	5.6	13.7	0.75	0.0	3.0	8	5.3	--	--
	25-85	7.8	73	3.8	9.0	8.1	25.0	0.40	0.0	2.0	9	8.6	--	--
	85-150	7.8	68	2.9	6.7	4.0	23.0	0.65	0.0	2.0	10	9.9	--	--

Table A-2. Chemical characteristics of soil profiles sampled - Beni Magdoul Area (continued).

Profile No.	Depth cm	pH[1/]	SP[2/]	E.C. mmhos cm^{-1} 25°C	Composition of the saturation extract, meq/l							SAR[3/]	CEC[4/]	ESP[5/]
					Ca	Mg	Na	K	CO_3	HCO_3	Cl			
35	0-20	7.9	64	1.0	3.4	3.6	5.2	0.15	0.0	4.0	2	2.8	--	--
	20-80	8.1	70	2.2	5.0	4.6	15.0	0.40	0.0	3.5	4	6.8	--	--
	80-150	7.7	73	2.6	3.9	5.7	19.2	0.55	0.0	2.0	8	8.8	--	--
36	0-17	8.0	67	1.1	3.9	2.5	6.3	0.20	0.0	4.0	3	3.5	--	--
	17-150	7.8	77	1.6	3.4	3.0	12.5	0.25	0.0	3.0	5	7.0	--	--
37	0-25	7.9	74	1.2	5.0	2.5	6.7	0.30	0.0	3.5	4	3.4	--	--
	25-80	7.9	77	1.2	2.2	1.5	10.5	0.40	0.0	3.0	3	7.7	--	--
	80-150	7.8	74	1.4	2.8	3.6	10.0	0.45	0.0	3.0	3	5.6	--	--
38	0-17	7.9	69	0.9	3.9	2.5	5.0	0.20	0.0	4.5	2	2.8	--	--
	17-150	8.0	75	1.6	3.4	4.6	10.5	0.40	0.0	3.0	3	5.3	--	--
39	0-30	7.8	75	1.9	9.5	3.9	7.2	0.45	0.0	3.5	7	2.8	--	--
	30-75	7.9	78	1.3	2.8	5.8	7.5	0.15	0.0	3.5	3	3.9	--	--
	75-150	7.6	77	1.1	1.7	2.6	8.3	0.10	0.0	3.0	3	5.7	--	--
40	0-30	7.8	27	1.2	5.6	3.4	5.2	0.65	0.0	3.5	3	2.4	--	--
	30-100	7.7	27	1.3	6.7	1.8	7.7	0.65	0.0	3.5	4	4.0	--	--
	100-150	8.3	27	1.1	5.6	1.4	6.5	0.45	0.0	2.0	4	3.4	--	--
41	0-60	8.4	34	0.8	3.9	0.9	4.3	0.65	0.0	3.5	2	2.7	--	--
	60-70	8.3	27	0.9	3.2	2.2	4.9	0.25	0.0	2.5	4	2.9	--	--
	70-100	8.1	42	1.2	3.4	1.9	8.5	0.20	0.0	3.0	6	5.2	--	--
	100-150	8.1	24	2.1	6.7	7.2	10.0	1.00	0.0	3.0	6	3.8	--	--
42	0-30	8.0	42	0.7	4.5	0.8	2.7	0.35	0.0	3.5	2	1.7	--	--
	30-60	8.0	27	0.8	2.8	2.1	4.6	0.35	0.0	3.0	2	2.9	--	--
	60-110	7.9	20	0.9	5.0	0.9	5.3	0.25	0.0	2.5	2	3.1	--	--

Table A-2. Chemical characteristics of soil profiles sampled - Beni Magdoul Area (continued).

Profile No.	Depth cm	pH[1/]	SP[2/]	E.C. mmhos cm^{-1} 25°C	Composition of the saturation extract, meq/l							SAR[3/]	CEC[4/]	ESP[5/]
					Ca	Mg	Na	K	CO_3	HCO_3	Cl			
43	0-25	8.3	41	1.4	5.6	1.9	9.2	0.45	0.0	3.5	2	4.8	--	--
	25-75	8.3	32	1.5	2.2	2.1	13.1	0.15	0.0	3.5	5	8.9	--	--
44	0-20	8.2	53	1.2	3.9	1.4	9.2	0.35	0.0	3.5	3	5.7	28.0	16.0
	20-80	8.3	80	2.2	2.2	2.1	20.0	0.15	0.0	3.5	6	13.6	35.0	17.0
	80-110	7.8	30	3.0	5.0	2.0	25.5	0.40	0.0	3.0	10	13.6	16.0	13.0
45	0-15	7.7	65	5.5	17.9	11.0	36.7	0.55	0.0	3.5	28	9.7	--	--
	15-150	7.4	80	6.0	17.3	13.2	42.0	0.25	0.0	2.0	40	10.8	--	--
46	0-25	8.0	75	2.4	6.1	4.1	18.5	0.25	0.0	4.0	11	8.2	--	--
	25-150	7.9	87	2.0	5.6	0.8	17.0	0.25	0.0	2.5	10	9.5	--	--
47	0-20	8.1	69	1.0	3.9	1.4	5.5	0.15	0.0	3.0	4	3.4	--	--
	20-80	8.0	81	3.1	8.4	6.0	22.2	0.45	0.0	2.0	14	8.2	--	--
	80-150	7.8	88	3.7	13.4	10.7	24.2	0.45	0.0	1.5	15	7.0	--	--
48	0-20	8.0	65	5.5	16.8	15.6	32.5	0.95	0.0	3.0	27	8.1	--	--
	20-75	7.7	65	5.8	17.3	18.5	35.5	0.55	0.0	2.0	42	8.4	--	--
	75-150	7.9	64	2.8	9.5	6.0	15.7	0.40	0.0	1.5	19	5.6	--	--
49	0-15	7.9	58	1.3	4.5	3.0	7.7	0.25	0.0	2.5	4	4.0	--	--
	15-80	7.9	61	1.3	2.8	2.5	11.2	0.25	0.0	2.0	2	6.9	--	--
	80-150	7.8	67	2.7	6.7	3.5	20.7	0.25	0.0	1.5	12	9.2	--	--
50	0-20	7.9	61	2.2	7.3	4.5	13.2	0.55	0.0	2.5	9	5.4	--	--
	20-75	7.8	70	4.5	10.1	8.6	35.2	0.45	0.0	3.0	18	11.5	--	--
	75-130	7.7	78	3.3	6.7	6.7	25.7	0.25	0.0	2.5	12	9.9	--	--

Table A-2. Chemical characteristics of soil profiles sampled - Beni Magdoul Area (continued).

Profile No.	Depth cm	pH[1]	SP[2]	E.C. mmhos cm^{-1} 25°C	Composition of the saturation extract, meq/l							SAR[3]	CEC[4]	ESP[5]
					Ca	Mg	Na	K	CO_3	HCO_3	Cl			
51	0-25	8.0	62	1.1	2.8	2.5	7.3	0.15	0.0	3.5	4	4.5	--	--
	25-75	7.8	68	2.0	3.9	2.5	15.7	0.25	0.0	3.5	8	8.8	--	--
	75-150	7.5	75	5.4	22.3	15.1	32.5	0.40	0.0	2.5	15	7.5	--	--
52	0-25	7.8	70	3.2	7.8	7.2	21.2	0.45	0.0	3.5	15	7.7	--	--
	25-80	7.8	71	3.3	6.1	5.5	24.2	0.45	0.0	3.0	14	10.0	--	--
	80-150	7.6	70	5.7	17.3	13.2	38.2	0.40	0.0	2.0	31	9.9	--	--
53	0-25	7.8	72	5.1	21.2	12.5	31.2	0.40	0.0	3.8	17	7.6	--	--
	25-75	7.8	73	3.9	10.6	10.8	28.2	0.40	0.0	3.0	14	8.6	--	--
	75-140	7.8	84	2.3	4.5	4.1	17.7	0.25	0.0	3.0	5	8.5	--	--
54	0-15	8.5	61	1.1	3.4	0.3	9.2	0.20	0.0	3.5	4	6.8	--	--
	15-100	8.2	68	1.5	3.4	6.2	8.7	0.15	0.0	3.5	5	4.0	--	--
	100-150	7.9	64	1.3	2.2	2.6	9.8	0.10	0.0	3.5	4	6.3	--	--
55	0-25	7.7	79	10.9	44.8	33.3	71.0	0.80	0.0	3.0	57	11.4	--	--
	25-150	7.8	81	4.9	16.8	13.1	34.2	0.40	0.0	3.0	23	8.8	--	--
56	0-25	8.0	67	1.1	4.5	0.8	7.2	0.25	0.0	3.5	3	4.4	--	--
	25-60	7.9	75	3.9	9.0	10.0	30.2	0.25	0.0	3.0	8	9.8	--	--
	60-150	8.0	67	2.0	3.9	4.1	13.5	0.40	0.0	3.5	5	6.8	--	--
57	0-30	8.0	63	1.5	7.8	2.9	7.2	0.25	0.0	3.5	7	3.1	--	--
	30-150	7.8	70	1.4	4.5	3.0	8.5	0.15	0.0	3.0	3	4.4	--	--

[1] pH of the saturation paste

[2] SP - Saturation percentage

[3] SAR - Sodium adsorption ratio

[4] CEC - Cation exchange capacity

[5] ESP - Exchangeable sodium percentage

Table A-3. Analysis of Ground Water in Beni Magdoul Area.

Profile Sample Number	pH	E.C. mmhos/cm at 25 c	Total Soluble Salts ppm*	meq per liter							SAR
				HCO_3	Cl	SO_4	Ca	Mg	Na	K	
1	7.8	4.0	3100	4.5	28.0	17.4	8.5	11.3	30.1	0.02	9.6
6	7.6	2.7	2170	6.3	10.0	16.1	4.0	6.4	21.9	0.02	9.6
13	7.8	13.7	1108	5.2	119.2	59.8	43.3	42.7	97.5	1.00	14.9
20	7.6	9.2	7400	5.0	63.2	52.4	26.9	34.2	58.5	1.00	10.6
25	8.0	5.2	4370	7.9	27.2	32.4	9.4	15.1	42.5	0.5	12.1
43	7.8	1.4	1060	5.1	2.0	7.9	2.8	2.7	9.4	0.02	5.7
46	7.6	4.7	3540	6.6	32.0	17.4	11.4	10.3	34.2	0.02	10.3
50	7.6	6.5	5300	6.8	33.2	44.2	14.4	30.3	38.5	1.00	8.1

*Calculated by using molecular weight
**Calculated by difference

Table A-4. Particle Size Distribution Calcium Carbonate Content and Total Soluble Salts of Selected Soil Profiles (El Hammami location)

		Particle size distribution 1/				Percentage of total soil	
Profile No.	Depth cm.	Clay %	Silt %	Fine Sand %	Coarse Sand %	$CaCO_3$	Texture
1	0-30	19.4	1.0	24.7	54.9	1.9	Sandy loam
	30-170	4.6	5.6	4.7	85.2	1.1	Sand
12	0-35	13.1	6.1	12.8	68.0	0.2	Loamy sand
	35-100	5.1	4.1	13.2	77.6	1.7	Sand
18	0-20	9.7	11.7	2.0	76.6	1.6	Loamy sand
	20-55	4.1	6.1	21.3	68.5	1.9	Sand
	55-150	6.0	8.6	4.6	80.8	0.6	Sand
26	0-30	4.6	0.7	11.1	83.6	1.2	Sand
	30-150	4.0	0.5	18.3	77.1	0.6	Sand
28	0-40	7.1	3.0	9.0	80.9	0.9	Loamy sand
	40-150	6.0	3.5	4.7	85.7	0.4	Sand
33	0-15	14.4	9.8	7.4	68.5	2.5	Loamy sand
	15-150	11.2	5.6	12.0	71.3	1.3	Loamy sand
35	0-20	7.1	1.0	6.4	85.5	1.0	Sand
	20-150	2.0	6.1	6.6	85.3	1.1	Sand
41	0-20	9.8	14.4	8.7	67.1	2.8	Loamy sand
	20-150	5.6	6.6	9.2	78.6	1.2	Sand
44	0-30	14.7	12.7	4.1	68.6	1.3	Loamy sand
	30-150	5.0	4.5	15.7	74.7	0.6	Sand
56	0-15	7.6	10.6	0.7	81.1	0.8	Loamy sand
	15-45	6.1	4.1	1.4	88.4	1.5	Sand
	45-150	4.1	6.6	5.2	84.2	1.3	Sand
61	0-20	11.2	6.6	0.3	81.9	1.5	Loamy sand
	20-60	7.6	3.6	6.5	82.3	2.3	Sand
	60-150	3.6	4.6	2.2	89.6	2.3	Sand
62	0-20	7.7	11.3	0.6	80.4	2.2	Loamy sand
	20-150	6.1	1.0	7.2	85.6	1.9	Sand
69	0-25	11.3	5.1	1.1	82.5	2.2	Loamy sand
	25-150	5.0	1.5	7.7	85.8	0.6	Sand
70	0-25	27.9	12.2	20.3	39.7	1.3	Sandy clay loam
	25-150	3.0	1.5	12.7	82.7	1.6	Sand

Table A-4. Particle Size Distribution Calcium Carbonate Content and Total Soluble Salts of Selected Soil Profiles (El Hammami location)

		Particle size distribution 1/				Percentage of total soil	
Profile No.	Depth cm.	Clay %	Silt %	Fine Sand %	Coarse Sand %	$CaCO_3$	Texture
72	0-20	7.1	2.5	11.0	79.4	0.7	Sand
	20-150	6.1	1.5	6.6	85.8	1.1	Sand
73	0-30	7.4	6.0	12.3	74.3	0.2	Sand
	30-150	6.1	1.0	15.5	77.3	1.9	Sand
81	0-20	6.1	4.1	8.5	81.3	2.1	Sand
	20-150	4.5	1.5	16.3	77.7	1.0	Sand
83	0-25	19.5	6.2	14.7	59.7	2.4	Sandy loam
	25-150	1.5	4.5	7.9	86.1	0.6	Sand
87	0-30	3.6	2.5	5.0	88.9	1.4	Sand
	30-150	2.0	4.1	7.0	86.9	1.5	Sand

1/Based on lime free soil.

Table A-5. Chemical characteristics of soil profiles sampled in the El Hammami Area.

Profile No.	Depth cm	pH[1]	SP[2]	E.C. mmhos cm^{-1} 25°C	Composition of the saturation extract, meq/l							SAR[3]	CEC[4]	ESP[5]
					Ca	Mg	Na	K	CO_3	HCO_3	Cl			
1	0-30	7.9	25	0.7	4.6	3.0	2.0	0.10	0.0	2.5	2	1.0	--	--
	30-170	8.3	21	0.8	5.0	0.3	4.2	0.40	0.0	2.5	4	2.6	--	--
2	0-40	7.9	27	2.0	8.5	4.4	8.5	0.80	0.0	4.0	12	3.3	--	--
	40-150	8.4	23	1.0	4.5	0.3	6.9	0.20	0.0	3.0	6	4.4	--	--
3	0-35	8.1	27	0.9	5.0	2.5	3.2	0.55	0.0	3.0	2	1.6	--	--
	35-150	8.1	23	1.9	7.3	1.7	5.0	0.20	0.0	3.5	8	2.4	--	--
4	0-30	8.1	28	0.8	5.6	2.4	3.4	0.40	0.0	3.0	2	1.7	--	--
	30-150	8.25	21	1.3	5.6	2.4	6.7	0.55	0.0	3.0	8	3.4	--	--
5	0-30	8.1	21	0.9	5.6	2.4	2.9	0.25	0.0	3.5	2	1.4	--	--
	30-150	8.2	22	1.4	6.1	2.5	6.2	0.40	0.0	3.5	8	3.0	--	--
6	0-35	7.8	22	6.1	24.6	21.4	27.5	0.35	0.0	3.0	24	5.7	--	--
	35-150	7.8	24	5.0	20.1	17.3	23.5	0.20	0.0	3.0	34	5.4	--	--
7	0-30	8.0	23	1.8	8.1	3.8	7.7	0.55	0.0	3.0	12	3.1	--	--
	30-150	8.2	22	1.3	6.7	3.5	5.5	0.75	0.0	3.5	6	2.4	--	--
8	0-40	8.4	23	1.0	5.6	0.8	4.7	0.45	0.0	3.5	5	2.6	--	--
9	0-40	8.3	23	0.9	6.1	0.9	3.7	0.65	0.0	3.5	4	2.0	--	--
	40-150	8.4	23	0.70	3.9	1.4	3.25	0.20	0.0	3.0	3	2.0	--	--
10	0-20	8.2	25	1.5	6.7	4.5	5.5	0.45	0.0	3.5	4	2.3	--	--
	20-150	8.3	23	1.5	6.1	2.5	7.7	0.55	0.0	3.5	7	3.7	--	--

Table A-5. Chemical characteristics of soil profiles sampled in the El Hammami Area.

Profile No.	Depth cm	pH[1/]	SP[2/]	E. C. mmhos cm^{-1} 25° C	Composition of the saturation extract, meq/l							SAR[3/]	CEC[4/]	ESP[5/]
					Ca	Mg	Na	K	CO_3	HCO_3	Cl			
11	0-30	8.0	26	3.8	16.8	9.4	17.7	1.15	0.0	3.0	13	4.9	--	--
	30-150	8.4	22	0.9	3.4	1.4	5.0	0.40	0.0	2.5	3	3.2	--	--
12	0-35	8.3	30	10.9	14.0	11.1	104.5	2.90	0.0	3.5	58	29.5	10.0	9.0
	35-100	8.3	22	5.7	7.8	24.3	36.2	1.70	0.0	3.5	23	13.2	5.0	12.8
13	0-20	8.2	24	1.6	7.4	3.9	6.7	0.65	0.0	3.0	4	2.8	--	--
	20-150	8.4	23	1.3	4.5	0.8	7.7	0.25	0.0	3.5	6	4.7	--	--
14	0-45	8.6	28	13.2	7.8	9.3	185.0	3.10	0.0	5.0	115	65.2	7.5	13.3
	45-150	8.2	23	3.0	7.3	2.9	23.5	0.35	0.0	3.5	18	10.4	6.0	9.0
15	0-35	7.9	25	3.4	16.2	8.9	11.2	0.80	0.0	3.0	10	3.2	--	--
	35-150	7.9	23	4.2	18.4	12.1	18.5	0.70	0.0	2.5	29	4.7	--	--
16	0-27	8.1	25	2.0	7.6	5.1	10.5	0.45	0.0	3.0	8	4.2	--	--
	27-150	8.4	24	1.5	5.6	3.0	8.5	0.55	0.0	3.5	4.0	4.1	--	--
17	0-30	8.2	27	2.5	7.3	5.0	15.7	0.65	0.0	3.0	10	6.3	--	--
	30-120	8.3	25	1.5	3.9	3.6	9.2	0.55	0.0	4.0	8	4.8	--	--
18	0-20	8.2	29	1.4	5.6	3.4	6.7	0.45	0.0	3.5	4	3.2	--	--
	20-55	8.1	27	1.6	5.6	5.8	6.7	0.45	0.0	2.5	6	2.8	--	--
	55-150	8.3	24	2.6	5.6	15.9	6.7	0.70	0.0	3.0	13	2.3	--	--
19	0-20	7.7	35	1.5	7.4	6.6	3.0	0.70	0.0	3.0	4	1.1	--	--
	20-70	8.1	25	1.0	3.9	4.1	2.8	0.30	0.0	2.5	4	1.4	--	--
	70-83	8.0	47	0.9	2.8	3.1	3.7	0.40	0.0	2.5	2	2.2	--	--
	83-150	8.2	22	1.4	5.6	6.2	4.2	0.55	0.0	2.5	8	1.7	--	--

Table A-5. Chemical characteristics of soil profiles sampled in the El Hammami Area.

Profile No.	Depth cm	pH[1/]	SP[2/]	E.C. mmhos cm^{-1} 25°C	Composition of the saturation extract, meq/l							SAR[3/]	CEC[4/]	ESP[5/]
					Ca	Mg	Na	K	CO_3	HCO_3	Cl			
20	0-30	7.9	24	1.7	8.9	4.4	5.5	0.80	0.0	3.5	5	2.2	--	--
	30-150	8.1	22	1.7	6.7	5.6	8.5	0.65	0.0	3.0	10	3.4	--	--
21	0-35	8.0	25	1.6	8.1	3.8	4.2	0.75	0.0	2.5	4	1.7	--	--
	35-150	8.3	22	0.6	2.8	2.0	2.4	0.20	0.0	3.5	2	1.5	--	--
22	0-35	8.4	23	2.7	3.9	3.1	22.8	1.00	0.0	4.0	10	12.2	6.0	9.3
	35-150	8.6	21	2.8	3.4	1.9	25.0	1.10	0.5	4.5	15	15.4	2.5	5.6
23	0-15	8.1	23	1.0	5.1	3.5	3.4	0.35	0.0	3.5	4	1.6	--	--
	15-150	8.0	22	1.6	7.4	3.9	6.7	0.45	0.0	3.0	11	2.8	--	--
25	0-15	8.7	27	2.4	3.4	0.3	22.7	1.15	3.6	5.5	7	16.7	6.0	8.0
	15-150	8.8	22	5.1	2.8	3.6	53.5	1.70	2.0	5.5	24	29.9	6.0	14.3
26	0-30	8.0	23	1.8	6.7	4.5	8.5	0.45	0.0	3.5	9	3.6	--	--
	30-150	8.3	21	1.1	3.4	4.6	5.5	0.25	0.0	3.0	4	2.8	--	--
27	0-35	8.3	24	1.1	2.8	3.6	7.7	0.55	0.0	3.5	3	4.3	--	--
	35-110	8.4	23	3.3	7.3	6.6	21.2	1.15	0.0	3.0	10	8.0	--	--
	110-150	8.2	23	2.1	7.3	6.6	7.7	1.35	0.0	2.5	10	2.9	--	--
28	0-40	8.2	33	0.7	3.4	1.9	2.4	0.35	0.0	3.5	2	1.4	--	--
	40-150	8.3	23	1.1	5.0	3.6	3.6	0.90	0.0	3.5	4	1.7	--	--
29	0-20	8.2	24	1.7	8.1	5.4	4.2	0.80	0.0	3.5	6	1.6	--	--
	20-150	8.3	24	1.3	5.1	2.9	6.7	0.80	0.0	3.0	10	3.4	--	--

Table A-5. Chemical characteristics of soil profiles sampled in the El Hammami Area.

Profile No.	Depth cm	pH[1/]	SP[2/]	E.C. mmhos cm^{-1} 25°C	Composition of the saturation extract, meq/l							SAR[3/]	CEC[4/]	ESP[5/]
					Ca	Mg	Na	K	CO_3	HCO_3	Cl			
30	0-20	8.5	27	2.3	2.2	2.6	20.0	0.55	0.0	4.5	10	12.0	10.0	5.4
	20-150	7.9	24	3.9	13.1	13.6	19.0	1.10	0.0	3.5	12	5.2	6.0	13.3
31	0-20	7.9	28	4.9	5.6	6.2	5.3	2.55	0.0	4.5	14	21.8	7.5	14.0
	20-150	8.1	24	1.1	3.3	3.1	5.5	1.30	0.0	2.5	4	3.1	6.0	13.3
32	0-20	8.1	30	2.9	6.3	6.7	20.5	0.90	0.0	4.5	4	8.0	--	--
	20-150	8.3	25	3.9	7.8	5.0	31.5	0.90	0.0	3.5	16	12.5	--	--
33	0-15	7.8	37	1.9	5.0	5.2	12.0	0.55	0.0	4.0	2	5.3	--	--
	15-150	8.0	20	1.7	6.1	3.5	10.3	0.30	0.0	2.5	4	4.7	--	--
34	0-35	8.0	23	2.0	8.4	5.5	8.7	0.65	0.0	3.0	6	3.3	--	--
	35-150	8.0	20	1.5	4.2	5.6	5.9	0.65	0.0	2.5	3	2.6	--	--
35	0-20	8.2	25	1.8	5.0	5.2	9.0	0.80	0.0	4.0	8	4.0	--	--
	20-150	8.5	24	1.9	5.8	4.5	10.3	0.80	0.0	4.0	4	4.5	--	--
36	0-20	8.1	23	2.5	3.4	3.6	20.0	0.65	0.0	3.5	15	10.7	6.0	11.5
	20-150	8.4	24	3.8	2.3	3.3	43.5	1.10	0.0	4.5	18	26.0	7.5	13.8
37	20-150	8.2	29	3.9	7.2	7.9	35.2	1.35	0.0	3.5	12	13.1	--	--
38	0-40	8.7	23	0.8	2.8	1.5	3.7	0.35	0.0	4.0	2	2.5	--	--
	40-150	8.2	23	1.4	3.4	3.6	7.7	0.60	0.0	3.5	8	4.1	--	--
39	0-35	8.1	26	0.9	3.9	3.6	3.3	0.60	0.0	3.0	2	1.7	--	--
	35-150	8.4	22	1.0	3.4	3.6	5.5	0.40	0.0	3.5	2	2.9	--	--

Table A-5. Chemical characteristics of soil profiles sampled in the El Hammami Area.

Profile No.	Depth cm	pH[1]	SP[2]	E. C. mmhos cm^{-1} 25°C	Composition of the saturation extract, meq/l							SAR[3]	CEC[4]	ESP[5]
					Ca	Mg	Na	K	CO_3	HCO_3	Cl			
40	0-15	8.2	22	1.2	3.4	3.0	5.5	0.65	0.0	3.0	4	3.1	--	--
	15-150	8.1	21	2.8	6.1	3.5	20.5	1.65	0.0	3.0	16	9.4	--	--
41	0-20	8.1	31	9.0	16.2	18.6	85.5	1.45	0.0	3.5	45	20.5	7.5	14.4
	20-150	8.2	25	3.5	2.8	3.6	32.5	1.15	0.0	3.5	16	18.2	5.0	8.0
42	0-35	8.3	28	2.8	3.9	4.7	20.5	0.80	0.0	4.0	11	9.9	6.0	10.0
	35-150	8.2	25	2.3	4.5	6.2	15.5	0.40	0.0	2.5	9	6.7	4.3	9.0
43	0-30	7.8	23	1.9	3.9	4.7	10.4	0.85	0.0	3.5	13	5.0	--	--
	30-150	8.0	22	1.2	4.5	3.5	4.0	1.35	0.0	3.0	4	2.0	--	--
44	0-30	7.9	24	1.1	3.6	4.2	4.3	0.40	0.0	3.0	5	2.2	--	--
	30-150	8.1	24	1.0	5.0	3.0	4.8	0.90	0.0	3.0	6	2.4	--	--
45	0-20	7.8	23	1.5	3.9	3.6	8.5	1.50	0.0	3.0	6	4.4	--	--
	20-150	8.1	25	1.2	4.5	3.5	5.3	0.40	0.0	3.0	5	2.7	--	--
46	0-25	8.0	24	1.0	3.4	3.0	4.7	0.45	0.0	3.5	6	2.6	--	--
	25-150	8.1	19	2.4	12.3	7.0	6.9	0.20	0.0	3.0	6	2.2	--	--
47	0-40	8.2	28	15.4	3.9	2.5	17.1	3.10	0.0	3.5	69	9.6	6.0	13.3
	40-60	8.5	24	3.2	6.1	6.7	31.2	1.35	0.0	3.5	8	12.3	4.5	8.8
	60-150	8.2	25	3.9	5.0	5.7	43.5	1.25	0.0	2.0	16	18.3	5.0	4.0
48	0-35	8.3	24	2.9	7.3	5.5	20.5	0.75	0.0	4.0	11	8.1	--	--
	35-150	8.6	24	5.5	5.0	2.5	56.5	1.85	0.0	4.0	25	29.2	--	--
49	0-25	8.4	24	1.3	2.2	1.5	10.3	0.25	0.0	3.5	5	7.5	5.0	12.4
	25-150	8.3	24	2.5	6.1	4.6	16.8	0.20	0.0	3.0	8	7.3	5.0	12.4

Table A-5. Chemical characteristics of soil profiles sampled in the El Hammami Area.

Profile No.	Depth cm	pH[1]	SP[2]	E. C. mmhos cm^{-1} 25°C	Composition of the saturation extract, meq/l							SAR[3]	CEC[4]	ESP[5]
					Ca	Mg	Na	K	CO_3	HCO_3	Cl			
50	0-35	8.0	28	1.2	4.1	4.6	5.9	0.30	0.0	3.0	7	2.8	--	--
	35-150	8.0	21	1.2	2.8	5.2	6.3	0.30	0.0	3.5	5	3.1	--	--
51	0-30	8.0	23	3.4	10.1	10.2	20.0	1.15	0.0	3.0	21	6.3	--	--
	30-150	8.1	22	1.3	5.0	2.5	7.7	0.25	0.0	2.5	4	4.0	--	--
52	0-25	8.3	23	1.9	3.4	3.0	15.1	0.30	0.0	4.0	5	8.4	7.5	12.0
	25-150	8.3	22	2.3	3.9	3.1	17.7	0.75	0.0	3.0	8	9.5	4.8	10.4
53	0-20	8.2	23	0.9	3.9	3.1	4.2	0.40	0.0	3.5	6	2.2	--	--
	20-150	8.1	23	1.04	3.9	2.5	5.5	0.35	0.0	4.0	5	3.1	--	--
54	0-20	8.0	24	11.4	30.2	24.9	89.0	4.55	0.0	2.5	42	17.0	--	--
	20-150	8.4	22	1.6	2.8	2.0	13.1	1.65	0.0	4.0	8	8.5	--	--
55	0-25	7.9	22	5.6	28.5	16.4	34.0	1.30	0.0	3.5	13	7.2	--	--
	25-150	7.9	22	2.6	8.4	5.5	15.7	0.55	0.0	3.5	11	6.0	--	--
56	0-15	7.8	31	8.8	26.8	23.5	68.5	1.15	0.0	3.0	62	13.7	--	--
	15-45	8.2	24	3.7	5.6	6.7	30.2	0.45	0.0	2.5	18	12.2	--	--
	45-150	8.2	26	3.9	7.8	6.6	31.2	0.55	0.0	2.5	18	11.5	--	--
57	0-20	8.8	35	2.0	2.2	2.3	28.2	1.15	trace	5.0	13	18.8	6.0	10.0
	20-150	8.0	26	1.2	4.5	3.0	6.3	0.35	0.0	2.5	8	3.2	1.8	8.3
58	0-30	8.1	24	2.4	6.1	6.2	15.1	0.45	0.0	3.0	6	6.1	--	--
	30-150	8.0	21	1.8	5.0	3.6	11.2	0.40	0.0	3.0	7	5.4	--	--
59	0-25	7.8	24	2.8	16.2	9.5	15.0	0.65	0.0	3.0	5	4.6	--	--
	25-150	8.0	21	1.5	5.0	3.6	7.9	0.30	0.0	2.5	6	3.8	--	--

Table A-5. Chemical characteristics of soil profiles sampled in the El Hammami Area.

Profile No.	Depth cm	pH[1]	SP[2]	E. C. mmhos cm^{-1} 25° C	Composition of the saturation extract, meq/l							SAR[3]	CEC[4]	ESP[5]
					Ca	Mg	Na	K	CO_3	HCO_3	Cl			
60	0-20	8.1	27	5.7	14.0	7.4	48.0	0.40	0.0	4.5	13	14.7	10.0	8.0
	20-150	8.5	19	1.4	3.4	2.5	8.3	0.35	0.0	3.5	6	1.5	5.0	7.5
61	0-20	8.4	23	6.6	5.0	4.6	68.5	2.35	0.0	3.5	21	31.3	6.0	8.5
	20-60	8.2	21	4.9	3.3	4.2	47.5	1.70	0.0	3.0	18	24.5	5.0	8.0
	60-150	8.3	21	3.8	5.6	4.0	40.2	1.40	0.0	3.0	15	18.3	3.2	6.5
62	0-20	8.4	23	5.9	7.3	7.1	60.6	1.40	0.0	4.0	18	22.1	5.0	11.0
	20-150	8.4	22	5.8	10.6	10.8	52.2	1.90	0.0	3.5	14	16.0	2.8	10.0
63	0-20	8.5	23	2.8	5.0	1.4	22.8	0.90	0.0	3.5	5	12.7	6.0	12.0
	20-150	8.9	23	4.8	5.0	3.0	54.5	1.00	0.0	5.5	17	27.3	5.0	9.5
64	0-25	7.6	35	2.5	13.4	5.9	8.5	1.30	0.0	3.0	5	2.7	--	--
	25-150	8.1	19	1.4	5.6	3.4	7.0	0.30	0.0	2.0	7	3.3	--	--
65	0-20	7.7	36	1.4	6.1	5.1	4.9	0.50	0.0	3.5	5	2.0	--	--
	20-150	8.3	19	0.9	4.5	3.5	4.2	0.30	0.0	2.5	3	2.1	--	--
66	0-30	8.0	22	1.7	6.7	5.6	6.1	0.45	0.0	4.0	8	2.4	--	--
	30-150	8.4	19	0.8	3.9	3.6	2.9	0.45	0.0	2.5	2	1.5	--	--
67	0-35	8.8	23	4.4	2.8	3.1	43.5	0.45	2.0	6.0	16	25.3	6.0	13.0
	35-150	8.7	19	1.9	5.0	3.6	13.7	0.30	1.5	5.5	4	6.6	2.0	18.0
68	0-20	8.6	26	3.9	3.9	4.7	39.2	0.75	0.0	3.5	11	18.9	6.0	11.0
	20-150	8.6	20	2.2	3.9	3.1	15.7	0.45	0.0	3.0	7	8.4	5.0	9.0
69	0-25	8.1	24	2.3	7.8	6.1	11.7	0.86	0.0	3.5	5	4.4	--	--
	25-150	8.2	23	1.6	6.1	3.5	7.5	0.70	0.0	3.0	6	3.4	--	--

Table A-5. Chemical characteristics of soil profiles sampled in the El Hammami Area.

Profile No.	Depth cm	pH[1]	SP[2]	E. C. mmhos cm^{-1} 25°C	Composition of the saturation extract, meq/l							SAR[3]	CEC[4]	ESP[5]
					Ca	Mg	Na	K	CO_3	HCO_3	Cl			
70	0-25	7.9	23	1.1	5.0	3.6	3.0	0.40	0.0	3.0	3	1.40	--	--
	25-150	8.4	23	0.8	3.4	3.0	2.9	0.30	0.0	3.0	4	1.60	--	--
71	0-20	8.0	27	1.2	6.7	3.5	3.4	0.40	0.0	4.0	4	1.5	--	--
	20-150	8.2	20	1.2	4.5	3.5	5.0	0.15	0.0	3.5	5	2.5	--	--
72	0-20	8.3	22	1.7	3.9	4.7	8.3	2.50	0.0	4.0	5	4.0	--	--
	20-150	8.1	21	1.3	3.9	4.1	5.5	1.10	0.0	4.0	7	2.8	--	--
73	0-30	8.0	26	1.3	5.0	4.6	4.7	0.35	0.0	3.0	7	2.2	--	--
	30-150	8.3	19	0.9	4.5	2.5	4.5	0.20	0.0	2.5	8	2.4	--	--
74	0-25	8.1	17	2.0	8.9	6.1	7.9	0.60	0.0	4.0	9	2.9	--	--
	25-150	8.4	18	2.0	5.6	6.7	11.0	0.50	0.0	4.0	9	4.4	--	--
75	0-30	8.2	22	2.5	6.1	7.8	15.0	0.65	0.0	3.0	9	5.7	--	--
	30-150	8.5	22	1.2	4.5	1.4	8.7	0.45	0.0	3.5	4	5.1	--	--
76	0-30	7.9	27	6.9	27.9	15.4	51.2	1.15	0.0	3.5	21	21.2	--	--
	30-150	8.3	22	2.7	3.9	4.1	25.0	0.55	0.0	3.0	7	12.5	--	--
77	0-15	8.1	25	2.0	6.1	6.7	8.9	0.55	0.0	3.0	9	3.5	--	--
	15-150	8.2	23	1.4	4.5	4.5	6.9	0.45	0.0	3.5	5	3.2	--	--
78	0-25	7.8	28	1.9	8.4	6.0	6.3	0.60	0.0	4.0	8	2.3	--	--
	25-150	8.2	21	1.5	6.1	5.7	6.1	0.45	0.0	3.5	7	2.5	--	--
79	0-20	8.1	23	1.6	8.4	3.9	6.1	0.60	0.0	3.0	9	2.4	--	--
	20-150	8.3	21	1.6	4.5	5.1	7.9	0.35	0.0	2.5	9	3.6	--	--

Table A-5. Chemical characteristics of soil profiles sampled in the El Hammami Area.

Profile No.	Depth cm	pH[1/]	SP[2/]	E. C. mmhos cm^{-1} 25°C	Composition of the saturation extract, meq/l							SAR[3/]	CEC[4/]	ESP[5/]
					Ca	Mg	Na	K	CO_3	HCO_3	Cl			
80	0-20	8.2	22	3.7	7.8	7.6	29.2	0.65	0.0	3.0	16	10.5	--	--
	20-150	8.3	20	2.2	4.5	6.2	14.0	0.40	0.0	2.5	12	6.0	--	--
81	0-20	8.1	25	1.1	5.6	3.0	2.8	0.75	0.0	3.0	3	1.3	--	--
	20-150	8.3	24	1.0	2.8	2.5	6.7	0.30	0.0	3.0	4	4.1	--	--
82	0-20	8.4	21	1.4	3.4	2.5	10.3	0.85	0.0	3.5	3	6.0	--	--
	20-150	8.5	21	1.6	2.8	1.5	14.5	0.60	0.0	3.5	7	9.9	--	--
83	0-25	7.7	33	1.2	6.7	2.9	3.0	0.30	0.0	3.0	3	1.4	--	--
	25-150	8.2	24	0.8	2.8	3.1	3.6	0.35	0.0	1.5	5	2.1	--	--
84	0-25	7.8	29	1.8	8.4	6.0	5.5	0.55	0.0	4.0	9	2.0	--	--
	25-150	8.0	22	1.6	5.6	5.1	7.5	0.30	0.0	3.5	7	3.2	--	--
85	0-10	8.1	33	0.9	4.5	3.0	3.4	0.60	0.0	3.0	3	1.8	--	--
	10-30	8.1	26	1.1	3.9	4.1	3.7	0.60	0.0	3.0	4	1.9		
	30-150	8.3	23	0.8	3.9	2.0	3.2	0.50	0.0	2.5	4	1.8	--	--
86	0-20	7.8	23	1.8	8.4	2.8	8.7	0,90	0.0	2.0	9	3.7	--	--
	20-150	8.0	22	2.2	8.4	6.0	8.7	0.60	0.0	3.0	16	3.2	--	--
87	0-30	8.6	25	1.3	3.4	0.3	11.0	0.25	0.0	3.0	5	8.1	--	--
	30-150	8.4	22	3.5	3.9	3.1	32.2	0.45	0.0	3.0	16	17.2	--	--
88	0-30	7.7	23	4.8	25.7	14.9	17.7	2.15	0.0	2.5	29	3.9	--	--
	30-150	8.3	22	1.6	2.8	5.2	10.0	0.55	0.0	3.0	9	5.0	--	--

1/pH of the saturation paste

2/SP - Saturation percentage

3/SAR - Sodium adsorption ratio

4/CEC - Cation exchange capacity

5/ESP - Exchangeable sodium percentage

Table A-6. Analysis of the Ground Water in El Hammami Area.

Profile Sample Number	pH	E.C. mmhos/cm 25 C	Total Soluble Salts ppm*	meq per liter							SAR
				HCO_3	Cl	SO_4	Ca	Mg	Na	K	
1	7.9	0.7	630	5.3	1.8	1.8	3.5	3.5	1.9	0.05	1.0
2	7.7	0.8	670	4.5	2.0	3.2	3.4	3.2	2.8	0.05	1.5
6	8.2	2.6	2060	7.0	5.6	16.9	5.7	6.5	15.3	2.05	6.2
12	8.1	3.7	2980	6.8	16.4	21.9	6.8	8.7	28.4	1.15	10.2
13	7.4	2.7	1860	5.2	7.6	19.9	6.7	5.1	18.7	2.15	7.7
16	7.7	1.8	1410	4.5	2.8	13.4	5.7	5.9	9.1	0.02	3.8
19	7.8	1.3	1140	4.5	2.4	9.9	7.9	6.0	2.9	0.10	1.1
22	7.7	3.0	2480	6.0	10.8	19.8	3.4	5.3	27.9	0.01	13.4
26	8.3	1.3	1100	8.6	2.0	4.2	1.6	3.4	9.8	0.10	6.3
30	7.7	2.7	2180	6.0	11.6	15.4	5.3	8.1	19.1	0.60	7.4
33	7.9	1.8	1390	5.6	4.0	10.8	3.5	6.6	10.3	0.02	4.6
41	7.8	3.3	2860	6.6	11.4	24.4	5.9	7.7	28.4	0.35	10.9
47	8.2	4.5	3970	5.7	21.2	33.7	9.1	11.7	39.0	0.85	12.1
55	8.3	1.1	870	8.2	2.0	1.5	3.2	3.2	5.3	0.02	3.0

Table A-6. Analysis of the Ground Water in El Hammami Area.

Profile Sample Number	pH	E.C. mmhos/cm 25 C	Total Soluble Salts ppm*	meq per liter							SAR
				HCO_3	Cl	SO_4	Ca	Mg	Na	K	
59	8.0	1.5	1090	7.4	2.4	5.7	7.9	4.7	2.9	0.02	1.2
64	7.5	1.5	1010	5.3	4.4	7.6	5.5	3.3	6.5	0.02	3.1
67	8.2	3.0	2480	8.5	8.4	18.2	1.6	4.2	27.2	2.05	15.8
68	8.1	2.4	1920	8.4	8.8	10.8	5.5	4.5	17.8	0.15	8.0
74	7.8	1.7	1190	6.9	4.0	5.6	6.1	3.2	7.1	0.15	3.2
77	7.8	1.4	1080	4.9	3.6	7.5	4.9	5.8	5.0	0.25	2.2
80	7.8	1.6	1200	4.4	5.6	7.6	5.7	2.2	9.4	0.25	4.8
88	8.0	0.9	910	7.7	3.0	2.3	4.4	5.6	3.0	0.01	1.3

*Calculated by using molecular weight
**Calculated by difference