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Research and Mapping of Land of

the Çukurova Agriculture Foundation

1988

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Research and Mapping of Land of the Çukurova Agriculture Foundation

Department of Soil, Agricultural Faculty,
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Preface

In order to increase the sources of water for irrigation and also the quality of the soil, it is necessary to conduct research pertaining to the soil and water by the agriculture foundations. This will support the country's economy and the data gathered could be used for further planning.

Though exploratory research on the foundations' lands have been carried out, the compiling of the main data is necessary, and the data can be used for many purposes research of the soil started in 1981 with the great help of the scientists from Cukurova University, Agriculture Faculty, Department of Soil. This research has continued until now.

Maps of land, required food plants, clay, salinity and drainage were prepared for the different stages of the soil research.

I hope that this study will continue further because it is a good example of using science for life, I acknowledge the efforts of those who made this report and I hope that this report will benefit the readers.

Yüksel YILDIRIM

General Director

Map - 1 Basic soil map of the Çukurova Agriculture Foundation

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Introduction

The main factor of agricultural production is the quality of soil which is the source of nutrients which enable the plants to grow. Therefore, soil should be analyzed systematically to determine the requirements. In this way scientific correlations between soil and plants can be obtained, and the results will be a valuable guide for plant farming. To gain the knowledge of soil characteristics and to explain them are the major tasks of the soil research and mapping studies.

Soil research provides identification of the kind of soil, to draw maps with borders between different kinds of soil and to forecast the reaction of the soil to a given or suggested method. Also, interpretation of soil according to its productivity under the several "AMENAJMAN" Systems is possible. The selection of soil for vegetables or any other products is made possible by the use of the detailed research. Depending on the region, soil shows different character, and therefore in each region soil should be processed according to its character and structure. The data on the type of clay, grain dimension of mineral, structure and absorption ability, can be used to draw soil maps. Following these maps, maximum productivity can be obtained.

The first scientific definition of soil was given by Dukuchaev in 1886. It says "Soil is an element of nature influenced by topography, time, climate, and the effect of living things." Dukuchaev et al. collected their data based on PODZOL and CHERNOZYEM which gives a profile of soil growth. Vilenski, in 1957, found a relation in podzolization, salinization, the existence of soil formation and the group of soil.

There are many discussions going on about the new definition of soil. Sibirtzev (1895) agreed with Dokuchaev's definition,

and also believed in the five factors that affect the soil. Especially, climate, and vegetation divides soil into three categories. They are Zonal, Intra-zonal, and Azonal (Vilenski, 1957).

Baldwin, Kellog, and Thorp in 1938 considered that Sibirtzev's Zonal soil category and they improved the "American Soil Category". In this classification they divided the soils as "Ordo, Altordo, family and series." After this, the system by Thorp and Smith (1949), and by Riecken and Smith (1949) were reorganized. This reorganized system has been widely used until recently (Boul et al., 1973).

When the differences of the nature of soil is considered, the first idea obtained as a main definition is soil genetics "the existence of soil factors." However, the relation between soil and environment is not sufficient to explain the process of the formation of soil. This means that it is very difficult to explain that which factors and how they affect the soil morphology. From this point, Simonson (1959) suggested that all kinds of physical, chemical, and biological phenomena affects the increase, decrease, change and moving of the soil system. According to his idea, the cause of the change in the horizons of soil is the effect of physical, chemical and biological phenomena at certain special times. The existence of soil and its characteristics are depend on the above-mentioned phenomena and also vary in accordance with the region. In other words the outside factors of soil existence (main elements, climate, topography, time, and plants and animals) prepare the conditions. According to the Simonson, the definition the inside factors (increase, decrease, move, change) depend upon the pedogenetic process; under these conditions the pedogenetic process shapes the soil profile (Schelling, 1970).

All the soils which cover the earth, consist of their individual special morphology. This morphology is the indication of existing conditions. In other words, the existing conditions, make different kinds of soils in different regions, and most probably this was understood by the primitive people when farming was first started. The classification of soil was done roughly when the people began to understand the difference in the soil. This starting was done to answer the practical necessities. The first classification answered a limited purpose. (Dinç et al., 1979)

The classification of soil reminds us of the important characteristics of soil; to use our knowledge via synthesis; and to see their relation between each other and their relation with each other and with the environment. Boul et al. (1973) explained the purpose of any kind of classification are same as mentioned before.

According to several researchers, there are two purposes for the soil classification; theoretical or scientific purposes and practical purposes. Soil classification of the theoretical and scientific purposes shows the soil genetics and its sources, and it increased our knowledge of the soil. Each system of soil classification gives us an opportunity to discuss the objects and exchange ideas. From this angle, generally the theoretical and practical purposes are almost the same. In other words, theoretical and scientific classifications provide support for practice. The classification according to the characteristics of the soil that is used to draw the border line between different kinds of soils can be done by the study of mapping research (Dinç et al., 1979).

To explain the existence of the soil in any time can not be supported by the investigation and/or interpretation; even now

the knowledge about the soil's formation is limited, and many kinds of soil have not yet been explained. The natural soil classification system is not only based on the soil genetics. To accept the formation of soil and its interpretation, the criteria of soil classification makes the classification wrong. That is the reason today's soil science gives new approaches for the classification. The new approach is based on only measurable morphology. In 1960 for the first time in America, the Scientific Soil Congress accepted the seventh approach prepared as a soil classification system (Soil Survey Staff, 1960; Boul et al., 1973). This system was rearranged and improved, and finally, in 1975 it was published ("Soil Taxonomy"). This system consists of six categories, from the first category to the last category, soils are defined in more detail (Soil Survey Staff, 1975; Young, 1976).

In order to study the relation between intercontinental soil units, experts from many countries joined together and made a new classification. The method is known as FAO-UNESCO soil classification. This system is based on the seventh approach system with some modifications, an upper classification almost the same as the seventh approach (FAO-UNESCO, 1974).

The soil was given its present appearance by ages of geomorphic activity. According to some researchers, soil existence consists only of complex phenomena and their factors. These complex phenomena and factors a) Accumulation of main elements and b) Differences inside the profile and existence of horizons (Pedogenetics), and this classification makes the formation of soil easy to understand (Pons et al., 1965; Boul et al., 1973).

Generally, soils consist of inorganic or organic main elements. Inorganic (mineral) main materials consist of strong rocks, heavily precipitated material or accumulated materials. The first of them is called local (autochthonous)

and the second foreign (allochthonous) called main material (Akalan, 1965). The foreign main material occupies the most important place. As a matter of fact, the soils which was formed from the alluvium's main material occupies a very small area of the earth (590 million hectares), however, these soils provide the requirements of 1/3 of the world's population (Kellog et al., 1969). The tillable alluviums occupy 4.1 million hectares in Turkey, which is 5.2% of the total area of Turkey (Canpolat, 1981).

The reason that alluvium is productive soil, is because it contains physical, chemical, and mineralogical characteristics. In other words, generally smooth or nearly smooth topography has alluvial soil, it accommodated deep roots for the plants, and it retains nutritious minerals which are soluble in water (Boul et al., 1973; Young, 1976).

In spite of the above-mentioned characteristics of alluvium soil, there has not been sufficient research on it. The reason is that this kind of soil has a very complex structure; accordingly the soil survey manuals mapping their classification has special problems, because genetic soil horizons do not appear in the alluvium structure. Profiles of this kind of soil has a different texture and different color layers because of the geological process (Soil Survey Staff, 1962).

With the new soil taxonomy in the progression of profiles of the alluvial soils defined as young soils, the horizons are not yet matured. Alluvial soils are classified in the fluvial soil group (Soil Survey Staff, 1975).

Alluvium can be found in any place. Its characteristics, compared to other classes of soil, such as texture and drainage, are changeable within short periods. For this reason it is difficult to symbolize with one type profile

(Young, 1976). According to Buring (1979), soil characteristics show big differences, because of the changes in alluvium material at a river overflow area and at the mouth of a delta.

Oakes (1958), completed his "General Soil Map of Turkey" based on the "Old American Soil Classification System". This map is scaled 1:800,000. He described the soil of The Ceyhan Plain in two forms, alluvium and hydroformic alluvium soil. The General Directorate of Soil and Water, 1965-1970 produced a "developed soil map of Turkey" scaled 1:200,000; in this map, The Ceyhan Plain Soils mapped as alluvium soils; salty, saltless, with insufficient drainage and with good drainaged factors were described (Topraksu, 1973). In the Özbek et al. (1981) studies, the existence of Ceyhan plain soils, important physical, chemical and mineral phenomena were classified at the serial level and mapped.

The value of the soil maps are becoming important in modern soil science, because of the suitability of classifications for use of soil combined with the soil maps (Pons, 1965). Some of the lands are suitable for some purposes but not others, but they can all be used for some purposes. The characteristics of the soil changes in accordance to regions. This means that their productivity is also different. In this way, it is necessary to mention the characteristics of soils on the soil maps; this is the purpose of soil maps (Hizalan, 1969). Different characteristics that are determined for the soils should be indicated when the production plan is prepared (Doyle, 1966; Bauer, 1966; FAO, 1977; Roberts, 1979). Today, land is being used for many purpose, the same as in the past. The uses of soils are different based on the different types of soils (Davis, 1976; FAO, 1977). Any land can be productive if the method of use is chosen carefully (Robert, 1979).

This study contains detailed soil research and soil mapping of the Cukurova Agriculture Foundations Land. As a result of this study, definition of different soil groups and their characteristics and uses will be clear. Interpretation of the gathered data will also be used for soil management, utilization planning, and to obtain other information for the foundations.

1. EXPLANATION OF CUKUROVA AGRICULTURE FOUNDATION

1.1 Geographical Location

The Çukurova Agriculture Foundation is situated in Adana City, inside the Ceyhan District's border. The foundation is bordered on the north by Bozbükchapul, in the south by Mercimek, in the west by Akmasat Çiftliği and Kelburnu, in the east by Yeşil Bahçe and the Ceyhan River (Figure 1). The total area of the Foundation is 35,140 decares.

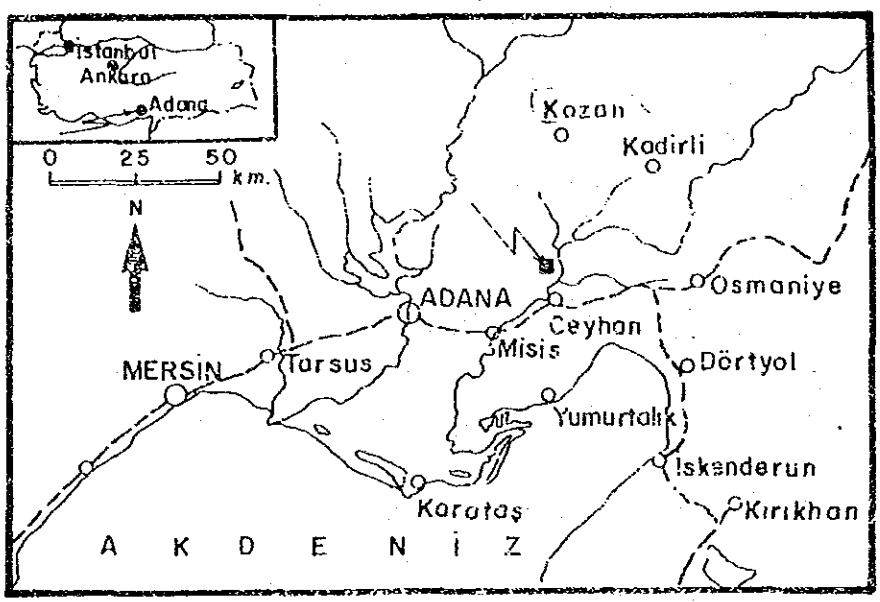


Figure 1 Geographical location of Cukurova Agriculture Foundation

1.2 Physical Geography

There are three physical units that receive attention in the foundation, those area; beside the Ceyhan River River ridges, next to the river ridges, old river traces and old river beds.

Most of the land contains accumulated alluvium materials which are carried by the overflow of the Ceyhan River.

Almost all the land of the foundation is level, and the slope is 0-1%. The elevation reaches 30 meters (at the highest point).

1.3 Climate

At the Çukurova Agriculture Foundation, climate is dry and hot in summer and warm and rainy in winter. This is typical Mediterranean climate. As long-term climate data, only the average rain fall amount is known. That is the reason Adana City investigation network used to get data which is very much like that of Ceyhan, and the climate is almost same as Adana. However, in the data interpretation, a 1 or 2°C lower temperature should be considered for winter data, and because of this some changes should be considered for the yearly average.

At Adana City, the average temperature was calculated as 17.6°C (1953) and in 1966 it was 19.9°C. According to data of the last 20 years, the average temperature for one year is 18.7°C. The hottest season is in August, and the coldest time is in January. Precipitation consists almost entirely of rain, and it fall during winter when the evaporation is slower. The total amount of precipitation is 659.5 mm. The yearly average temperature of the soil surface (50 cm under the surface) is 21.1°C and the lowest temperature (taken in January) is 11.4°C. There is a 20°C difference between the hottest and coldest months (Cölaşan, 1970).

1.4 Geology

Most of the foundation land is covered by the Ceyhan River's alluvium full of "Holocene" and "Pleistocene".

1.5 Vegetation

The land of the foundation was used for pasture, but recently, it started to be used for cultivated crops such as cotton, cereals, soybeans, citrus fruits, corn, sun flowers, fodder plants and several kind of vegetables. During 1985-1986 the land was used as below:

	Total area of foundation	:	35,140 decares
	Irrigated land	:	9,000 decares
1.	Total field land	:	26,320 decares
	Total clover acreage	:	1,500 decares
	Future planned clover acreage	:	1,500 decares
	Natural pasture land	:	1,000 decares
	Silage corn	:	1,554 decares
	Vetch	:	500 decares
	Fodder plant (a kind of barley)	:	500 decares
	Rape	:	100 decares
2.	Total meadow land and pasture land	:	7,654 decares
	Total area of fruit orchards	:	117 decares
	Vegetable acreage	:	200 decares
	Park and forests	:	30 decares
	Future planned foundations	:	200 decares
3.	Total garden land	:	367 decares
	Total cultivated land	:	(1+2+3)+34,341 decares
	Industrial center	:	200 decares
	Roads and canals	:	199 decares
	Forests	:	400 decares
4.	Total uncultivated land	:	799 decares
	Percentage of used area	:	97.7%
	Total area of foundation	:	35,140 decares

2. MATERIAL AND METHOD

2.1 Material

The Çukurova Agriculture Foundation land is surrounded by the Yeşilbahgçe and Ceyhan rivers on the east, Akmasat Çiftliği and Keiburnu on the west, Merçimek on the south and Bozbuk Capul on the north. The total area of the foundation is 35,140 decares. Soil samples were taken from different soil areas, which were determined beforehand through an aerial photography by means of the typical horizontal cross-section technique, and used as a sample in this study.

2.2 Method

This study has been done in three stages. At first a 1:20,000 scale black & white air photograph (taken as mentioned before) of foundation land was studied in the office. Physiographic units and boundary area were determined. According to this study, a photo-interpretation map was determined. The second stage of this feasibility study was done on the selected physiographic unit samples by means of interpretation of the photographic maps. Different kinds of series were determined. A typical series legend was developed. Special representative samples of each series were analyzed for required parameters in the laboratory using genetic horizon techniques. At the third or last stage of this work, the land boundary which was determined from the air-photograph was checked and fixed by an expert, and fitted, and symbols were entered on the map.

A detailed study and mapping of soil series, and its important phases, are used as main material. Special properties such as deep slopes, salinity and drainage which cause phase separation was studied by the Soil Survey Staff (1962) and Özbek et al. (1974).

Basic cartographic material (air-photos) were interpreted by using a mirror stereoscope. Different soils under different stereo viewing and different gray color, were determined as a design of drainage, slope, and other useful proper ties, and boundaries were drawn carefully by the Soil Survey Staff (1962; Vink, 1963). All results which were obtained by appropriate air-photos, and chemical and physical experimental results are shown on the map.

To examine the morphological properties of soils a) Munsell color scale to determine color and b) 10% HCl to determine lime were used by the Soil Survey Staff (1962).

All experiments were made carefully as explained in the Soil Survey Staff (1962) - Soil Survey Staff (1975). The classification of soil series and soil taxonomy were studied by the Soil Survey Staff (1975).

All soil samples which were collected from different soil series were tested for texture, pH, organic content, total salinity, % of clay, cation exchange capacity, changeable cation, productivity, and the useful phosphoros pentoxide.

Texture determination was made by the Bouyoucos (1952) hydrometer method. % of clay by the Scheibler Calcimeter method (Black, 1965), pH of concentrated clay by the Beckman Zeromatic pH meter (Black, 1965). Total salinity was measured by means of the electrical conductivity of mud with a (EC) conductivity meter (Richard, 1954), KDK and DK by the sodium acetate extraction method (Usda, 1954). Organic content by the Walkey (1947) method. And useful phosphorous pentoxide by the sodium bicarbonate extraction method (Olsen, 1952).

3. RESULTS OF RESEARCH

3.1 Results of Physical and Chemical Analysis and Morphological Properties of Çukurova Agriculture Foundation Land

A cross section of all samples which are representative of their soil series explained their morphologies. In this section, soil series are explained as a formation physiographic unit, and some physical and chemical analyses are given. An important phase distribution area is shown in Map 1.

Geng Nehir (Name of a place) Terrace

Land which can be viewed easily from the air-photo appears as lines following along the old and new Ceyhan river beds. This land was formed as a result of deposits from the Ceyhan river overflow. Since this soil is a collected material, the bottom portion usually contains sand and gravel. This physiographic unit is called the Haciköse and Kastal series.

. Hacıköşe Series (H)

This area was formed on the old river bed and consists of young soils. The upper portion of the soil is clay, and the bottom portion has a silt and clay texture. According to the cross-section analysis, organic compounds are collected in the upper portion. But, the cross section of the other side has no pedogenic formation. As a result, the upper part of the soil is dark grey to brown, the bottom part is yellowish brown. This soil series is usually good, but has insufficient drainage in some places. All profiles have much calcium carbonate and the calcium carbonate concentration increases as the depth increases. The physical and chemical analysis results of

the Hacıköse land series are given in Table 1 and Figure 2. The upper layer of soil has a medium amount of organic compound, and the pH value is between 7.4 and 7.8.

Soil profile number 5. Hacıköse clay, insufficient drainage, 0-1% slope (HK)

Horizon	Deep (cm)	Description
Ap	0-37	In wet condition, dark gray to brown (10YR 4/2); in dry condition, grey to brown (10YR 5/2); clay; weak; contains small rectangular blocks; granular in dry condition; slightly tight; sticky and elastic in wet condition; contains much lime and fine roots.
AC	37-54	In wet condition, dark brown (10YR 4/3); clay; solid; dispersible in moist condition, sticky and elastic in wet condition; contains much lime and fine roots, and fresh water shell animals.
C_1	54-67	Yellowish green in wet condition (10YR 5/4); silty clay; solid; dispersible in moist condition, sticky and elastic in wet condition; contains much clay; fine roots and fresh water shell animals.
C_2	67-87	Bright greenish brown in wet condition (2.5 Y 5/4); Silty clay; solid; slightly dense in damp condition, in wet condition, a little bit sticky and less elastic; contains much lime; very weak secondary lime concretions.

C_3	87-107	Bright yellowish brown in wet condition (2.5 Y 6/4); clay; solid; slightly dense in damp condition; slightly sticky in wet condition; contains much lime; rarely contains rust spots.
C_4	107-130	Olive brown in wet condition (2.5 Y 4/4); clay; solid; not sticky in wet condition, not elastic; contains much lime; rarely contains rust spots.

Height : 25 meters
Relief : (0-1%) flat, nearly flat
Drainage : insufficient
Vegetation: first product soybeans
Location : One km southeast of Tay, on the left side of the Kadirli asphalt pavement

Table 1 Physical and chemical analysis results of the Hacıköse series

Horizon	Depth (cm)	pH 1:1	Total Salinity (%)	KDK (milli equivalents/100 gr.)	Changeable Cation (milli equivalents/ 100 gr.)			Lime (%)	Organic Element (%)	Distribution of Grain			Classification of Texture
					Ca^{++} Mg^{++}	K^{+}	Na^{+}			Sand %	Silt %	Clay %	
Ap	0-37	7.70	0.065	11.5	9.92	1.0	0.53	20.4	2.93	17.1	36.7	46.2	C
AC	37-54	7.40	0.070	15.3	14.47	0.64	0.27	39.4	1.15	6.2	36.8	57.0	C
C_1	54-67	7.80	0.045	10.5	10.8	0.35	0.15	33.8	0.20	17.7	46.0	36.3	SiCL
C_2	67-87	7.40	0.042	9.9	9.02	0.38	0.33	34.6	1.09	15.8	48.3	35.9	SiCL
C_3	87-107	7.60	0.040	9.6	6.80	2.56	0.24	33	0.95	32.5	37.6	29.9	CL
C_4	107-130	7.60	0.035	7.4	6.88	0.22	0.27	31.2	0.58	26.2	20.7	53.1	C

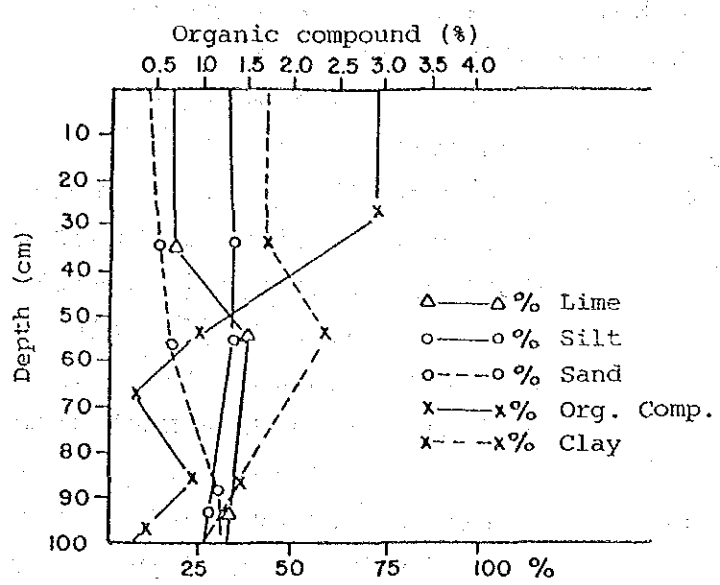


Figure 2 Distribution of contents of lime, organic compounds, sand, clay and silt in the Hacıköse soil series

. Kastal Series (S)

The Kastal soil series has occurred in the foundation's land in the young alluvium deposits. The serial land is located near the Ceyhan river site. The first layer of soil texture is very light in accordance with the topography, therefore it might have separated from the Haciköse soil series. All the profiles of the Kastal series have dark brown color and are not perfectly horizontal, and this soil series is located near the Ceyhan river. In this area insufficient drainage exists in some area because of base water.

Soil profile No. 4 Kastal silt, clay, insufficient drainage, and 0-1% slope (Ssy)

Horizon	Deep	Description
Ap	0-32	In dry condition, dark brown (10YR 3/3); in damp condition very dark grey-brown (10YR 3/2); silt, clay, weak, medium angular block; dispersible in dump condition, sticky and elastic in wet condition; contains much lime.
A_{11b}	32-42	In dry condition, dark grey-brown (10YR 4/2); in damp condition, very dark grey-brown (10 YR 3/2); solid; dispersible in damp condition; sticky and elastic in wet condition; contains much lime.
AC	42-70	In dry condition, dark brown (10YR 3/3); in damp condition very dark grey-brown (10YR 3/2); silty clay; solid in damp condition, sticky and elastic in wet condition; contains much lime.
C_1	70-93	In dry condition, dark brown (10YR 4/3); in damp condition, dark brown (10YR 3/3); silty clay and solid; dispersible in damp condition, sticky and elastic in wet condition; contains much lime rare red rust parts.
C_2	93-118	In dry condition, dark brown (10YR 4/3); in damp condition, dark brown (10YR 3/3); silty clay, solid; dispersible in damp condition; sticky and elastic in wet condition; contains much lime, and slightly red red rusty parts.

C_3	118-137	In damp condition, dark brown (10YR 4/3); clay; solid; dispersible in damp condition; sticky and elastic in wet condition; contains much lime and occasional grey rust parts.

Height : 25 meters
Relief : slightly rough
Drainage : insufficient
Vegetation : cotton (irrigation farming)
Location : 500 meter southwest of cattle dealing, west of set road

These soil series, which have been developed by alluvial deposits, have very deep profile. Physical and chemical analysis results of these series are given in Table 2, and Figure 3. This soil series has a medium level of lime and a 7.4 to 7.9 pH value. Distribution of organic compounds are irregular.

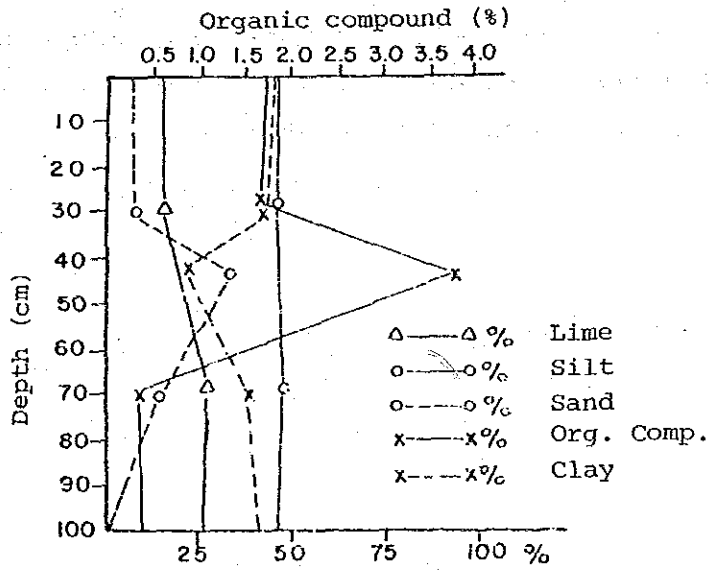


Figure 3 Distribution of contents of lime, organic compounds, sand, clay and silt in Kastal soil series

Eski Nehir (old river) Terraces:

These areas are located far from the Ceyhan river, and these soils were deposited before the Kastal soil series. The textures of these soils are heavier than the other river ridge soils, and there is clay activity (because of location and time).

. Mercimekli Series (M)

These soil series is spread out widely. And they are located far from the river and have flat topographic properties. Their alluvial deposits have a clay profile. For this reason, permeability properties are very low and especially during the winter season water accumulates on the land. Since these soil series have thin clay, drainage properties is different from place to place from good to bad or insufficient. During the summer season cracks with a one meter length, and a 5-6 cm width, have occurred. Because of this, plant roots can not grow, and working with agriculture machines becomes difficult. Soil colors around the profile change from grey to greenish-brown. In addition, the surface is slippery, and lime holes have appeared in deep profiles.

Table 2 Physical and chemical analysis results of the Kastal series

Horizon	Depth (cm)	pH 1:1	Total Salinity (%)	KDK (milli equivalents/100 gr.)	Changeable Cation (milli equivalents/ 100 gr.)			Lime (%)	Organic Element (%)	Distribution of Grain			Classification of Texture
					Ca^{++} Mg^{++}	K^{+}	Na^{+}			Sand %	Silt %	Clay %	
Ap	0-32	7.80	0.069	16.8	16.05	0.83	0.11	23	1.72	10.6	41.8	44.6	SiCL
A_{12}	32-42	7.40	0.095	19.9	18.70	0.64	0.53	25.2	3.90	34.2	44.8	21.0	L
AC	42-70	7.60	0.047	13.5	12.98	0.32	0.16	24.6	0.48	11.5	47.1	41.4	SiC
C_1	70-93	7.70	0.048	13.5	12.69	0.32	0.45	26.2	0.46	9.9	48.9	41.2	SiC
C_2	93-118	7.90	0.055	13.8	13.15	0.42	0.22	26.6	0.46	7.2	47.1	45.7	SiC
C_3	118-137	7.90	0.080	16.1	15.40	0.48	0.15	25.2	0.67	4.4	38.8	56.8	C

Soil profile No. 1 Mercimekli clay, good drainage, 0-1% slope (Mc)

Horizon	Depth	Description
A_{11}	0-12	In dry condition, grey (5Y 5/1); in wet condition, greenish (5Y 4/3); clay; medium, medium angular blocks, later granular; very rigid in dry condition, very hard in damp condition, very sticky and elastic in wet condition; contains much lime.
A_{12}	12-56	In dry condition and wet condition, greenish grey (5Y 4/2); clay; very big angular blocks, slightly prismatic; very rigid in dry condition; very tight in damp condition; sticky and very elastic in wet condition; contains much lime, very rarely little secondary lime holes, weak slippery surface.
A_{13}	56-80	In dry and wet condition, greenish grey (5Y 4/2); clay; solid; very rigid in dry condition, very tight in damp condition, very sticky and elastic in wet condition; very slippery surface.
A_{3ca}	80-111	In dry condition, greenish grey (5Y 4/2); in wet condition, light greenish grey (5Y 3/2); clay; solid; very rigid in dry condition; very tight in damp condition; very sticky and elastic in wet condition; contains much lime, condensed big lime holes, evidently slippery surface.

C_1	111-130	In dry condition, greenish brown (2.5Y 4/4); in wet condition, light greenish brown (2.5Y 5/6); clay; solid; very rigid in dry condition; elastic in damp condition; contains much lime, and a few big lime holes, evidently slippery surface.
C_2	130-150	In dry and wet condition, greenish brown (2.5Y 4/4); clay; solid; very rigid in dry condition; very tight in damp condition; very sticky and elastic in wet condition; contains much lime, a few big lime holes, evidently slippery surface.

Height : 30 meters
Relief : flat
Drainage : good
Vegetation : natural pasture land
Location : 200 meter west of the sheep fold

Lime in the Mercimekli soil series increased with the depth of the profile. In addition, after 12 cm the slippery surface appeared and the lower levels, slippery surfaces increased gradually. Physical and chemical analysis results are given in Table 3 and Figure 4. According to the table this soil has a 7.5-8.0 pH value, contains thin clay and has a slight saline property.

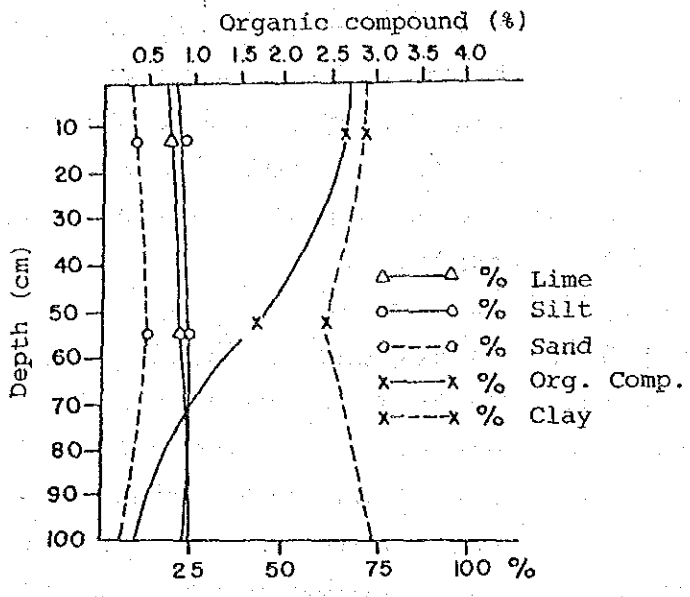


Figure 4 Distribution of contents of lime, organic compounds, sand, clay and silt in the Mercimekli soil series

. Çukurkamiş Series (C)

This soil series spread out widely like the Mercimekli soil series. This soil, which was deposited on the old alluvial deposits have heavy clay properties. However, clay concentration is less than that of the Mercimekli soil series. The organic compound contents changes from the surface to a depth of 80 cm and also is less than that of the Mercimekli soil series. Between 50 and 88 cm there is silty clay, after this depth, it has the texture of clay. The lime content did not change with the depth and this soil contains more lime (20-24%). Permeability properties are of weak to medium level. Surface drainage is good, and water accumulates in pits like the Mercimekli soil series. To work with agriculture machines is not so easy. Color changes around the profile from grey to greenish brown. Besides, after 50 cm, soft lime holes, slippery surfaces and deep fractures are seen.

Table 3 Physical and chemical analysis results of the Mercimekli Series

Horizon	Depth (cm)	pH 1:1	Total Salinity (%)	KDK (milli equivalents/100 gr.)	Changeable Cation (milli equivalents/ 100 gr.)			Lime (%)	Organic Element (%)	Distribution of Grain			Classification of Texture
					Ca^{++} Mg^{++}	K^{+}	Na^{+}			Sand %	Silt %	Clay %	
A_{11}	0-12	7.55	0.10	22.76	20.98	1.73	0.049	21.6	2.68	5.7	23.9	70.4	C
A_{12}	12-56	7.50	0.090	30.49	28.59	0.97	0.093	23.4	1.72	9.0	23.1	67.9	C
A_{13}	56-80	7.50	0.135	24.36	23.35	0.77	0.024	22.8	1.56	6.7	19.8	73.5	C
A_{3ca}	80-111	8.00	0.10	21.47	20.53	0.88	0.048	25.8	0.46	2.3	22.0	75.7	C
C_1	111-130	8.00	0.150	22.76	21.73	0.87	0.016	28.2	0.27	6.8	19.8	73.4	C
C_2	130-150	7.95	0.230	16.83	14.37	0.87	0.078	30.4	0.27	2.7	24.7	72.6	C

Soil profile No. 3 Cukurkamis clay, insufficient drainage (Ccy)

Horizon	Depth	Description
Ap	0-24	In dry condition, dark grey-brown (2.5Y 4/2); in damp condition, very dark grey brown (2.5Y 3/2); clay, weak, medium, angular block; very rigid in dry condition, very tight in damp condition, sticky and elastic in wet condition; contains much lime and a small amount of branched roots.
A_{12}	24-48	In damp condition, very dark grey brown (2.5Y 3/2), and dark brown (10YR 3/3); clay; solid; very rigid in dry condition; very tight in damp condition; sticky and elastic in wet condition; contains much lime and same branched roots.
AC	48-88	In damp condition, dark grey brown (2.5Y 4/2); silty clay; solid; very rigid in dry condition; very tight in damp condition; sticky and elastic in wet condition; contains much lime and some soft medium lime holes, evidently slippery surface, a few branched roots.
C_1	88-116	In damp condition, greenish brown (2.5Y 4/4-4/2); clay; solid; very rigid in dry condition; very tight in damp condition; sticky and elastic in wet condition; contains much lime and medium concentration, medium size soft lime holes, evidently slippery surface.

C_2	116-130	In damp condition, greenish brown (2.5Y 4/4); clay; solid; tight in damp condition; sticky and elastic in wet condition; contains much lime, and some secondary lime holes, evidently slippery surface and surface material filling in the cracks.

Height : 30 meters
Relief : flat (0-1%)
Drainage : good
Vegetation : wheat stubble (irrigated farming)
Location : 500 meter southeast of Tay branch, right side of Kidirli road

Physical and chemical analysis results of Çukurkamiş series are shown in Figure 5 and Table 4. According to the table, the series soil pH value changes between 7.3 and 7.9.

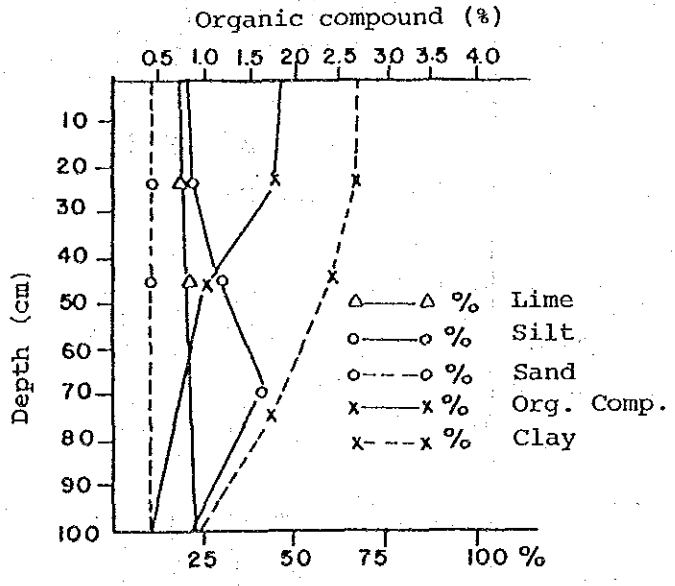


Figure 5 Distribution of contents of lime, organic compounds, sand, clay, and silt in Çukurkamiş soil series

Table 4 Physical and chemical analysis results of the Cukurkamis series

Horizon	Depth (cm)	pH 1:1	Total Salinity (%)	KDK (milli equivalents/100 gr.)	Changeable Cation (milli equivalents/100 gr.)			Lime (%)	Organic Element (%)	Distribution of Grain			Classification of Texture
					Ca^{++} Mg^{++}	K^{+}	Na^{+}			Sand %	Silt %	Clay %	
Ap	0-24	7.30	0.140	21.47	18.94	1.92	0.61	20.4	1.86	11.7	24.1	64.2	C
A_{12}	24-48	7.50	0.09	19.87	18.78	0.643	0.45	23.2	1.05	11.3	28.6	60.1	C
AC	48-88	7.70	0.068	18.26	17.53	0.58	0.16	23	0.48	10.9	42.2	44.9	SiC
C_1	88-116	7.80	0.08	18.27	16.96	0.64	0.67	24	0.46	11.1	24.0	64.9	C
C_2	116-130	7.90	0.08	18.27	17.48	0.64	0.15	23.6	0.53	21.7	26.3	52.0	C

. Karahöyük Series (K)

These series of soils are distributed in different places in the foundation. These soils follow the old river beds and contain a few rounded pebbles with a diameter 0.5 cm in each profile. The structure of the soil, in the surface silt, is silty clay, and contains more rough compounds in lower layers. In the area of medium level permeable soils, poor surface drainage and insufficient drainage under the surface has been found. Their colors change along the profile from dark gray to yellowish brown.

Soil profile No. 2 Karahöyük silty clay, weak surface, insufficient internal drainage (Kssy).

Horizon	Depth	Description
Ap	0-29	In a damp condition, very dark gray (10YR 3/1); silty clay; medium, medium angular black; very tight in damp condition; very sticky and elastic in wet condition; contains much lime, and scattered branched roots (medium level).
AC	29-44	In damp condition, dark gray brown or dark brown (10YR 4/3); clay; solid; slightly tight in damp condition; very sticky and elastic in wet condition; contains much lime, dispersed secondary lime holes in medium level, branched roots in medium level.
C_{1ca}	44-76	In damp condition, yellowish brown (10YR 4/4); clay; solid; slightly tight in damp condition; very sticky and elastic in wet condition; contains much lime,

		secondary lime holes in medium level, matrix have dark gray soil (poured from surface).
C_2	76-120	In damp condition, yellowish brown (10YR 5/4); silty clay; solid; slightly tight in damp condition; very sticky and elastic in wet condition; contains much lime, some secondary lime holes.

Height : 30 meters
Relief : 0-1% flat, nearly flat
Drainage : insufficient
Vegetation : stubble
Location : 150 meter east of Kadirli road, 50 meter northeast of the cattle dealing stubble.

Physical and chemical analyses are shown in Table 5 and Figure 6. According to Table 5, the value of the pH is 7.4 to 7.7.

There are some movements in lime. But it can only make calcic horizons. All profiles have lime and saltless soil.

Table 5 Physical and chemical analysis results of the Karahöyük series

Horizon	Depth (cm)	pH 1:1	Total Salinity (%)	KDK (milli equivalents/100 gr.)	Changeable Cation (milli equivalents/ 100 gr.)			Lime (%)	Organic Element (%)	Distribution of Grain			Classification of Texture
					Ca^{++} Mg^{++}	K^{+}	Na^{+}			Sand %	Silt %	Clay %	
Ap	0-29	7.40	0.055	24.35	23.57	0.58	0.21	21.2	1.74	7.8	40.4	51.8	SiC
AC	29-44	7.70	0.075	12.82	12.20	0.51	0.11	33.0	1.19	19.8	27.9	52.3	C
C_{1ca}	44-76	7.60	0.058	12.82	11.99	0.38	0.45	40.2	1.45	11.0	36.6	52.4	C
C_2	76-120	7.70	0.048	10.58	9.92	0.45	0.26	37.6	0.26	21.0	40.2	38.8	SiCL

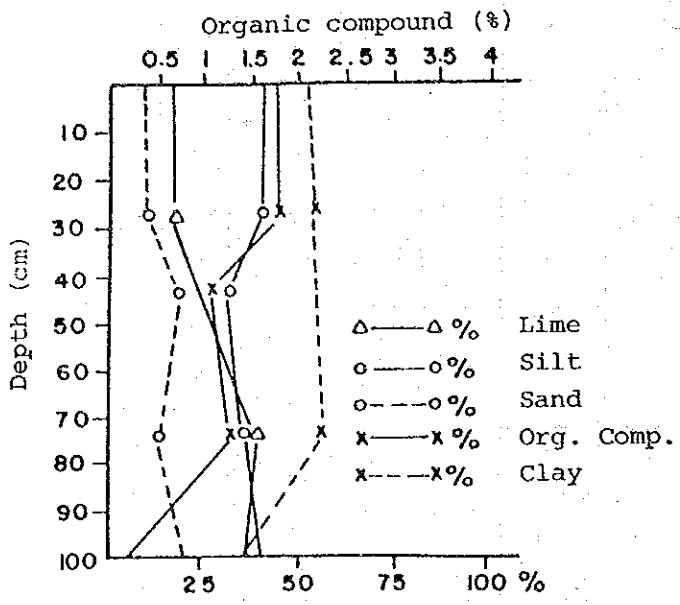


Figure 6 Distribution of contents of lime, organic compounds, sand, clay and silt amounts of Karahöyük soil series

3.2 Soil Classification of Çukurova Agriculture Foundation

The Çukurova Agriculture Foundation area has five different types of soil series and those were classified as "Ordo", "Sub Ordo", group and Sub group level (Soil Survey Staff, 1975 - Table 6). All soil series are very young soil and their profiles are weak. These properties were obtained from the alluvial soils of working area soils.

Mercimek and Çukurkamiş soil series have high density clay, has 120 cm cracks, and an evidently slippery surface. For those reasons, they have vertical properties. They are classified as a typical "Chromoxerert verticals".

Since the Karahöyük Series has "Ochric Epipedon" and calcic horizon properties, it has been classified in the inceptisol and Calcixerollic Xeroll sub Ordo. Kastal Series has mollic horizon therefore, it has been classified mollicol type and sub classified as Eluventic Haploxeroll. The Hacıköse Series is located near the Young River terrace, so, this area frequently effected by over flows. In that case there is only "Ochric Epipedon" Epipedon definitive horizon, therefore the place is classified Entisol type and Mollic Xerofluvent sub class.

Table 6 Soil Survey Staff of the Ground Series of the Çukurova Agriculture Foundation, Classification according to 1975 Data

Ground Series				
Mercimekli	Typic Chromoxerert	Chromoxerert	Xerert	Vertisol
Çukurkamiş	" "	"	"	"
Karahöyük	Calcixerollic Xerochrept	Xerochrept	İlchrept	İnceptisol
Hacıköse	Mollic Xerofluvent	Xerofluvent	Fluvent	Entisol
Kastal	Fluventic Haploxeroll	Haploxeroll	Xeroll	Mollisol

4. CONCLUSION AND INTERPRETATION

4.1 Soil Formations in the Çukurova Agriculture Foundation

The existence of soil has been completed in accordance with time and depend on the certain region's climate, vegetation, main materials and topography (Joeff, 1949).

All of the Çukurova Agriculture Foundation land was formed by the activities of rivers. The most important river in the region is the Ceyhan River, which has acquired the characteristics of the region. Most of the land is covered by the Ceyhan River's alluvium, and it consists of smooth or nearly smooth lands.

The study of the alluvial soil series in the area reveals all the characteristics of the main compounds. They are AC horizoned young soils. In most of the soils there is no profile growing except the horizon A, which was accumulated by organic compounds. In this area, alluvial soils have been carried from a lime area, therefore they contain lime and changeable Ca and Mg.

Morphologic definition of series soils show that some of the characteristics are changeable, such as physical and chemical analysis results. They contain organic compounds, drainage, in contrast texture distribution increase with distance from river bed (Özbek et al., 1981). As a matter of fact, the average clay density is 43%, sand 22%, in the young river Hacıköse terrace series. On the other hand, in the old river terrace, the Mercimekli clay density is 77%, and the sand density is 5.5%. Moreover, the organic compound density measured 1.7% at the young river terrace Kastal series. But in the old river terrace of the Mercimekli series, the drainage has been found to range from good to bad, and the density of organic compounds near the surface is about 2.6%.

Because of the overflow of the Ceyhan river water and sediments split into two parts. In this way, young river terraces appeared. Hacıköse and Kastal series are situated in the Young river terraces. Young river terraces which were formed by the accumulated rough materials such as sand and clay. Old river terraces are situated for the most part in the higher area, compared to the young river terraces. In this way, the thin clay deposits of "Çukurkamis and Mercimekli" series were established. From the clay-silt, clay texture deposits the Karahöyük series land was established (Figure 7).

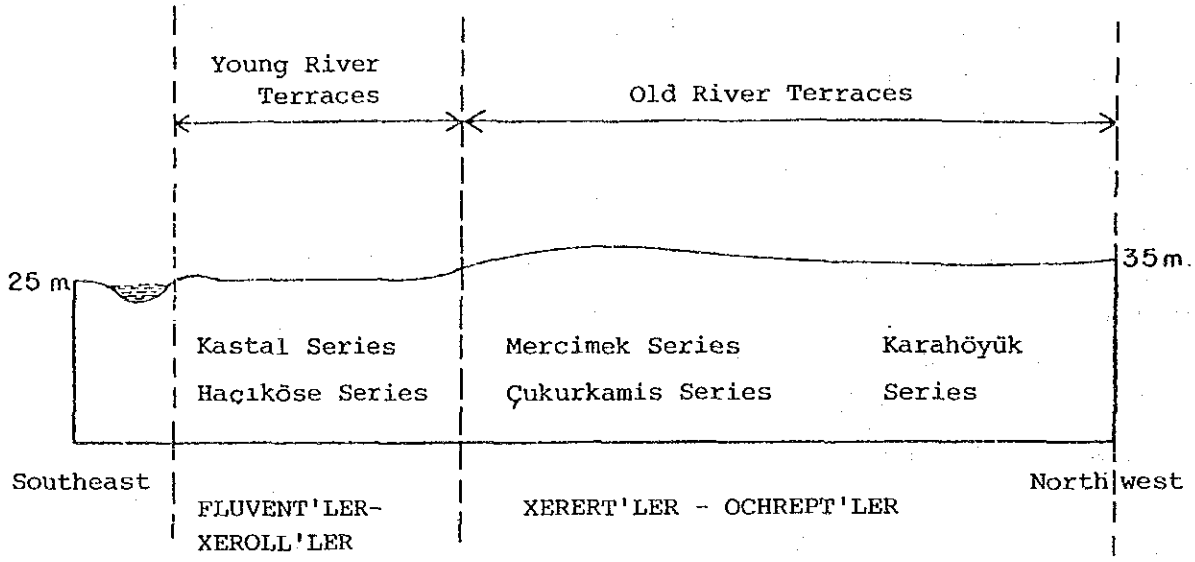


Figure 7 Cross section diagram of the Çukurova Agriculture Foundation soil series; their physical geography, and their location

Big pedogenic differences were determined to exist between the young river terrace soils and the old river terrace soils. As a matter of fact, secondary lime (packets) holes appeared by the washed calcium carbonate in the deep layers. At the Karahöyük series, the movement of the lime can be influenced to create calcic horizons. But in the Mercimekli and

Çukurkamiş series, because of the vertic properties there are no calcic horizons, because the vertic properties negatively effects the creation of calcic horizons. The Mercimekli and Çukurkamiş series soils, during the summer and climate develop wide and deep splits, and in winter those splits are closed while being swollen by the rain. In this way, slippery surface are caused by the rain in winter. Comparing the two series, the Mercimekli series contains 10-20% more clay than the Çukurkamiş series.

The profiles of the Kastal and Hacıköse series indicate a very young series, and in this case, movement of lime can not be seen. These two series are situated on the young river bed. The only important pedogenic feature is the dark colored surface of the soil. It was caused by the accumulation of organic compounds. The accumulation of organic compounds are big enough to create "Mollic epipedon".

4.2 Main Soil Problems of Çukurova Agriculture Foundation

4.2.1 Content of Free Lime

All of the foundation's soils are very limy. The lime levels are between 20% and 30% in the Mercimekli, Kastal and Çukurkamiş series. In the Karahöyük series the percentage of lime is over 30%. All soil series have this problem from the surface to the bottom of profiles. This causes a very big problem. This condition also effects the plant nutritative elements. According to Black (1968), a high amount of carbon cations (Ca^{2+}), can not be easily dissociated, especially with phosphor and also with other micro-compounds and it makes complex compositions. Therefore, it causes limitations of the plant nutritative elements.

Analysis results of all the series, percentage of phosphor has been found very low. Only Mercimekli series contains medium level phosphor.

4.2.2 Drainage

Big part of foundation land have drainage problems. Generally, soil series have insufficient drainage but some parts have bad drainage.

Drainage problems are depend on different factors. Most important factor is irrigating without any flatting or insufficient flatting which keeps to water in small holes on the surface, thus, base level of water became high. The other reason is drainage channels. There is not enough number of drainage channels in fields.

General texture of the foundation's lands is very heavy. Therefore, their permeability are weak or medium. That is the reason, during the irrigation or rain, water accumulated in the small holes. This situation can be seen very clearly in the Mercimekli and Çukurkamiş series, because, this soils contain heavy clay, water absorption ability is high but permeability is very slow.

Heavy textured soils of the foundation get tight by the heavily use of agricultural machines, this causes to appearance of solid plowing layer. This layer is the reason for the bad filtration and small lakes on the fields.

Before considering the drainage problems and possible solutions, we have to tell three main problems.

1. The land should be smoothed or flattened.

2. New drainage channels should be established in the field.

Also, the present channels should be used more beneficially.

3. In case of strong plow bases occurred, this kind of places should be exploded and the water should be infiltered inside the profile.

4.2.3 Salinity and Alkalinity

When the foundation's land was investigated and analyzed, there was not an important salinity problem. But salinity can be a problem any time, in case of wet farming conditions. As expected, the Mercimekli and Çukurkamiş series soils have light salinity. In the laboratory analysis, the amount of salinity for the Mercimekli series has been found to be greater in the bottom profiles. This may be a problem in the future, especially during raining season or irrigation times because this saline bottom profiles can move to the upper portion and the evaporation of this water will make the salinity to increase. In order to prevent this problem, drainage should be provided where the wet farming is planned. Apart from this plants that can withstand high salinity, concentrations can be planted first followed by the desired plantation.

In the Çukurkamiş series surface soil, there is also a small amount of salinity. For this series also, the above-mentioned guidelines or protections should be considered, and surface and bottom drainage systems should be established. Nowadays, it is not necessary to wash out the salt, but if it is required, it should be carried out after all the protections. There is no alkalinity problem.

4.2.4 Process of the Soil

For cultivated plant growing, unwanted grass growth is controlled by processing the soil bed for seeds and plowing. When the first farming is carried out, it is essential to study the characteristics of soils and the requirements of the plants to be grown. If the right time and right method is applied, the productivity is maximum. At a particular time, the temperature of the soil attained is ideal for processing. However, if the soil is processed too much, the structure of the soil will be destroyed, and an unwanted impermeable "Plowing layer" is formed.

In the Çukurova Agriculture Foundation, the big problem is soil processing. A large part of the foundation land contains heavy clay texture (Mercimekli and Çukurkamiş series). And a small part of foundation, Karahöyük, contains a silty clay texture (surface). The Mercimekli series contains more than 70% swollen clay. This affects the processing of the soil and also the use of agricultural equipment. In addition to this, the Mercimekli soils contain splits with lengths as long as 120 cm and widths of 5-6 cm. These splits appear during the dry periods and they prevent root growth. Compared to the Mercimekli series of soils, the Cukurkamis soils have less clay. Because of this, the processing of soil and the use of agricultural equipment is not so difficult as in the Mercimekli series. The Çukurkamiş and Hacıköse series of soils need slight smoothing. The surface soil of the Karahöyük series contains clay and silt. Its structure is not well organized and is poor in organic compound content. So it makes indispersible medium-size or big, strong rectangular soil blocks. These kind of soils take a long time to reach the necessary time and temperature for planting, and also this particular time is short. For this problem, unless plowing is started in the wet condition the soil becomes dry due to the above-mentioned reason, and plowing becomes impossible.

In order to prevent this problem, some solutions are given below, though not in detail.

a) Crop rotation: There are certain types of plants which can be recultivated each year or term. For this kind of plant it is necessary to plan alternative planting.

b) Farming without soil processing: Recently, many kinds of cultivated plants have been sown directly on the stubble using special equipment.

c) Deep plowing and explosion: Planting at the same depth each year causes a "Plow layer", this can be prevented by deep plowing or deep explosion.

d) Soils with a heavy clay texture take a longer time to become ready for planting, and the formation of small lakes after rainfalls can be prevented by shaping of the soil surface as shown in Figure 8.

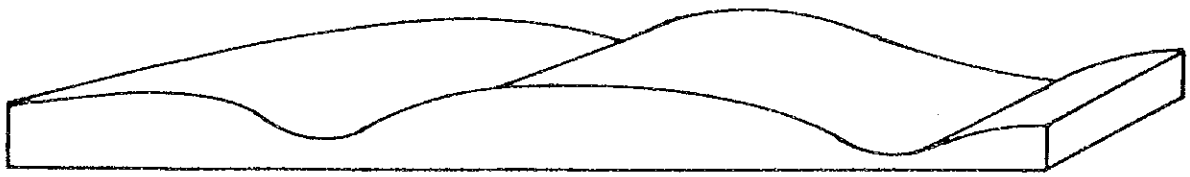


Figure 8 Cross section of the fish ridge type bed

4.2.5 Plant Nutrition Elements and Their Productivity

One of the most important soil properties for the intensive growing of crops is that the soil should have enough plant nutrition elements. Before the adding of nutrition elements, some knowledge is required. These depend on the plant which will be grown in that area, and the amount of the deficient nutrients, their application methods, etc. The subjects

mentioned here are usually affected by soil properties. For this reason plant nutrition elements and properties of soil should be tested by appropriate methods and applied for intensive growing of crops.

In foundation land soils, typical series profiles as well as analysis results of 25 productive sample have medium or low levels of phosphorous. However the potassium level is sufficient. The phosphorous level can be increased by using commercial fertilizer and nitrogen can also be increased in the same way. The foundation land soil contains 20% lime and the Haciköse series contains more than 30% lime. For high level calcium cations, dissociation is difficult with phosphorous. So phosphorous can not easily be used by plants as a nutrition element. The solution for this problem (excessive calcium carbonate) is given in Chapter 4.2.1.

4.3 Classification of Usability of the Çukurova Agriculture Foundation's Lands and Plant Adaptation

The land of the foundation should be used in the most productive way with a good plan. The using plan shows the farming methods for different types of soil, and the ratio of suitability (Hizalan, 1969). In the using plan, classes are shown in accordance to limitation factors. Their reaction to the processing and using were also considered. In the technical classification, any kind of soil can be classified in three levels. They are:

- Ability classification
- Sub-ability classification
- Ability units

The ability classes are symbolized from I to VIII with Roman numerals. These are the widest category classifications.

From the first (I) as the number of the class increases the limitation factors also increase. I, II, II, and IV classes can be processed by good management and by good protection. This is good for culture farming. V, VI and VII classes are not good for the farming process. They can be used for pasture land or tree growing. VIII class land is certainly not good for any kind of plants (Dinc, 1981).

These ability classes, which are shown by Roman numerals, have sub-ability classes. These sub-ability classes can be symbolized by attaching subscript letters to the Roman numerals. These letters signify the limitations for farming (for example, II_s, IV_{ws}, etc.). As there are not many limitations in case of I class soil, no subscripts are given. Sub-ability classes are:

e - Sloping and erosion (water-wind) damage (e)
s - Insufficiency of soil (shallow, stony, very slight and rough texture, low productivity, salinity, alkalinity) (s)
w - Growing limitations for culture plants because of extreme water (bad drainage, overflows) (w)
c - Climate problems (extremely cold, or extremely dry) (c)

Ability units are presented by attaching arabic numbers to the sub-ability classes. (for example II_{s-1}, IV_{sw-3}, etc.). These arabic number subscripts are the recommended solutions.

Map of Land Usability of the Çukurova Agriculture Foundation (Enclosure 2) has been prepared based on the base soil map (Enclosure 1). The recommendations for the processing of soil and management of soil were explained as follows. Also, the planned plant adoptation map (Enclosure 4) has been prepared based on the plant growing, limited soil characteristics and land classifications.

Ability Class I

Soil in the working area which belong to "ability class I" have a smooth or nearly smooth structure. Their surface and bottom drainage are good and permeabilities are good to medium. They can easily attain a proper planting condition (proper temperature of soil), and their soil processing is easy. In the foundation only, the Hacıköse series can be included in this class (silt and clay).

This class of soil has high productivity, and any kind of local plants can be grown here. However, their productivity should be maintained by crop rotation. For every four to five years, a product plan should be performed including the use of green grass fertilizer. For any type of use plant remains should be kept in the soil to get more organic compounds.

Ability Class II

1. Çukurkamiş clay: insufficient drainage
2. Mercimekli clay: insufficient drainage
3. Karahöyük clay;
   Karahöyük silty clay: insufficient drainage
4. Çukurkamiş clay;
   Mercimekli clay: slightly sloping, insufficient drainage
5. Mercimekli clay: slightly sloping
6. Karahöyük clay: slightly sloping
7. Kastal silty with clay: insufficient drainage
8. Kastal silty with clay:
   insufficient drainage, slightly silty
9. Karahöyük clay: insufficient drainage
10. Çukurkamiş silt with clay: slightly sloping
11. Karahöyük silt with clay: insufficient drainage
12. Hacıköse clay: insufficient drainage

These soils are classified according to their properties and problems. Then, this classification again branches into its ability units according to the way of use and processing differences.

II_s

This class of soils has a heavy structure at surface and bottom, which determines the way of use in the foundation. Çukurkamiş clay, Mercimekli clay, Karahöyük silty clay and Karahöyük clay are placed in this class.

Soils of this class have a good water and nutrient element absorbing quality. They also have very high productivity. However, silty clay and clay structure on the surface makes plowing difficulties, and attained the proper planting condition (Proper temperature) takes time. Especially after the plowing, clods appear.

In the product plan, sowing should be done by turn. As a plant type, cotton, cereal, corn, sun flower, wheat, beans or fodder plants can be chosen. Farming manure and the remains of plants should be kept in the soil and also every three to five years green grass fertilizing should be done. In this way, productivity will be increased.

II_{es}

In this class of soil, the heavy texture and slight slope prevent use. In this class Karahöyük clay, slightly sloping, Mercimekli clay, slightly sloping and Çukurkamiş silty clay, slightly sloping soils are included. The difference from the previous class is only that they are situated in a slightly sloping area. This causes difficulty in the use of agricultural equipment for plowing, sowing, and harvesting. In the production plan, in addition to the

above-mentioned recommendations, sowing should be done parallel to the smoothing curves. Surface aeration should be done carefully.

II_{se}

This kind of soil affects the usage, because of the heavy texture in the surface and bottom, slightly sloping surface and insufficient drainage conditions. In this class, only Mercimekli clay, insufficiently drained, slightly sloping soils are included.

When the production plans are prepared, the recommendations mentioned above should be considered. Beans, wheat families and fodder plants should be planted in turn. In this kind of soil, a strong plow layer can appear because of the heavy texture, plant growing and use of heavy equipment. In order to prevent this layer, deep and wide root plants should be planted in turn.

In order to increase the productivity, the plant remains should be kept in the soils, and green grass fertilization should be done.

II_{e}

The limitation of the use of this class of soils is only the slight slope. The surface soils are medium-structured and have good drainage. Karahöyük silty, slightly sloping soils belong to this class.

The method of sowing parallel to the smoothing curve, is necessary. The productivity capacity is medium. In order to prevent the appearance of plow layer surface sowing should be done in the line system and fodder plants should be grown in turn.

II_w

Smooth and nearly smooth topography and medium-structure surface are features of this group. Sub-structure layers are medium in this surface, but near the bottom they get heavy. Their drainage is insufficient. In the foundation the soils listed below belong to this class:

- Karahöyük silty, insufficient drainage
- Kastal silt with clay, insufficient drainage

The good and medium levels of permeability of these soils, because of their unusually concave topography and heavy structure in the bottom layers, have insufficient drainage.

This class of soils has good productivity. In the cultivation, deep-rooted plants should be grown. Cereal, cotton and fodder plants might be suitable in turn. Besides, field fertilizer and green grass fertilizer can give good results when applied every three or five years.

II_{sw}

This class of soils is found in the smooth or nearly smooth topography, and their drainage is insufficient. Surface textures contain clay. Hacıköse clay, an insufficient drainage soil, is included in this group.

The ability to hold water and nutrition elements is fair. This soil's surface has a clay texture. This causes many problems, however it can be prevented by the green grass fertilizing and addition of field fertilizer. In this way, attainment of the proper condition (proper temperature) of the soil will not be a problem. Any kind of local plants can be cultivated. However, the characteristics of drainage should be considered in the process.

II_{ws}

This class, because of the topography and partly heavy structure, has drainage problem soils.

II_{ws-1}

This group of soils are deep, medium structured and medium level permeability, sometimes slightly salty. In the foundation, Kastal silt with clay, insufficient drainage, slightly salty soil groups, belongs to this class.

In the plant production plan, plants resistant to salt, and plants having a good capability of absorbing water should be considered. For good sowing turn barley, cotton and clover might be considered. In order to prevent evaporation of water and the consequent salt concentration, capillaries should be broken.

II_{ws-2}

The problems in this class of soils are a little different to that of II_{ws-1}. The members of this class in the foundation are Mercimekli clay, insufficient drainage; Karahöyük silty clay, insufficient drainage; Çukurkamiş clay, insufficient drainage, Karahöyük clay, insufficient drainage soils (enclosed map 2). Generally these kinds of soils have very heavy structure in the surface and in the bottom because of the concave topography. Their characteristics are insufficient drainage, with base water becoming high and low periodically.

Their productivity belongs to the medium-good class. In these soils, cereals, sunflowers, cotton and corn can be cultivated.

Ability Class III

In the foundation, soils with bad drainage, somewhat salty, and soils with surface ponds are classified in this group. Their topography and their conditions affects the surface and bottom layers. Because of this kind of problems, the plants that can be grown are very limited, and also their process methods are different.

These classes are further divided into sub-classes and units as given in enclosed map 2. In the foundation III class soils:

- Çukurkamiş clay, fair drainage
- Mercimekli clay, fair drainage
- Karahöyük clay, fair drainage
- Mercimekli clay, bad drainage
- Karahöyük silty clay, fair drainage
- Çukurkamiş clay, bad drainage
- Çukurkamiş clay, bad drainage, slightly salty
- Karahöyük clay, bad drainage, slightly sloping
- Çukurkamiş clay, bad drainage, slightly sloping
- Mercimekli clay, bad drainage, slightly salty
- Mercimekli silty clay, fair drainage
- Karahöyük silty clay, bad drainage, slightly salty

III_{sw}

This group of soils have drainage problems because of their heavy surface and heavy sub-structures. The degree of drainage changes from fair to bad. The partly concave topography affects this slightly.

III_{sw-1}

This group of soils has heavy surface structure, consequently the irrigation or rain water penetrates very

slowly. The lower layers are lighter than the surface. This class includes:

- Karahöyük clay, fair drainage, Hacıköse clay, fair drainage
- Karahöyük silty clay, fair drainage soils

The productivity of this group of soils is fair to good. Their surface structures are heavy. Because of these characteristics, drainage and attaining a proper planting condition (temperature) are problems. Consequently, the processing of the soils is also difficult. In order to prevent negative surface effects, remaining plants should be kept in the soil, and mixing of heavy manure every three to five years and green grass fertilizer application should be done. In addition, irrigation and rain water should be removed by good surface drainage systems.

III_{sw-2}

In addition to III_{sw-1} group, this group has heavy structure in all profiles. Core drainage is fair, surface drainage is insufficient or bad. In the foundation, this group soils include the following:

- Mercimekli clay, fair drainage
- Çukurkamiş clay, fair drainage
- Mercimekli silty clay, fair drainage
- Çukurkamiş clay, fair drainage, slightly sloping

This group of soils has fair productivity. Attaining of proper planting condition and temperature and soil processing are difficult. Crop rotation including the bean family, wheat cotton and sunflowers might be suitable. In order to prevent negative influence of the soil structures, the amount of organic compounds should be increased by means

of 2 to 4 years of green grass fertilizing and 3 to 5 years of deep plowing or bottom explosion. If irrigation farmaing is considered, a closed drainage system should be established.

III_{sw-3}

Generally this group has a more concave topography and bad drainage. These soils have heavy structure and buried profiles. In the foundation, this group of soils includes the following:

- Mercimekli clay, bad drainage
- Çukurkamiş clay, bad drainage
- Mercimekli clay, fair drainage, slightly salty

These soils have concave topography, consequently they sometimes have slight salinity. In order to increase their productivity, increase the organic compounds, and do sowing in turns (first deep-rooted fodder plants), and green fertilizer. In case of irrigation farming, surface and closed drainage system should be established. These areas are suitable for growing fodder plants and cereals.

III_{sw-4}

- Karahöyük silty clay, bad drainage, slight salinity
- Çukurkamiş clay, bad drainage, slight salinity
- Mercimekli clay, bad drainage, slight salinity;
  These soils belong to this group.

Surface and bottom structures are heavy, their topography is partly concave, consequently these soils have bad drainage and slightly saline properties. Productivity properties are less than medium level. Organic compounds must be increased in these soils by mixing stable manure with soils, once in

two or four years green fertilizer should be applied. Crop rotation with short-root fodder plants first, should be grown. After effective surface and drainage systems are obtained, decreasing the salinity by washing is advantageous.

III_{ws} class

This class of soils has heavy textured topography, consequently rain or overflow water accumulates on the surface for a long time. In that case drainage of this soil is very bad. Choice of good conditions for processing of soil, working time, sowing time, and harvest conditions are limited.

III_{ws-1}

The basic source of the problems of this soil is especially its location, and soil class problems are less important. Mercimekli clay and soil which accumulates water on the surface in the winter season are in this class. According to the topography, this class of soil has bad drainage. Consequently, a drainage development study should be made. First, soil arrangement and effective surface drainage studies should be made. Now these soils are used to grow cotton, cereals, fodder plants, and as pasture. If topography and drainage conditions are developed, it can be used widely and effectively for agriculture.

III_{ws-2}

This class of soils have more concave topography than the III_{ws-1} class soils. Therefore they are affected by surface ponds. This limits plant cultivation. Mercimekli silty clay, which has winter flooding, is a member of this class. Smoothing of the III_{ws-1} class is effective for this class also.

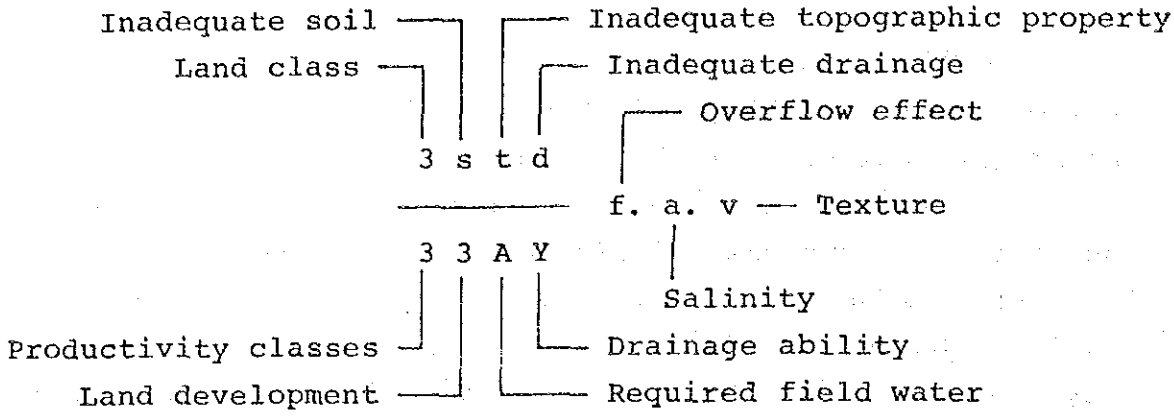
V class

This class of soils can not be used under the present conditions. Because of their smooth and nearly smooth texture, they are influenced by frequent over-flowing and bad drainage structure. Their topographic conditions makes long term surface ponds during the winter precipitations until the beginning of summer. In this group Mercimekli clay, bad drainage, long term surface ponds soil are members of this group. These soils can be cultivated after good drainage is provided.

4.4 Irrigation Ability of Çukurova Agriculture Foundation

The irrigation farming land classification contains soils that have insufficient precipitation or irregular precipitation which affects normal products. The purpose of this classification system is to find the possibilities of the irrigation water and to perform research on the physical, chemical, morphological properties of the land. In this way, the suitability of the soils for irrigation farming in an economic way should be interpreted by different processes.

In accordance of the above-mentioned purposes, the Çukurova Agriculture Foundation base soil map is interpreted and the soils are classified for suitability for irrigation farming. In the classification, the symbols given below were used (enclosed map 3).



Productivity Classes

1. Good
2. Medium-good
3. Medium
4. Low
5. Very low

Land Development

1. Low
2. Medium
3. High
4. For special products
5. Very high

Required Water Class for Field

A. Low
B. Medium
C. High

Drainage Ability Class

X. Good
Y. Limited
Z. Poor

By using this symbols, the irrigation farming ability classes of the foundation soils are given in Table 7 and in Map 3.

The Çukurova Agriculture Foundation area has a Meditteranean climate, as mentioned in the climate chapter. The total amount of rain seems to be enough for the water required for the culture plants. However, the rainfall does not occur at the right time, when the plants need the water. As a matter of fact irrigation farming gives higher productivity than the dry farming. This is the reason that the water should be saved, and irrigation is necessary.

The importance of irrigation should be known, also when passing from dry farming to irrigation farming the rules should be adopted, the knowledge for processing of soil should be known.

The biggest problem in the foundation soil is drainage, as mentioned before, this problem originated from several reasons. These reasons are insufficient drainage channels, local topography, soil surface and soil base have very heavy structure, accumulation of water in the uneven surface, etc. More than these factors, hole topography and heavy structure effect the Çukurkamiş, Mercimekli and Karahöyük series. The series of Hacıköse is completely suitable for irrigation. However, the above-mentioned reasons also affect this area. It is recommended that the methods of use given in Table 8 should be followed, and these suggestions can be improved by the technical personnel of foundation by means of local investigations and knowledge.

In the irrigation farming conditions, cultivated plants needs more nutrition compounds. After the watering some plant nutrition elements are washed out. Considering this reason, enough nutrition elements should be provided for the soil. Planting should be done in rotation, organic compounds should be increased and green grass fertilizer should be used.

Table 7 Suitability cagetories of irrigation farming of the Cukurova Agriculture Foundation

Class of irrigation farming land	Limitation factors		Requirements for irrigation
1	-	Hs	Smooth surface lightly, increase permeability
2s	Heavy surface texture	Çç,Mc, Kc,Ks	Smooth surface slightly, controlled irrigation, green fertilizing, plowing under of remaining plants
2sd	Heavy surface texture, medium permeability, in bottom insufficient drainage	Çcy,Mcy, Hk,Kcy, Kszy	Establishment of surface drainage and establishment of surface drainage after finding a place for disposal control irrigation. Increased organic compounds.
2d	Insufficient drainage, slight salinity	Kly, Ssys,Ssy	Controlled irrigation after the establishment of drainage. Increased organic compounds.
2t	Slight sloping, insufficient topography	Ksh	-
2ts	Heavy surface texture and slight sloping, insufficient topography	Kch, Gch, Mch	Establishment of drainage system, increase of permeability, smoothing surface, and parallel soil process to the smoothing curves
2tsd	Insufficient topography, heavy surface texture medium-low permeability, insufficient drainage	Mcy	In addition to plowing under remaining plants, green fertilizing, controlled irrigation

Class of irrigation farming land	Limitation factors		Requirements for irrigation
3sd	Heavy texture in all profile, medium-slow permeability, insufficient to bad drainage	Mco,Çoo, Mso,KCO, Kso,Mcos, Çcoh	Establishment of close drainage system and drainage system after finding place for disposal, fish ridge soil process, green fertilizing, plowing under of remaining plants, controlled irrigation
4sd (only for pasture land)	Heavy surface texture, concave topography, low to medium permeability, bad drainage, slightly sloping	Mcf,Çcf, Ksf	Finding a place for disposal of surface and core drain system
4dst (only for pasture land)	Because of the factors of insufficient topography	Kcfh	Finding a place for disposal of the surface and core drain system
6ds	Heavy texture in all profiles, bad drainage, low permeability, ponds on the surface, slight salinity	Çcfs	Not suitable for irrigation

SUMMARY

In this study, in a 35,140 decare area, physical, chemical and morphological properties of the Çukurova Agriculture Foundation soils were investigated and a soil map prepared.

Foundation lands are situated inside the Ceyhan District on the alluvium structure. The most important water source is Ceyhan River, which flows through the eastern part of the foundation. This river gives a complex structure by its different activities at different times. It has been found that there are some small rivers which join the Ceyhan River, and affect the structure.

The area studied has been classified based on the differences between physiographic units as "old river terraces" and "young river terraces" and physiographic units. On these units five different soil types were determined and mapped.

In this study, the soil series, their important phases and different type land were chosen as mapping units according to the detailed soil study and mapping method. Black and white 1:20,000 scale aerial photographs was used as a basic cartographic material.

The determined soil series have heavy soil properties, and in the Mercimekli series the clay content is 72%. Foundation soil was formed by the young alluvial deposits which contain 20-25% $CaCO_3$, therefore it can be said that it has much lime. Very little salinity was found. Only in the local holes of Çukurkamiş, Mercimekli and Karahöyük areas, a small amount of salt was found.

The investigated soils are classified as "ordo", "sub ordo", "big group" and "sub group". These soils are classified as Çukurkamiş and Mercimekli in the Vertisol ordo, Kastal is in

Mollisol ordo and Karahöyük series, and the Entisol ordo group.

The most important problems in the foundation were found as high lime concentration, heavy texture because of the clay and silt, insufficient drainage and some salinity.

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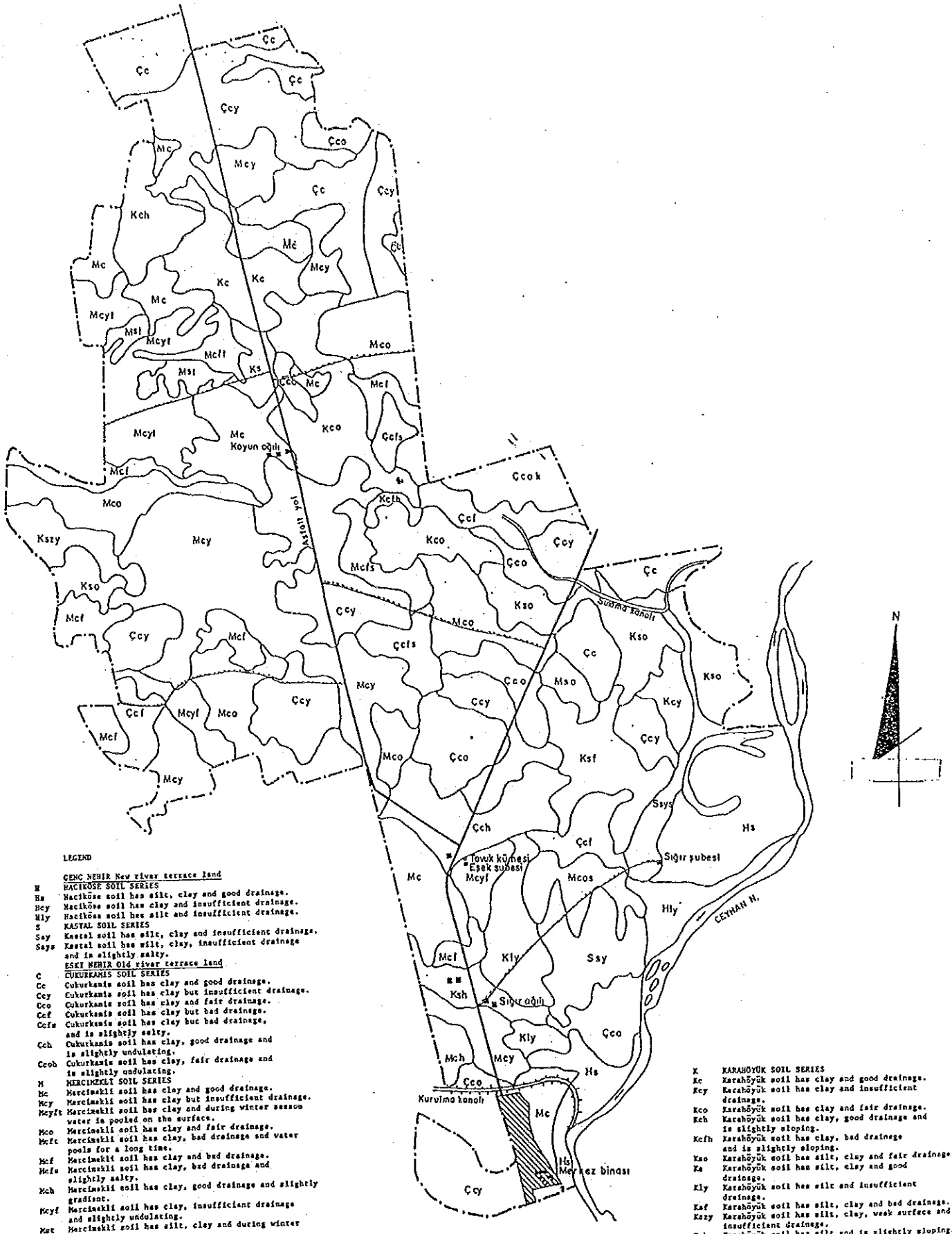
Map - 1 Basic soil map of the Cukurova Agriculture Foundation



LEGEND

ÇENC NEHİR New river terrace land

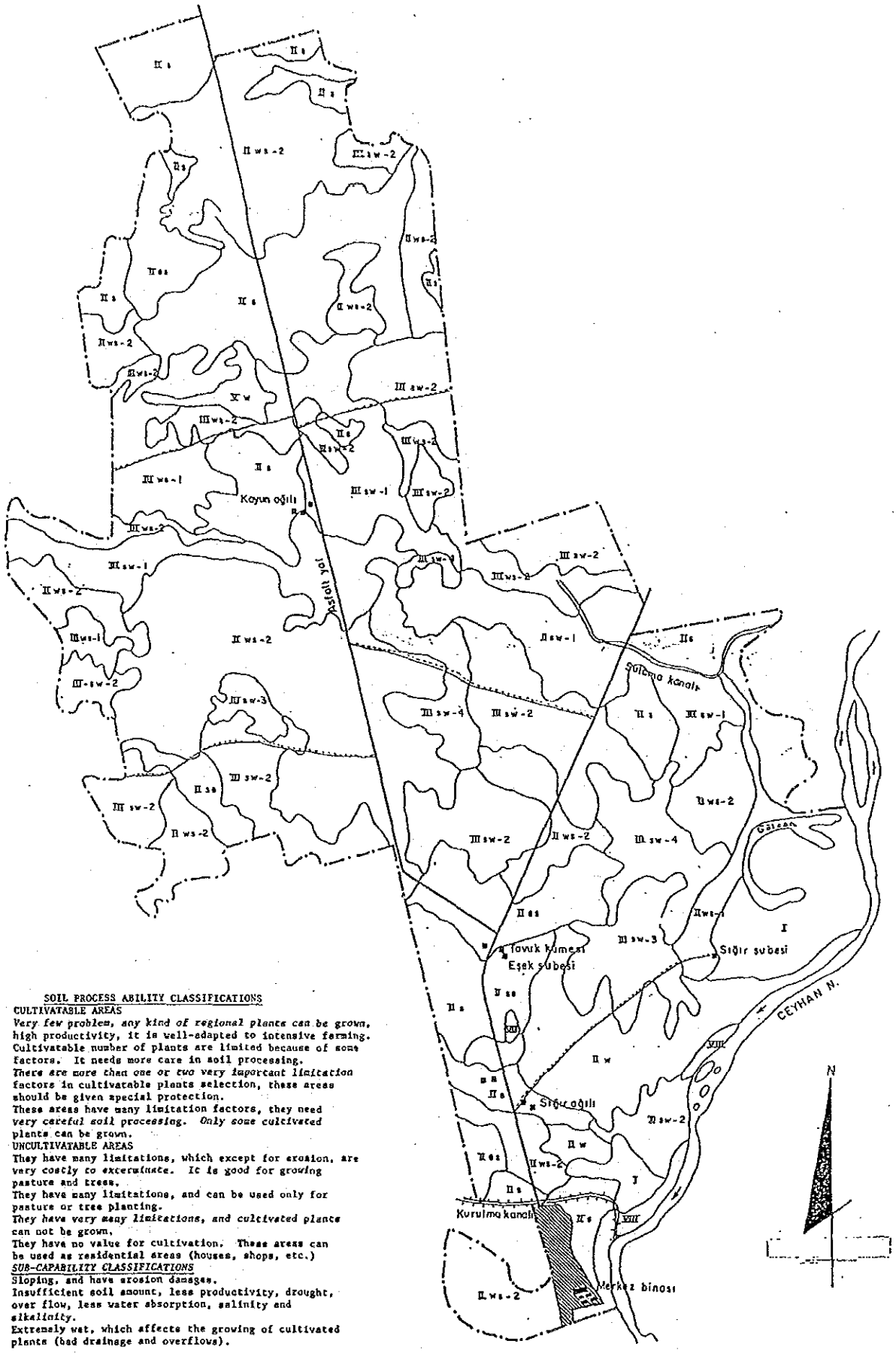
H HACIKÖSE SOIL SERIES
Hs Hacikőse soil has silt, clay and good drainage.
Hcy Hacikőse soil has clay and insufficient drainage.
Hly Hacikőse soil has silt and insufficient drainage.
S KASTAL SOIL SERIES
Scy Kastal soil has silt, clay and insufficient drainage.
Scys Kastal soil has silt, clay, insufficient drainage and is slightly salty.

ESKİ NEHİR Old river terrace land

C ÇUKURKANIS SOIL SERIES
Cc Çukurkanis soil has clay and good drainage.
Ccy Çukurkanis soil has clay but insufficient drainage.
Cco Çukurkanis soil has clay and fair drainage.
Ccf Çukurkanis soil has clay but bad drainage.
Ccfs Çukurkanis soil has clay but bad drainage, and is slightly salty.
Cch Çukurkanis soil has clay, good drainage and is slightly undulating.
Ccob Çukurkanis soil has clay, fair drainage and is slightly undulating.
M MERCİMEKLİ SOIL SERIES
Mc Mercimekli soil has clay and good drainage.
Mcy Mercimekli soil has clay but insufficient drainage.
Mcyft Mercimekli soil has clay and during winter season water is pooled on the surface.
Mco Mercimekli soil has clay and fair drainage.
Mcfc Mercimekli soil has clay, bad drainage and water pools for a long time.
Mcf Mercimekli soil has clay and bad drainage.
Mcfs Mercimekli soil has clay, bad drainage and slightly salty.
Mch Mercimekli soil has clay, good drainage and slightly gradient.
Mcyf Mercimekli soil has clay, insufficient drainage and slightly undulating.
Mst Mercimekli soil has silt, clay and during winter overflowing area.
Mso Mercimekli soil has silt, clay and fair drainage.
Mcos Mercimekli soil has clay, fair drainage and slightly salty.

K KARAHÖYÜK SOIL SERIES
Kc Karahöyük soil has clay and good drainage.
Kcy Karahöyük soil has clay and insufficient drainage.
Kco Karahöyük soil has clay and fair drainage.
Kch Karahöyük soil has clay, good drainage and is slightly sloping.
Kcfh Karahöyük soil has clay, bad drainage and is slightly sloping.
Kso Karahöyük soil has silt, clay and fair drainage.
Ks Karahöyük soil has silt, clay and good drainage.
Kly Karahöyük soil has silt and insufficient drainage.
Ksf Karahöyük soil has silt, clay and bad drainage.
Kszy Karahöyük soil has silt, clay, weak surface and insufficient drainage.
Ksh Karahöyük soil has silt and is slightly sloping.

Map - 2 Classification map of usability of the Cukurova Agriculture Foundation land



SOIL PROCESS ABILITY CLASSIFICATIONS

CULTIVATABLE AREAS

I *Very few problem, any kind of regional plants can be grown,* high productivity, it is well-adapted to intensive farming.

II Cultivatable number of plants are limited because of some factors. It needs more care in soil processing.

III *There are more than one or two very important limitation* factors in cultivatable plants selection, these areas should be given special protection.

IV These areas have many limitation factors, they need *very careful soil processing. Only some cultivated* plants can be grown.

UNCULTIVATABLE AREAS

V They have many limitations, which except for erosion, are *very costly to exceruinate. It is good for growing* pasture and trees.

VI They have many limitations, and can be used only for pasture or tree planting.

VII *They have very many limitations, and cultivated plants* can not be grown.

VIII They have no value for cultivation. These areas can be used as residential areas (houses, shops, etc.)

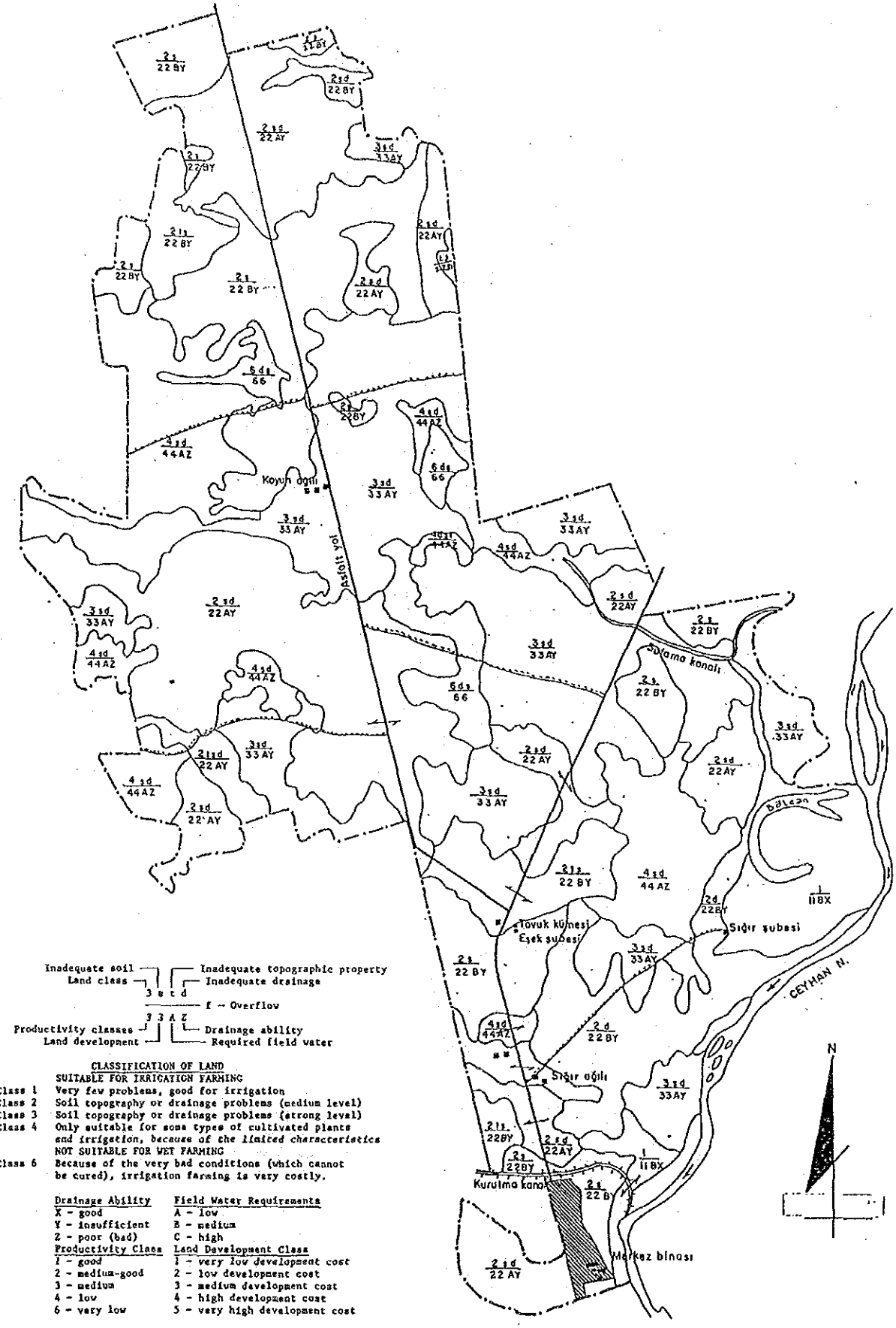
SUB-CAPABILITY CLASSIFICATIONS

e Sloping, and have erosion damages.

s Insufficient soil amount, less productivity, drought, over flow, less water absorption, salinity and *alkalinity.*

w Extremely wet, which affects the growing of cultivated plants (bad drainage and overflows).

Map - 3. Classification map of irrigation farming possibilities of the Cururova Agriculture Foundation



Inadequate soil — Land class — Inadequate topographic property — Inadequate drainage

3 s t d — f – Overflow

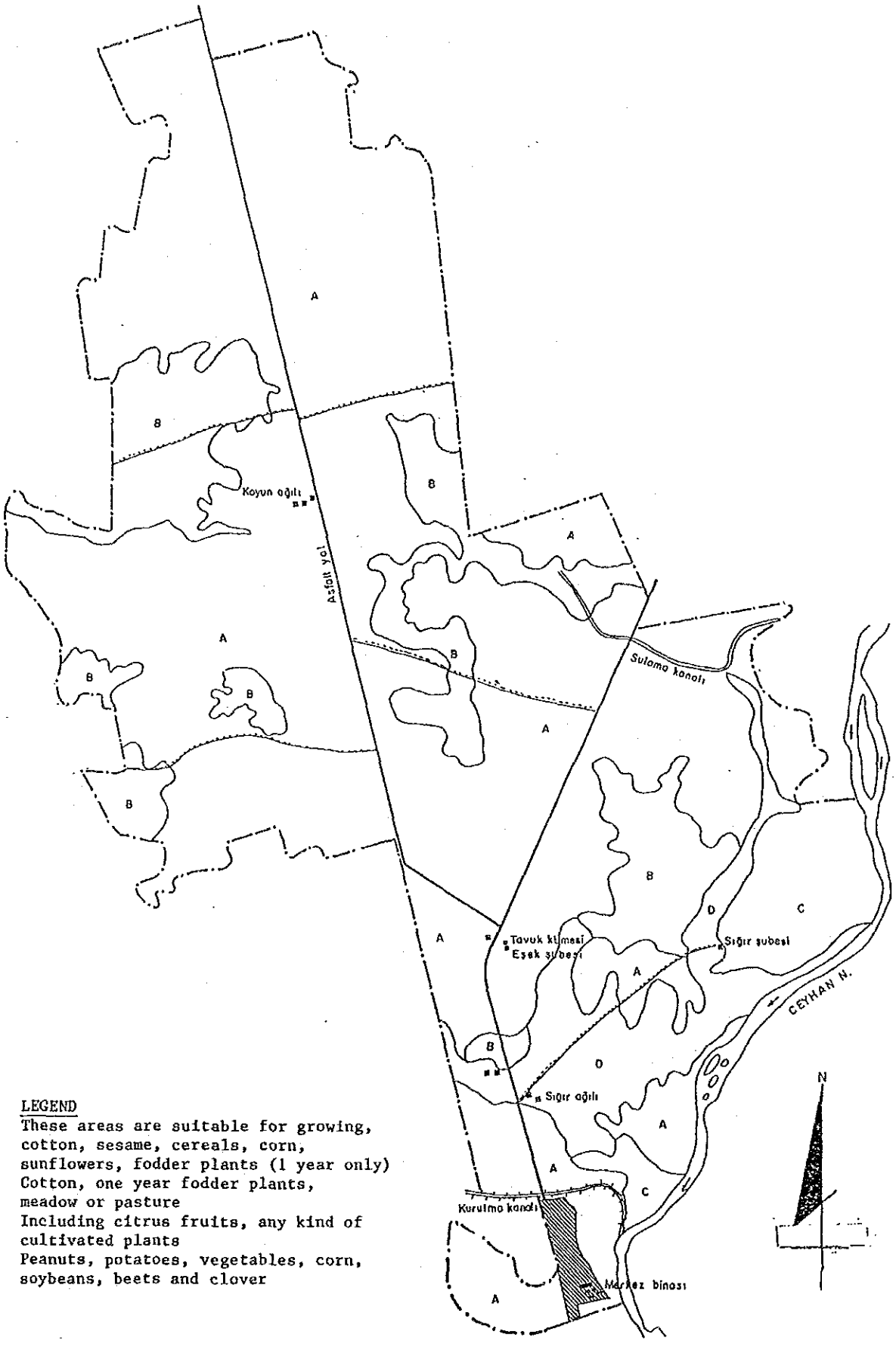
Productivity classes / Land development — 3 3 A Z — Drainage ability — Required field water

CLASSIFICATION OF LAND
SUITABLE FOR IRRIGATION FARMING

Class 1 Very few problems, good for irrigation
Class 2 Soil topography or drainage problems (medium level)
Class 3 Soil topography or drainage problems (strong level)
Class 4 Only suitable for some types of cultivated plants and irrigation, because of the limited characteristics
NOT SUITABLE FOR WET FARMING
Class 6 Because of the very bad conditions (which cannot be cured), irrigation farming is very costly.

Drainage Ability	Field Water Requirements
X - good	A - low
Y - insufficient	B - medium
Z - poor (bad)	C - high
Productivity Class	**Land Development Class**
1 - good	1 - very low development cost
2 - medium-good	2 - low development cost
3 - medium	3 - medium development cost
4 - low	4 - high development cost
6 - very low	5 - very high development cost

Map - 4. Map of plant adaptation of the Cukurova Agriculture Foundation



LEGEND

A - These areas are suitable for growing, cotton, sesame, cereals, corn, sunflowers, fodder plants (1 year only)

B - Cotton, one year fodder plants, meadow or pasture

C - Including citrus fruits, any kind of cultivated plants

D - Peanuts, potatoes, vegetables, corn, soybeans, beets and clover