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9. ABSTRACT

A description of how the U.S. System of soil classification can be used to convey the idea of soil water behavior and the availability of such water for crop production. A system of soil classification will be useful to agriculture only if the system can show relationship to behavior and eventually to management. The U.S. System has this attribute more than the other systems to date. The Suborder category and some of the lower categories show relation to wetness and the soil moisture regimes. The Family category indicates parameters such as texture, mineralogy, and temperature regimes; parameters which are all important to agriculture and non-agricultural interpretations of soils. Soil water release characteristic curves of selected soils have been presented to show soil-water behavior in soils of Hawaii. Because there is high correlation between soil water release or retention and properties such as soil structure and because the latter is related closely to mineralogy, especially in the Tropics, the Family category of the U.S. System has special significance. That is, if the Family category of a soil is recognized, much of the behavior of related soils can be predicted.

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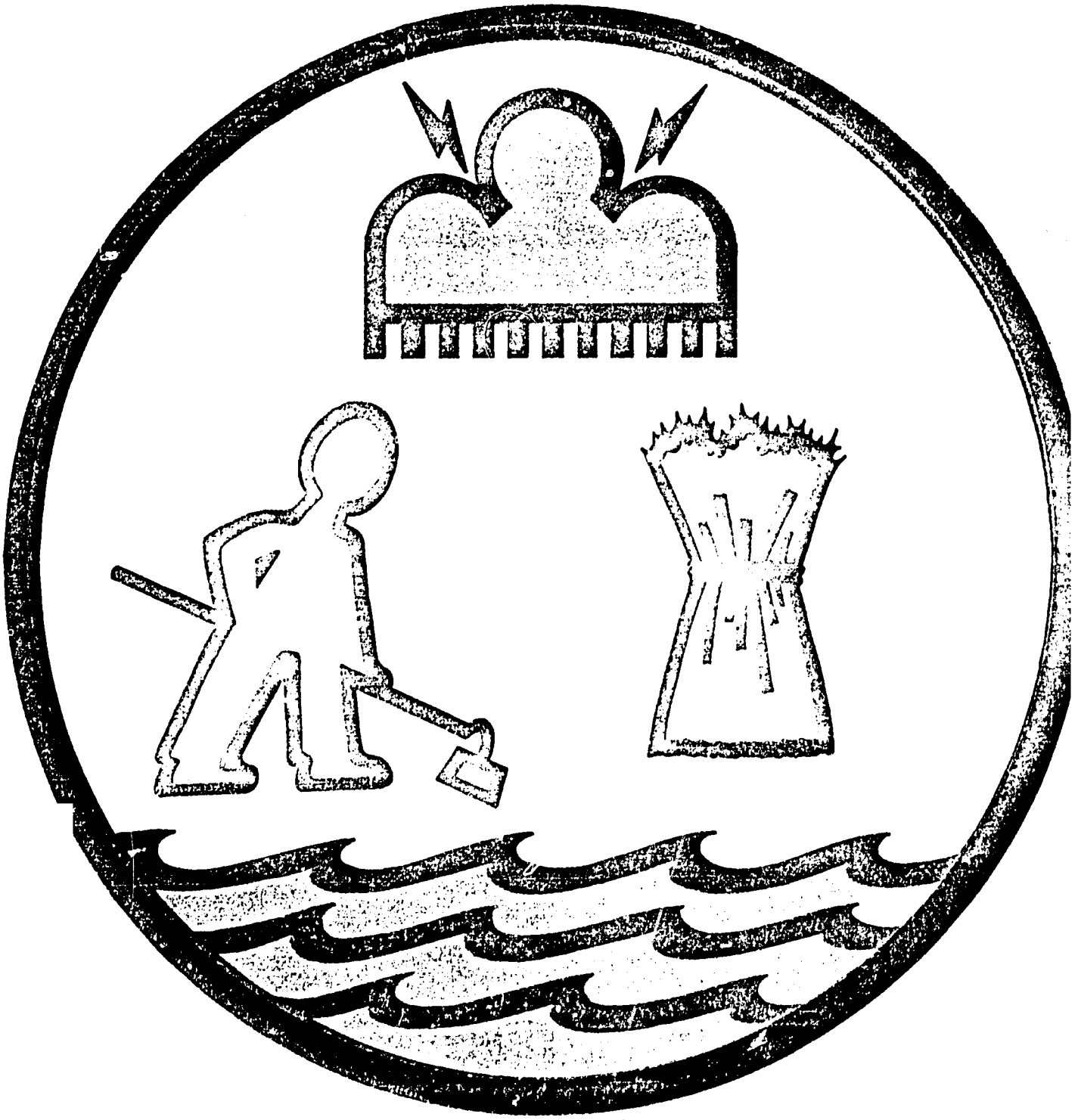

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SYSTEMS OF SOIL CLASSIFICATION AND THEIR RELATION TO WATER MANAGEMENT

L. D. Swindale, G. Y. Tsuji, and H. Ikawa[1]

Introduction

Soils are classified for several reasons. One of the reasons is to learn or to understand the relationships of the different soils as they apply to agriculture. Presumably, under a given set of environmental conditions, soils which are similarly classified should have similar properties and behavior and should respond nearly alike to management practices. Man has been classifying soils from early times and much has been written on this subject. For example, some of the later works on the basic principles of soil classification are covered by Baldwin et al. (1938), Cline (1949), Soil Survey Staff (1970), Kellogg (1963), and Smith (1968).

Several systems of soil classification are used throughout the world and these systems are described in a recently published book by Buol, Hole, and McCracken (1973). These classification systems or schemes are those of USSR, France, Belgium, the United Kingdom, Australia, Canada, and Brazil.

Although the different systems emphasize different bias, they n vertheless convey the importance of climate, availability of soil water, and/or soil management as influenced by soil water.

The purpose of this paper is to describe how the U.S. System of soil classification, one of the more highly developed systems, can be used to convey the idea of soil water behavior and the availability of such water for crop production.

Soil Classification System of the U.S.

The latest U.S. system of soil classification is known by several names but more commonly as the U.S. Comprehensive Soil Classification System or the U.S. Soil Taxonomy. Various members of the Soil Survey staff of the U.S. Department of Agriculture as well as other soil scientists are responsible for this system, which was developed over a period of about 30 to 35 years. but Dr. Guy D. Smith deserves much of the credit in taking the leadership in finalizing the system.

The U.S. System consists of six categories. The highest category, which is made up of 10 so-called Orders, are differentiated one from the other by some soil forming processes as indicated by the occurrence of one or more diagnostic horizons. These Orders in turn form the Suborders based on properties which are influenced by wetness, soil moisture regimes, parent material, and vegetation in the mineral soils and by the degree of organic fiber decomposition in organic soils. The Suborder, then, is when the classification system first shows some relationship to water characteristics in soils. In the Great Group, which represents the third category, are soils of the Suborders possessing similar diagnostic horizons and layers, base status, and soil moisture and temperature regimes. The Subgroup constitutes the fourth category which indicates whether or not a particular Great Group represents a central concept taxa or whether or not that group shows close relation to other Great Groups, Suborders, or Orders. Then, there is the Family category, probably one of the most important categories. Characteristics such as soil texture, mineralogy, and temperature regimes which are important for agricultural and nonagricultural interpretations and uses are stressed. Finally, the Series represents the sixth category which includes soils with horizons possessing similar morphological, chemical, and mineralogical properties.

This paper will describe in the next few sections how certain categories of the U.S. System show relevance to moisture characteristics in soils and finally to water management.

The U.S. System and Its Relation to Moisture Characteristics

As described in Soil Taxonomy (Soil Survey Staff, 1970), there are three soil moisture regimes–the saturated, leaching and nonleaching regimes. The moisture regime is influenced by groundwater, moisture retention at different tensions, and period of wet condition. For a comprehensive review, the Soil Taxonomy should be consulted. The review will also be essential to learn the classes of moisture regimes–the aquic, udic, ustic, xeric, and aridic, or torric regimes. The definitions will reveal that the aquic regime represents soil moisture conditions which are quite saturated, whereas the aridic or torric regime is one in which soil moisture is usually a limiting factor. Soil utilization for crops under these

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extreme conditions requires either removal or application of water.

Influence of the Moisture Regime on the Taxa of the U.S. System

As mentioned previously, the suborder is the category when some relationship to water characteristics in soils is first known. Examples are presented in Table 1 to show this relationship.

There are actually 47 Suborders but Table 1 lists only 22 of them which have properties showing association with wetness and soil moisture regimes. Where applicable, the Great Groups also show these influences, and examples will be presented in succeeding sections.

Except for the Suborder Folists, the Order Histosols by definition indicates a wet or saturated regime. No Subgroups of Histosols are, therefore, presented in Table 1. Aridisols by definition similarly denote a very dry condition in which there is insufficient water for normal plant growth unless irrigated. Table 1 lists, therefore, those Subgroups that show special significance to water characteristics in the different soils.

Examples of relationship between moisture regime and the taxa at the lower categories are, for example, the Subgroup Ustoxic Humitropepts for a soil series called Kolekole or the Subgroup Aridic Haplustolls for a soil series called Mahukona.

Influence of Soil Water Characteristics on Water Management

Water management in agriculture involves (1) protecting or reclaiming land from excess precipitation or flooding, (2) husbanding and managing soil moisture, (3) optimizing cropping practice to the moisture regime, (4) impoundment, distribution, and application of irrigation water supplies, and (5) coordinated management of watershed areas (CUSUSWASH Annual Report, 1973). All of the topics are wholly or partially dependent on the water release or water holding characteristics of a soil.

For most soils found in the temperate zones, the water release characteristics of a soil can be predicted from its texture or particle size distribution. That is, in most instances, coarse-textured soils would likely have high water infiltration rates and low water holding capacities while a clay-textured soil would have low infiltration rates and high water holding capacity. Either type of soil would therefore require vastly different water management practices.

Prediction of water release characteristics based on soil texture may not be valid for some of the agriculturally important soils in Hawaii and, in all probability, for similarly classified soils in other tropical areas of the world. For Hawaiian soils, particularly those classed as Oxisols and Ultisols, the water release characteristic curves are similar to those of sand at low suctions (Figures 1 and 2). Unlike sand, however, these soils retain as much as 30 percent water by volume at 15 bars of suction. The large water holding capacity of these four soils at high suctions were attributed to the presence of intra-aggregate pores (Sharma and Uehara, 1968; Tsuji, Watanabe, and Sakai, 1973). Since all four soils, the Wahiawa (Tropeptic Eutrustox), Molokai (Typic Torrox), Manana (Orthoxic Tropohumult) and Paaloa (Humoxic Tropohumult), have textures of a clay soil, soil structure rather than soil texture was considered to be more influential in determining the pore size distribution and the water release characteristics of these soils.

Examples of water release characteristic curves for soils of the Inceptisols and Vertisols Orders are presented in Figures 3 and 4. The Akaka (Typic Hydrandept) and the Lualualei (Typic Chromusterts) soils both shrink on drying. The former dries irreversibly because of its amorphous mineralogical constituents while the latter, predominantly montmorillonitic, shrinks and swells reversibly on drying and wetting.

Except for the Akaka and Lualualei soils, field capacity for the soils of Figures 1, 2, and 3 occurs at suctions less than the "standard 1/3 bar." In terms of water management practices, this is of utmost importance. If knowledge of the water characteristics of say an Oxisol were not available a farmer who samples a soil which is at 1/3 to 15 bars suction under field conditions will find little difference in water content. He may then incorrectly conclude that the amount of available water is sufficient. Similarly, if an irrigationist finds that tensiometer readings have not exceeded 1/3 bar, irrigation may be delayed and

Table 1. Influence of the moisture regime on the Suborder names.

ORDERS:	Entisols	Inceptisols	Spodosols	Histosols	Mollisols	Ultisols	Alfisols	Oxisols	Vertisols	Aridisols
SUBORDERS:	Aquents	Aquepts	Aquods		Aquolls Udolls Ustolls Xerolls	Aquults Udults Ustults Xerults	Aqualfs Udalfs Ustalfs Xeralfs	Aquox Ustox Torrox	 Uderts Usterts Xererts Torrerts	

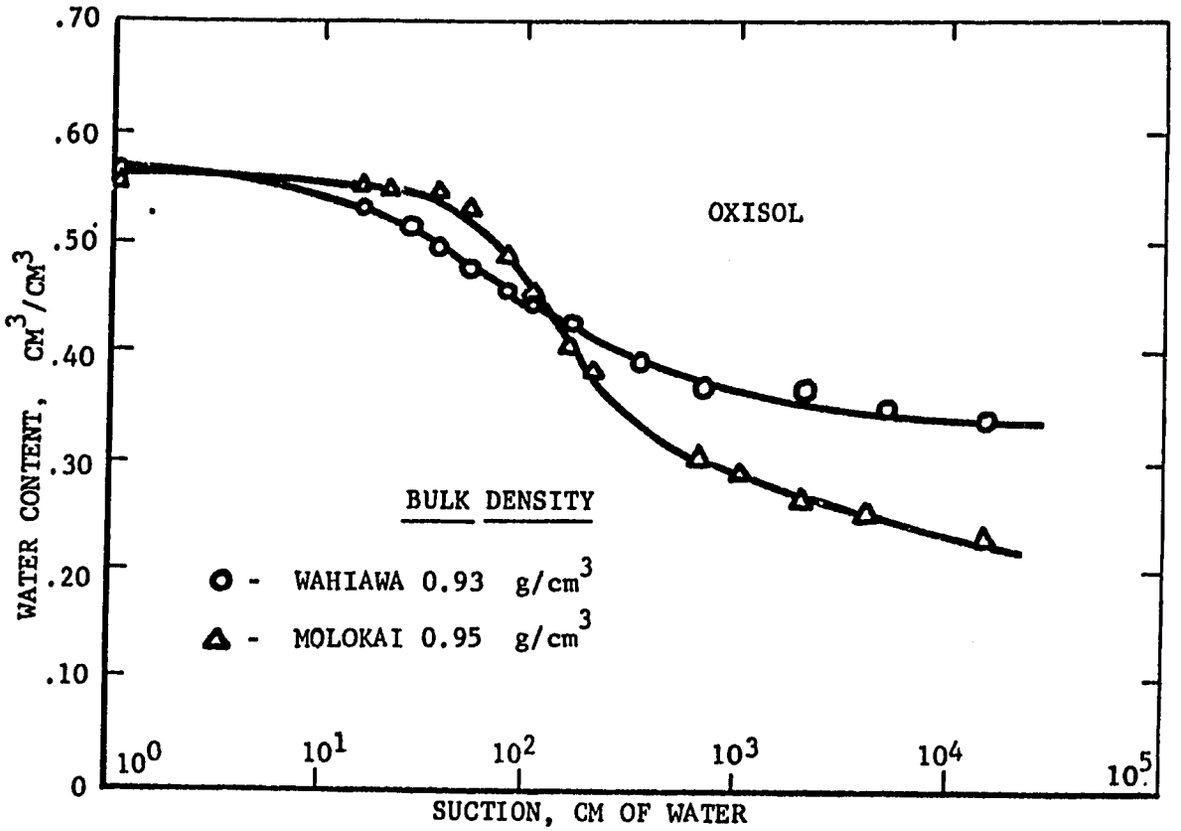

Figure 1. Soil water release characteristic curves for Wahiawa (Tropeptic Eutrustox) and Molokai (Typic Torrox) soils (After Tsuji, Watanabe, and Sakai, 1973).

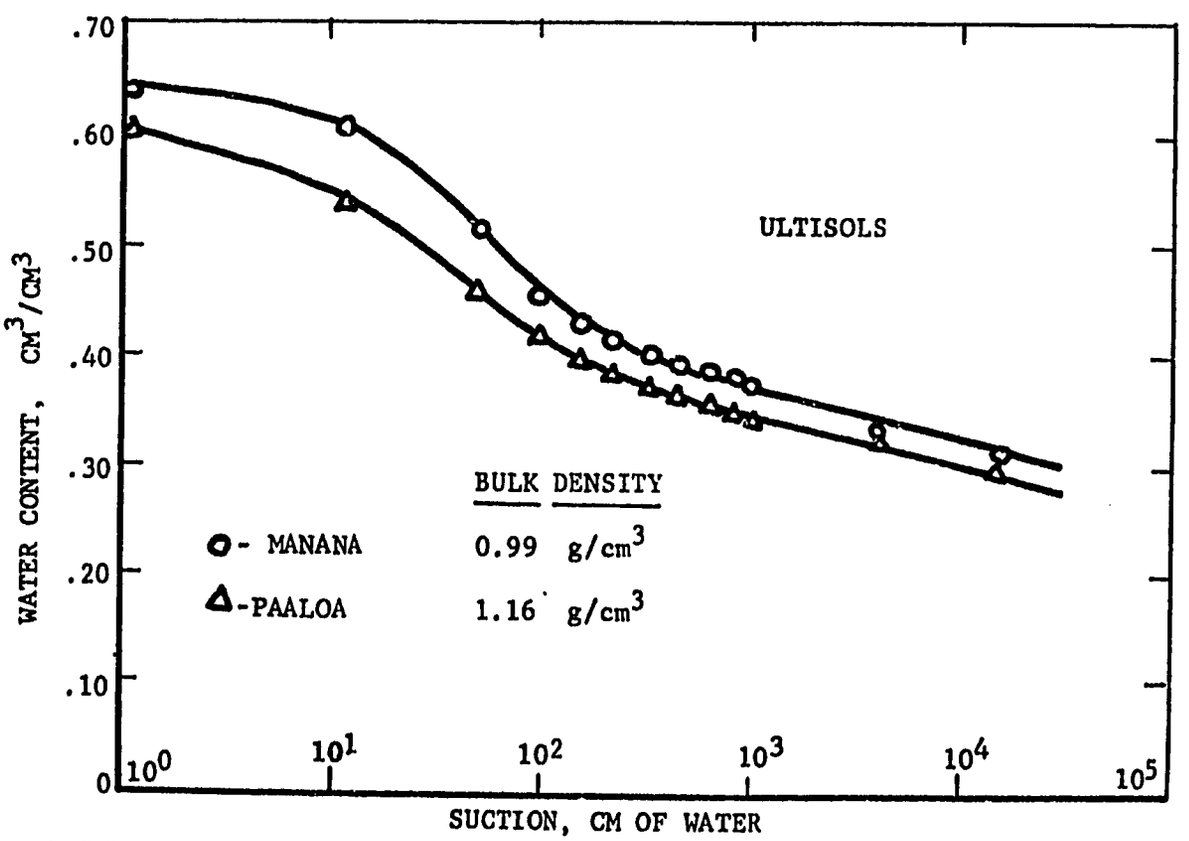

Figure 2. Soil water release characteristic curves for Manana (Orthoxic Tropohumult) and Paaloa (Humoxic Tropohumult) soils. (After Tsuji, Watanabe, and Sakai, 1973.)

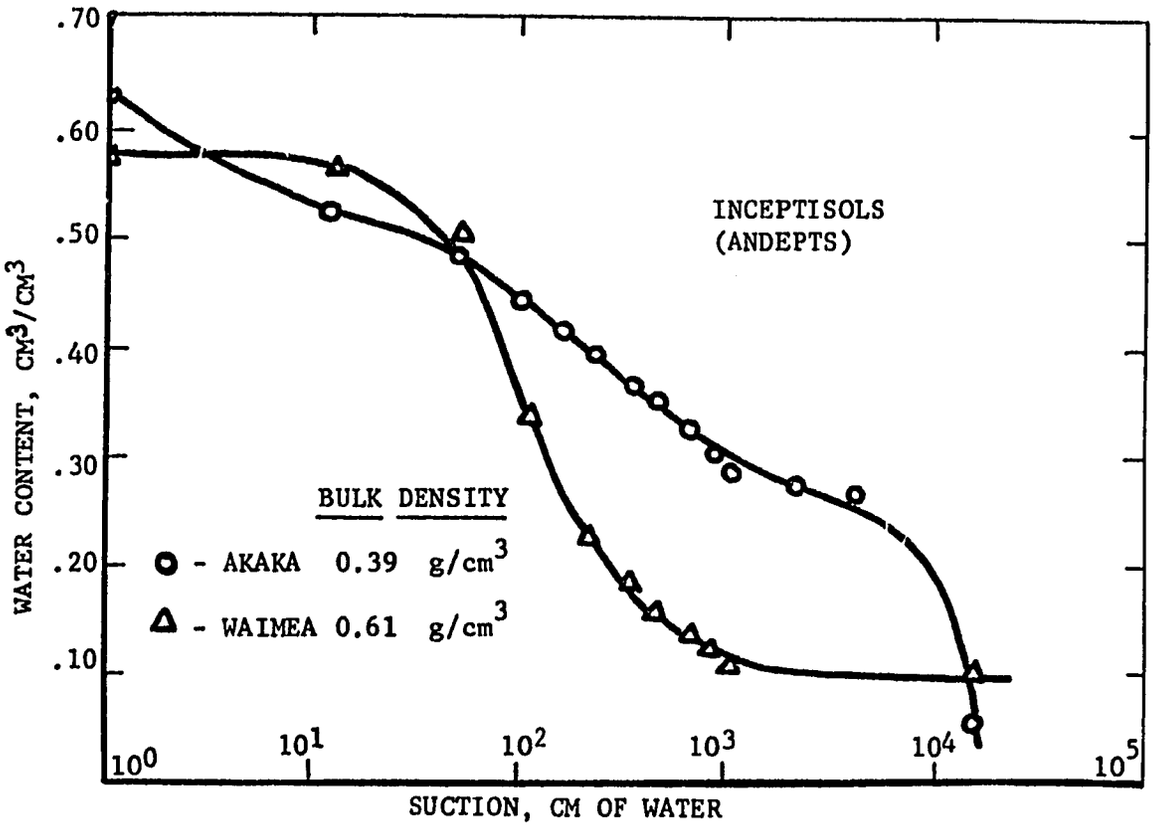

Figure 3. Soil water release characteristic curves for Akaka (Typic Hydrandept) and Waimea (Typic Eutrandept) soils. (After Tsuji, Watanabe, and Sakai, 1973.)

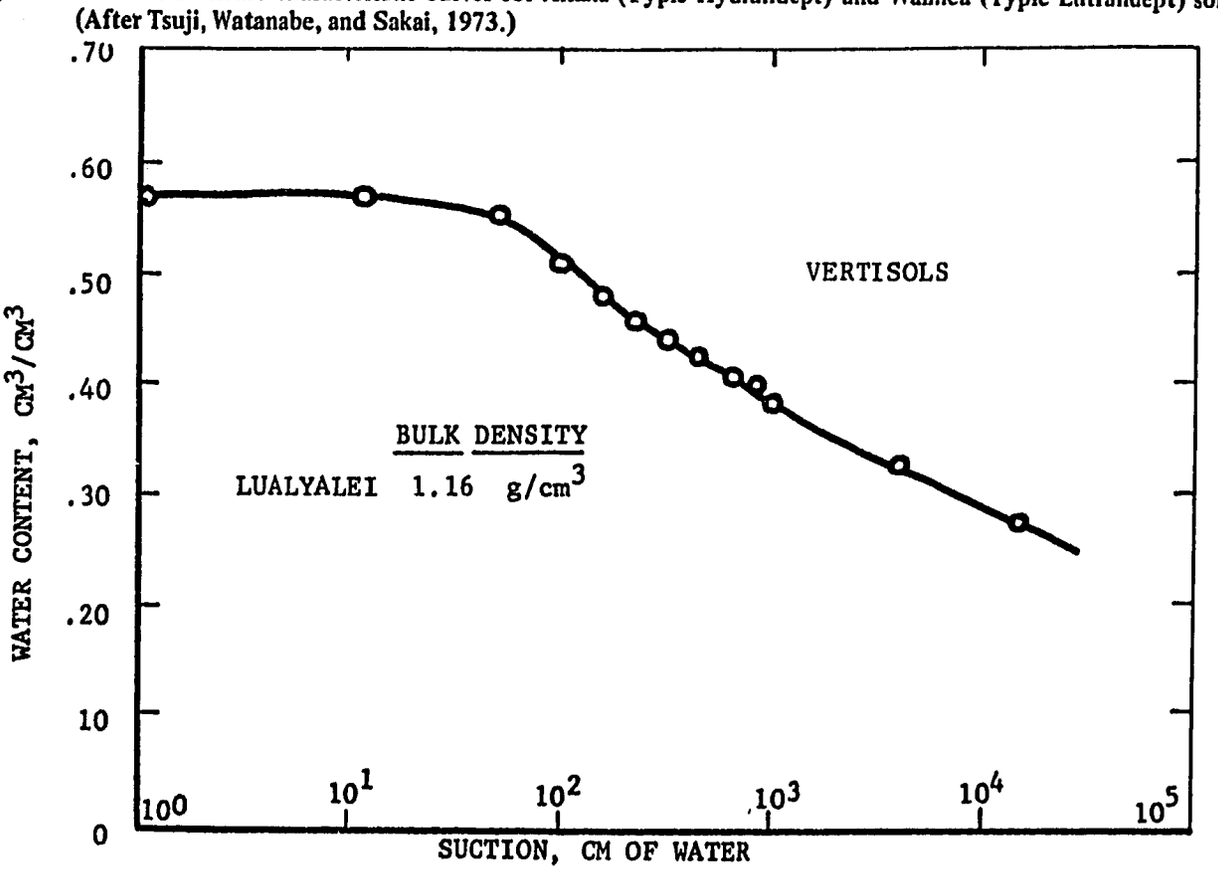

Figure 4. Soil water release characteristic curve for Lualualei (Typic Chromusterts) soil. (After Tsuji, Watanabe, and Sakai, 1973.)

10^4 10^5

subsequently result in irreparable damage to crops under cultivation.

Soil Water Characteristics and Soil Classification

Water characteristics of soils can also be related to soil properties other than the soil moisture regimes. There are three major factors that influence the retention of water in soils. They are texture (pore size distribution), composition (inorganic and organic constituents), and temperature. Coincidentally or not, all three factors are diagnostic in determining the classification of soils at the Family category However, as pointed out in the previous section, textural class alone cannot be used to predict the pore size distribution of strongly aggregated clay soils such as the Wahiawa, Molokai, Manana, and Paaloa. At the Family category level, the soil classification parameter that can most likely be used in predicting the water release characteristics of a soil is soil composition, or more precisely, the mineralogy. That is, soils of similar mineralogical composition should have nearly identical water release characteristics. Consider, for example, soils of the Oxisols and Ultisols Order in Figures 1 and 2. Under the Family category, the Wahiawa and Molokai are described as clayey, *kaolinitic*, isothermic and clayey, *kaolinitic*, isohyperthermic, respectively, while the Manana and Paaloa are both described as clayey, *oxidic*, isothermic.

In Figure 1, the curves show that water is more easily extracted from the Wahiawa than the Molokai at low suctions. The opposite is true at higher suctions. Such behavior has been attributed to stronger aggregation in the Wahiawa than in the Molokai by Sharma and Uehara (1968). This difference in water release characteristics may also be related to mineralogy. The Wahiawa, although classified as kaolinitic, may in fact contain more oxides or hydrous oxides than the Molokai but less than the Manana and Paaloa. Juang and Uehara (1968) have also shown that mica is present in the Paaloa, Manana, and Wahiawa but absent in the Molokai. If differences or similarities in mineralogy can be used to predict the degree of soil structural development, then the water release characteristics of the Wahiawa, Manana, and Paaloa should be similar. This assertation appears to be borne out when curves in Figures 1 and 2 are compared.

Summary and Conclusions

A system of soil classification will be useful to agriculture only if the system can show relationship to behavior and eventually to management. The U.S. System of soil classification has this attribute more than the other systems to date. The Suborder category and some of the lower categories show relation to wetness and the soil moisture regimes. The Family category indicates parameters such as texture, mineralogy, and temperature regimes; parameters which are all important to agriculture and nonagricultural interpretations of soils. Soil water release characteristic curves of selected soils have been presented to show soil-water behavior in soils of Hawaii. Because there is high correlation between soil water release or retention and properties such as soil structure and because the latter is closely related to mineralogy, especially in the Tropics, the Family category of the U.S. System has special significance. That is, if the Family category of a soil is recognized, much of the behavior of related soils can be predicted. Relationship between the mineralogy and behavior of tropical soils has already been presented by Uehara, Swindale, and Jones (1972) in another Symposium sponsored by the AID.

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