EFFECT OF WATER QUALITY ON PLANT PRODUCTION ON CAJON SOILS

by

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ABSTRACT

The experimentation described in this manuscript is part of a project which was initiated in 1947 to study how a saline-sodic soil could be managed, to maintain maximum crop production, without the addition of expensive chemicals.

An attempt was made in this project to evaluate the basic soil and water factors that affect soil chemical changes, seedling plants, and crop yields on a saline-sodic soil on the University of Arizona Agricultural Experimental Station Farm between the 1954 to 1962 period.

The study was accomplished first by deep plowing the experimental field and then applying well water and river water of two different qualities in six combinations of leaching and irrigation source to maintain maximum crop stands and yields. The water quality treatments were arranged so that any statistical differences due to either the water used for leaching or irrigation practices could be separated and tested by statistical methods.

The well and river water used in the above experimentation were analyzed periodically to detect any chemical changes in composition. The results showed that even though the well water varied it has not changed in the amount of salt it contains from 1954 through 1962; however, the sodium content in relation to other cations showed an

increase. The river water has increased both in the salt and sodium content. In spite of these changes in both the well and river water there is no statistical correlation between the total soluble salt, the sodium-absorption-ratio, and the sodium percentage with respect to time.

Soil samples analyzed from the field showed the following results: (1) the soil saturated paste pH values were not affected appreciably by any one water quality treatment, (2) the total salts accumulated progressively under all water quality treatments, especially where well water was used exclusively, (3) the exchangeable-sodium-percentage increased the highest in the soil where well water was used exclusively, and (4) the river water leaching and irrigation combination appears to be the most effective as compared to the well water leaching and irrigation combination in keeping the salts flushed out of the soil profile and keeping the exchangeable-sodium-percentage down.

The crop yields produced on the field appear to be closely related to the initial seedling emergence. The river water leaching treatment appears to be the most effective in keeping the salts flushed out of the surface so that a good seedling stand can be produced on this soil. The cotton lint yields produced on field D showed a progressive decrease in the pounds per border after three years of continual cropping. Any significant difference in yields was due to the source of water used for leaching. The river water is preferred over the well water.

INTRODUCTION

The Safford Valley Area lies along the Gila River, within Graham County, in the southeastern part of the State of Arizona. This valley is bounded on the north by the Gila mountains, on the east by the Peloncillo mountains, and on the southwest by the Pinaleño and Santa Teresa mountains. The basin is 50 miles long and from 15 to 20 miles wide. The cultivated lands lie along the Gila River and are 0.5 to 3.5 miles from the river. The land area surveyed in 1933 had a length of about 45 miles, and ranged from about 1.5 to 4.5 miles in width and comprised a total acreage of 106 square miles or 67,840 acres (48). The estimated crop acreage, in 1961, in Graham County was 38,150 which is approximately 3.2 percent of the total acreage cropped in the State of Arizona.

The valley lies in that part of Arizona included in the arid southwest region, where clear, bright weather and intense sunlight are predominant during the greater part of the year. The amount of rainfall varies considerably from year to year. The lowest recorded rainfall is 2.98 inches and the highest, 17.38 inches. The following amounts of precipitation were recorded in Safford, Arizona according to the annual reports on ground water in Arizona by years: 1955,

6.59 inches; 1957, 10.28 inches; 1958, 12.09 inches; 1959, 7.63 inches; 1960, 7.65 inches, and in 1961, 11.52 inches. Because most of the precipitation becomes lost to high evaporation, the agriculture in the area consequently is dependent entirely upon irrigation and thus the demand for water is great.

Like other valleys in other states in the arid southwest, as well as in Arizona, the Safford valley has a problem directly arising from an inadequate supply of high quality water. As a consequence, farmers have been forced to depend more and more on well water of notoriously poor quality. The increased use of well water has changed ground water levels to a point where increasingly salty water is being pumped from farm wells.

This problem is a prime example of the fact that although the quantity of available water is the primary consideration in the development of irrigation agriculture, the quality of water becomes a more and more critical factor as the supplies of surface and ground waters are depleted.

This is certainly true in the United States where questionable ground water from pumped wells, in many areas, constitutes the principal source of irrigation supplies. These well waters in many cases are characterized by high salt contents. Some of these have unfavorable sodium to calcium ratio compared with surface river waters. In addition, even surface irrigation supplies often will contain

varying amounts of salts and sodium depending on the sampling sites along and within the same stream. The salt content of most irrigation water, however, ranges from 0.1 to 5 tons of salts per acre foot of water (28, 64).

The adverse effects of salts and sodium in these waters, as well as in the soils, are a problem in most arid lands. The expansion of supplemental irrigation, the use of concentrated fertilizer, and even the use of soft water has increased the intensity of such problems.

In Arizona, the demand for water has exceeded the amount available in streams. The demand has been partially met by the development of ground water resources and diverted irrigation water supplies from outside (27). Since 1945, the ground water has made up at least half of the state's total annual water needs; from 1955 through 1961, about two-thirds of the state's annual water needs were supplied by ground water (66, 67). There is a growing concern about our natural ground water resources. Harshbarger (27) has expressed this concern as follows: "Indeed, the annual use of water in Arizona is more than three times that available from the surface streams. The use of water from the ground water reservoirs has caused a depletion of water resources and a continual mining of water may eventually cause exhaustion."

Arizona farmers are faced with water shortage as well as the deterioration in the quality of water in stream and well waters (26, 27).

This is particularly true in areas such as the lower and upper Salt River valley and the lower and upper Gila River valley where the chief source of irrigation water is well water. In many cases these waters are characterized by high salts with very unfavorable sodium to calcium ratios as compared to river water (26, 39, 40). The use of such water on soils has been observed to disperse the soil badly causing the infiltration and penetration of waters to be greatly reduced. Crop emergence and establishment often are seriously hindered by surface crusting and salt accumulation. Because of these effects of poor quality well waters, the production of crops in some irrigated valleys has not reached a maximum.

During several dry years, 1940-1950, in the Safford Valley, for example, the reactions between the irrigation water and the soil caused a serious deterioration in soil structures (39, 40). Increased use of well waters during this period lowered the ground water levels and increasingly salty waters were being pumped from farm wells throughout the Safford Valley. This was particularly evident in 1947 when the soil of the University of Arizona Safford Experiment Station "turned bad" (40). Analyses of the soil and pump water at the station showed that the total salt content of the water had increased approximately 100 percent during these dry years, and that during the passage of this water through the soil, an excessive amount of sodium ions had been left behind on the soil complex. There is little likelihood that

this situation will change much. It appeared to observers at that time that there would be no improvement in the quality of water, rather the reverse seems more inevitable in spite of the current emphasis on water economy.

Research on the Safford Station has been seriously handicapped by the lack of a solution to the problems of soil and irrigation management. Many experiments in field and vegetable crop production have been abandoned because of the failure to secure adequate stands. For example, during the course of experimentation in 1959, two cotton crop seedling failures were experienced because of poor germination.

Satisfactory crop production has been obtained by investigators of the United States Salinity Laboratory (Riverside, California) under greenhouse and small plot conditions of equal or greater salinity than exist in the Safford Valley. Such findings give hope to the possible solution of the soil and irrigation management problem on a field basis such as exists on the University of Arizona Safford farm. However, the results from one experimental area, while suggestive, are not always wholly applicable to other areas since fundamental differences exist in the quality of water used for irrigation and reclamation purposes. In addition, the broad valleys differ from the more narrow valleys in their soil characteristics such as texture, productivity, genesis and morphology, and the conservation practices used there.

Since the Safford Area is representative of problem areas having poor quality waters, and the difficulty in obtaining crop stands is also encountered here, this area represents an excellent site for salinity experimentation. In addition, the Gila River, a perennial, good quality stream, can be used in certain combinations with well water. This offers ideal conditions for the study of wide variations of water quality on soil characteristics.

Because of these advantages, the University of Arizona Agricultural Experimental Station Farm which has a saline-sodic soil problem was selected as an experimental area for the water quality studies reported in this manuscript. Furthermore, the farm has an advantage of being equipped with adequate farm machinery which makes it possible to carry out controlled water and soil management practices.

Past work on soil and water management on the Safford Farm as well as in other areas of the state, has demonstrated the great importance of tillage practices in relation to the use of both well and river water (39, 40). Results show that the adverse influence of the continued use of poor quality well water on soil properties and crop production may be overcome in part by the proper use of river water and rough tillage.

In order to more fully explore the relationship between tillage, water and soil management and their effects on crop production,

the Department of Agricultural Chemistry and Soils, in 1954, planned and undertook the following experiment on Field D, at the Safford Experimental Farm.

The over-all procedure in this project involved deep plowing to promote water penetration into the soil, the use of well and river water combinations for leaching and irrigation source, and the proper soil management practices in an attempt to maintain a maximum crop production.

Samples of well water and river water were taken periodically for analysis to determine their total soluble salts, sodium percentage, sodium-absorption ratio, and other inorganic constituents. The amount of irrigation water delivered to each border in the field was controlled as much as possible.

The Soil Conservation Service surveyed the farm for soil variations and such variations were characterized. Key soil samples were taken in designated spots and analysis for such chemical properties as the total soluble salts, the total and exchangeable sodium content, the soil pH, and other inorganic constituents were made. Such properties were evaluated in relation to the soil and water management practices.

An attempt was also made to evaluate the basic soil and water factors which control seeding emergence, stand, and crop yield. The indicator crops were cotton planted from 1955 to 1959. The field was

then plowed and planted with barley and alfalfa. From 1960 to 1962, alfalfa remained as the main crop until the field was plowed in the late fall of 1962.

REVIEW OF LITERATURE

Roughly one-half of the dry land of the earth is in an arid and semi-arid climatic zone (23). A characteristic feature, although not limited to such areas, is the accumulation of excessive amounts of soluble salts. Rainfall in these zones is inadequate to remove salts released by the weathering of rocks, or the salts initially present in the soil-forming material.

The ways in which soils become salt and sodium affected can occur through a number of processes. Kovda (32) distinguishes the following cycles of salt accumulation: (1) Continental cycles, connected with the movement, redistribution and accumulation of salts in inland regions that have no run off, (2) Marine cycles, connected with the accumulation of marine salts on the coasted plains of dry land and along the shores of shallow bays, (3) Delta cycles, widely distributed in nature and of great importance for mankind, insofar as areas of river deltas have been extensively used for irrigation since ancient times, (4) Artesian cycles, connected with the evaporation of deep underground waters and their thinning out on the surface through teutonic fractures and destroyed structures or in deep continental depressions, and (5) Anthropogenic cycles, resulting from errors in the

economic activities of man, or a lack of knowledge of the laws of salt accumulation. It is interesting to note the extent to which salinity can occur. For example, McCall, et al. (38) and McNaught and Houston (41) in their studies used high levels of fertilizers on greenhouse crops; and Doxtator (18), Grogan and Zink (25) used high levels of fertilizers in intimate contact with seeds, both showing that high levels of fertilizers can cause salt injury no less damaging than that resulting from natural soil salinity.

The process of salt accumulation in soil (salinization) and the process whereby the exchangeable sodium content of a soil is increased (sodicization) and their chemical and physical effects on soil and plants, have been known for a considerable time. Yet it has only been within the last decade that the world has witnessed remarkable advances in the various phases of salt-affected soil reclamation. Among these are such developments as the prevention of lowering of surface evaporation, the cultivation and management of salt-affected lands, the cultivation and breeding of salt enduring plants, the use of chemicals, and the desalting of poor quality irrigation waters.

Regardless of these advances, a quick glance at the present state of the world immediately reveals agonizing problems of misery, hunger, poverty, and ignorance which need a remedy without delay (2, 65). For a long time it was thought that it was unnecessary to pay much attention to these problems, because they could readily be solved

by certain improvements in production or adjustments in distribution; but more recently the world population has increased at an alarming rate. Today it exceeds 2,500 million and this figure is likely to double in less than 50 years (65).

The increasing demands of the world population necessitates the development and exploitation of our natural resources in areas which man formerly neglected because he had discovered more favorable conditions elsewhere. Apart from the oceans, these areas are chiefly situated in the Tropical Zones, in the Frozen Zones, and in the Arid and Semi-Arid Zones. Since the Tropical and Frozen Zones at the present are not known to be favorable for agricultural crops, this leaves the Arid and Semi-Arid regions for development. The increase in crop acreage in the world can be done by reclamation of arid wastes, marginal, and salt-affected lands in the Arid and Semi-Arid regions.

Occurrence of Salt-Affected Soils

In the United States, salt-affected soils occur mainly in the 17 western states west of the 100th meridian (58). Sandoval, et al. (51) have described the solodized slick spots soils of southwestern Idaho. Spots range in size from a few inches to 50 feet or more in diameter. The soils in these areas show solodized features with characteristic solonetz morphology of the B horizon which also contains high concentrations of soluble salts. Under the solonetzic horizon is a zone of a

heavy calcium carbonate accumulation which forms a bowl-shaped layer. In North Dakota, calcium carbonate solonchaks occur on slightly elevated positions in relation to the surrounding humic gley or chernozem soils (49). It is believed that lime and salts accumulate in the water table perched over the frozen sub-soil in the spring and move into and accumulate in the calcium carbonate solonchaks. The United States Salinity Staff (64) in 1958 reported that more than one-fourth of the irrigated farmland in the United States is salt-affected. Fuller (23) states that one-fifth of the irrigated lands in 14 of our western states is affected by excessive accumulations of salts.

The salt-affected soils of the northwestern United States are similar to those in the arid region of western Canada. Ehrlich and Smith (22) examined 11 halomorphic profiles in their studies near Manitoba. Exchangeable calcium and magnesium dominated the exchange complex. The authors concluded that the high level of exchangeable sodium is not essential for the development of characteristic solonetzic features and that exchangeable magnesium may function in a similar way to exchangeable sodium in soils which are low in sodium.

Salt-affected soils occur also in the arid high plains of Mexico, and on the western pacific slopes of South America. Other areas with extensive salt problems occur in countries of North and South western Africa, in Asia, Australia, and only small areas in Europe, principally in Hungary and parts of countries bordering the Mediterranean (58).

Properties of Salt-Affected Soils

Salt-affected soils are classified according to either chemical or morphological systems (4, 56). Of the two, the chemical system is simpler to define and so it will be defined first. Saline soils contain high concentrations of soluble salts which depress plant growth (61, 62, 63). For purposes of distinction, the lower limit for saline soil has been set at 4 millimhos per centimeter (electrical conductivity of the saturation extract at 25° C.), and for sodic soils, at 15 percent exchangeable sodium. The meaning of the combined terms sodium-sodic and nonsaline-sodic, is self explanatory. According to the morphological classification of soils, the saline soils are Solonchaks, and the sodic soils are generally Solonetz (4). In the latter case, the high level of exchangeable sodium is associated with considerable modification of the soil profile with respect to physical as well as chemical properties. A decrease in exchangeable sodium and other associated chemical changes in the surface horizon of a Solonetzic soil due to leaching, leads to the formation of a Solod soil (4). As with any system of classification, marginal cases are known and it is well to keep in mind that the numerical limits for salinity and sodicity are not intended to be rigid. The final arbiter is the plant involved. If it is adversely affected by the concentration of soluble salts present, then the soil is saline as far as this species is concerned. The United

States Salinity Laboratory has recognized that severe salinity effects may occur at salinities as low as 2 millimhos per centimeter with such salt sensitive species as beans and strawberries (63).

Irrigation

Although salt-affected soils occur naturally in many arid and semi-arid parts of the world, they frequently occur as the result of man's use of the land, particularly under irrigation agriculture. For instance, in the United States one-fifth of the irrigated lands in 14 of our western states is affected by excessive accumulation of salts (23).

Ancient Irrigated Agriculture

No one knows for sure when man began to irrigate; but we do know for sure that the task of finding, developing, diverting, and distributing suitable water for crop production was recorded in the early records of Assyria, Babylonia, Egypt, Persia, India, and China (58). Remains of ancient water conveyance structures and irrigation systems are evidence that large civilizations have been based upon applying stored, diverted, and transported water to soil to aid in crop production in arid and semi-arid regions of the world (43, 58).

There is no general agreement on the cause of the decline of many of these ancient civilizations discussed above (58). Evidences from the available historical sources today tend to favor the theory that the

failure is due to the destruction of the central government and the poor methods of soil and water management.

There is archaeological evidence that shows that at one time a large area in the Salt River Valley, Arizona, was irrigated. In some areas there still exist portions of ancient canals and ditches (43). According to Dr. S. A. Taylor[1] several remains of these ancient canals on both sides of the Salt River in the vicinity of Mesa, Arizona, are still evident. The course of many of these ancient distributing ditches can still be followed through the fields that are now being cultivated. These ditches can be traced through fields of alfalfa, cotton, and sorghum.

Dr. Taylor observed that plant growth remains inferior along the courses of the ancient distribution systems, even after many years of tillage under modern irrigation farming, which includes leveling, frequent tillage operation and heavy fertilizer programs. The water infiltration into the soils along the ancient ditches was greatly retarded with respect to adjacent soils. Dr. Taylor also pointed out the fact that Dr. T. W. Barrett, soil scientist at Arizona State University at Tempe, has found that the percent exchangeable sodium and the pH are slightly higher in soil that is located along the ancient distribution channels.

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[1] Dr. Sterling A. Taylor, (Soil Physicist) Professor of Agronomy, Utah State University, Logan, Utah.

These ancient evidences from the Salt River Valley point out some of the important problems resulting from poor management of soil and problems of a sustained agriculture based on irrigation. These problems are: (1) salt accumulation in the soil, (2) reduction of the water infiltration rate into the soil because of silt and salt that the water deposits in the soil, and (3) the deterioration and loss of desirable soil structure as a result of irrigation practices.

Arizona Irrigated Agriculture

The development of irrigated agriculture in the State of Arizona has been influenced by the following factors: physiography, climate, and geology. These factors control the topography, precipitation, soil genesis and morphology, and the occurrence of surface and ground water and have localized the development of irrigated agriculture throughout the state (26, 66, 67). In turn, the whole state can be divided into three areas based on topography, geology and the occurrence of surface and ground water (66, 67). The latter areas, or provinces, shown on Figure 1 are: (1) the Plateau Uplands, (2) the Central Highlands, and (3) the Basin and Range Lowlands.

Since both the Plateau Uplands and the Central Highlands have limited agriculture, although not limited from salinity or salt-affected soil problems, the bulk of this discussion will center around the state's agricultural area which is the Basin and Range Lowlands.

Figure 1. Physiographic Provinces of the State of Arizona.

According to White (66), about 80 percent of the population and more than 90 percent of the irrigated acreage of Arizona are concentrated in the latter province, which constitutes more than 45 percent of the total area of the state.

The southern and western parts of the state compose the desert region. In this region, isolated northwest trending mountain ranges are separated by broad and narrow, gently sloping alluvial valleys with very deep unconsolidated sediments up to several thousand feet in thickness (26). These valleys contain much of the land in Arizona that is suitable for agriculture.

Geologically, the valleys of the desert regions are highly suitable for irrigated agriculture. The alluvial fills in the valleys are composed of poorly consolidated gravel, sand, silt, and clay and some caliche. Groundwater is obtainable in most places, drainage is good, and sufficient lime is present to maintain the soils in good condition except under problem conditions (26).

The climate of Arizona, especially in the southern part of the state, is semi-arid. According to White (67), roughly half the state receives less than 10 inches of rainfall annually. With the exception of limited rainfall, the region is highly favorable for farming. The growing season is long and the temperature varies little. The long hot summer days give an ideal environment for such

crops as cotton, alfalfa, sorghum, barley, corn, wheat, vegetables, grapefruit, oranges, lemons, and crops of lesser importance (26).

Due to the development of soils under limited rainfall, high temperatures, and sparse vegetation, in many cases, salt problems were inherent in some of the southern Arizona soil in its virgin state. More serious problems have arisen since the land was placed under cultivation. In most cases, these latter problems had developed from a failure to fully appreciate the conditions that arise when soluble salts and sodium ions in irrigation waters and their subsequent accumulation in soil are not controlled (39).

It can readily be seen from the foregoing discussion that although irrigation has been practiced for many centuries, most of the early projects no longer exist. Some of them came to an end because water supplies failed or because irrigation works were destroyed by invading armies (58). Many, however, have to be abandoned because the land became water-logged or too heavily charged with salts and sodium to grow crops successfully. Poor drainage, over irrigation, the use of poor quality waters, and seepage from canals all contributed to the failure of these projects. Today, the same factors are causing much irrigated land to become water-logged or too salty and sodic for successful farming (58, 61).

Quality of Irrigation Water

All natural waters used for irrigation contain dissolved inorganic salts which are derived originally from the rocks or solid phase materials through which water percolates. The dissolved inorganic salts found in water determine its quality and thus set the water apart from others through a classification system. It should be recognized that while the classification of irrigation water, with respect to quality, serves a useful purpose, too rigid a dependence is unwarranted (16, 29). Since crop production is the main concern in irrigated agriculture, the usefulness and ultimate criterion of the quality of water is its effect on the plants and, of course, the soil on which it is used (16, 68).

Classification

In determining the quality of irrigation water, the most important characteristics to be considered are: (1) the total soluble salts, (2) the percent sodium, (3) the concentration of boron, (4) the bicarbonate content, which has been questioned, and (5) undissolved solids. If the crop to be irrigated is specifically sensitive to chloride or sodium, special cognizance of these ions may be required (29).

Total Soluble Salt

The total soluble salts, TSS, is commonly measured as electrical conductance which is given in micromhos per centimeter, EC x 10^6. As an index of the total salt content of irrigation water, in general, when the electrical conductivity exceeds 3,000 micromhos per centimeter, accumulation of salts probably will be harmful (29). The total concentration of salts may be expressed as parts per million (p.p.m.), tons per acre foot, or milliequivalent per liter by using the proper conversion factors (69, 70, 71, 72).

Sodium Hazard

The second criterion of water quality is important because a high proportion of sodium in irrigation water results in a high proportion of sodium in the soil solution and on the exchange complex of the soil (16, 19, 68). Adverse changes in the physical properties of the soil result from accumulation of sodium in the exchange complex. High sodium soils tend to become puddles or dispersed and their permeability is usually decreased. One method for indicating the sodium hazard of irrigation is the soluble-sodium percentage, SSP. This term is also referred to as the percent sodium, or sodium percentage. It is a calculated value and is defined by the following equation in which the concentrations are in meq./L.

$$SSP = \frac{\text{Soluble Sodium Concentration X100}}{\text{Total Cation Concentration}}$$

This is useful in characterizing a water, since a high value indicates a soft water and a low value indicates a hard water. No precise limits for sodium percentage can be set because soils of different types react differently to water of a given sodium content; but if the percent of sodium is less than 60, it is not likely that trouble will be encountered (29, 40).

A more satisfactory indicator of the sodium hazard of irrigation water is the sodium-absorption-ratio, SAR, as defined by the following equation in which the concentrations are expressed in meq./L.

$$SAR = \frac{Na+}{\sqrt{\frac{Ca++\ Mg++}{2}}}$$

It has been shown that when the irrigation water and the soil solution are in equilibrium, there is a significant relationship between the SAR of the irrigation water and the exchangeable-sodium-percentage, ESP. Therefore, by knowing the SAR of the irrigation water, it is possible to make a reasonable estimate of the resulting ESP (9, 40, 63, 68).

There are four classes of irrigation water based on SAR values with major divisions at 10, 18, and 26. Such values are based primarily with respect to the effect of sodium on the soil (29, 36, 55, 63, 68, 69, 70, 71).

S1 - Low-sodium water. This water can be used for most soils with little chance of a sodium hazard developing, although some sodium sensitive crops may be injured.

S2 - Medium-sodium water. This water may be used on soils with good permeability, but will present a sodium hazard on fine-textured soils with a high cation exchange capacity.

S3 - High-sodium water. Most soils will require special management if this type of water is used. Crops must be selected with regard to their sodium tolerance.

S4 - Very high-sodium water. This water is generally unsatisfactory and can be used only in special cases.

The Salinity Laboratory Staff (63) has prepared another classification of irrigation water based on the integration of electrical conductance and the SAR. This relationship between the EC and the SAR is shown by the diagram in Figure 2.

Boron Content

Boron, as a factor in water quality, has been investigated extensively by Eaton, Scofield, Wilcox, and others (19, 21, 52, 53, 54, 71, 72). When irrigation water containing boron is allowed to flow through soil, some of the boron is absorbed by the soil until the absorbed boron and the dissolved boron in the concentrations of the irrigation water and the soil solution are in equilibrium. If water

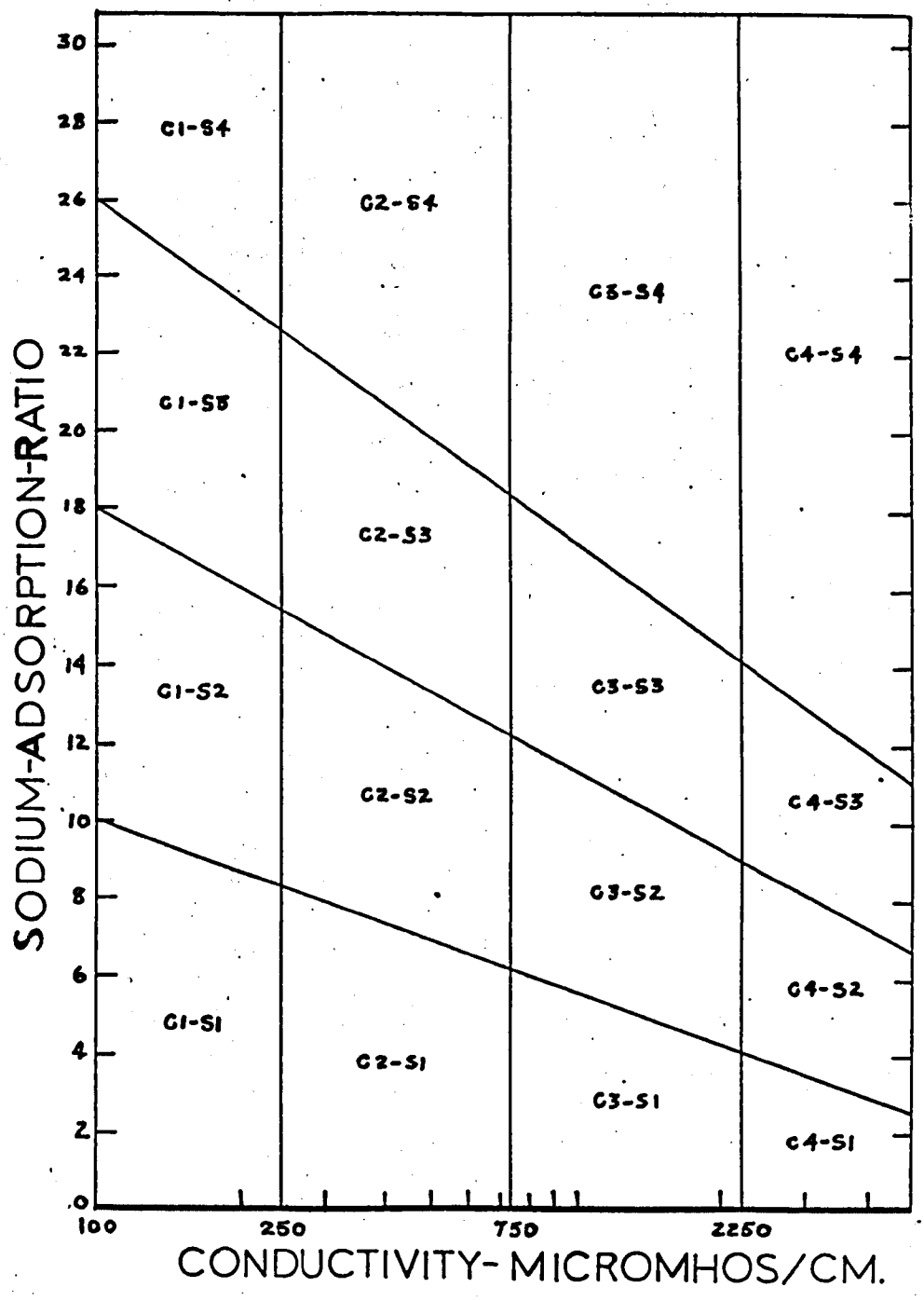


Figure 2. Diagram for classification of irrigation waters.

having a lower concentration of boron is then applied, desorption of boron occurs until a new equilibrium between dissolved and absorbed is established.

Concentration of boron as low as 0.67 p.p.m. may be toxic to the most sensitive crops, and even the most tolerant crops are likely to be injured where water containing boron in excess of 2 to 3 p.p.m. is used for irrigation (71, 72). In Arizona, the boron toxicity problem is not caused by excessive concentration of boron in the soils, but rather by excessive amounts in the irrigation water (54).

Carbonates and Bicarbonates

According to Eaton (20) as water, containing Ca^{++} and HCO_3^- ions evaporates, CO_2 is lost from the system and $CaCO_3$ (solid) precipitates according to the following reaction:

$$Ca^{++} + 2HCO_3^- \longrightarrow CaCO_3 \text{ (solid)} + H_2O + CO_2$$

Thus according to the above equation, when a soil containing soluble Ca^{++} and HCO_3^- ions dries out, $CaCO_3$ (solid) is precipitated, and the ratio of Na^+ to Ca^{++} ions in the soil solution increases, the SAR increases and the soil pH also increases. Eaton (19, 20) has, therefore, suggested three calculated values upon which irrigation waters should be evaluated and these are expressed in meq. /L. concentration. These values are found in the literature as (1) "the

sodium percentage found," (2) "the possible sodium percentage," and (3) "the residual sodium carbonate."

However, within the last few years, other workers (1, 3, 4, 59) have viewed the concept of residual sodium carbonate and possible sodium percentage in field soils as proposed by Eaton as of controversial nature. Thorne and Thorne (59) could not find any significant correlation between carbonate and bicarbonate of irrigation waters. Babcock et al. (3) in lysimeter studies showed that the estimation of the exchangeable sodium percentage in equilibrium with a given irrigation water, based on exchange equations or on Eaton's principle, may not serve to predict field behavior when a crop is grown. Argawal et al. (1) concluded that canal water in India presents less salt and sodium hazard than the well waters in the state. However, prolonged use of the latter well waters has not been as damaging as the calculated residual alkalinity($(HCO_3^- + CO_3^=) - Ca^{++} + Mg^{++}$) and the possible sodium percentage, $Na+/($(total cations) - $HCO_3^- + CO_3^=$), would lead one to expect.

Eaton's residual sodium equation has been used to classify waters with high carbonate and bicarbonate content as follows: those with more than 2.5 meq./L. residual carbonate are unsuited for irrigation purposes, 1.25 to 2.5 meq./L. are marginal, and less than 1.25 meq./L. are probably safe (69, 70, 71, 72).

The Effect of Irrigation Water on Soil

In many instances, salinity and sodium problems developed after the land was put under irrigation, and in such instances, salinity of the irrigation water is obviously a contributing factor. Other factors which influence salinity effects are the concentration and composition of salts in the irrigation waters, adequacy of soil permeability, and drainage, management practices, and inherent soil characteristics (8, 9, 10, 14, 17, 19, 28, 29, 33, 36, 44, 52, 61, 63, 68).

Continued application of irrigation water to soils produces many chemical and physical changes and may profoundly affect the soil's productivity. Chapman and Harding (14) list the following effects of irrigation water on soil: (a) increase the concentration of salts in the soil solution variable with depth; (b) the deposits of calcium and magnesium carbonates, calcium sulfate and silicates on soil minerals and roots, under some conditions; (c) an increase of sodium on the exchange complex; (d) the generation of sodium carbonate in some cases; (e) a change in the soil pH; (f) decreased availability of iron, zinc, copper and manganese; (g) increase in certain toxic elements such as boron, lithium and thorium; (h) changes in soil flora, and (i) changes in soil structure permeability.

C. A. Bower of the U. S. Salinity Staff (8), states that the principal direct effects of irrigation on soils may be grouped into two categories:

(a) effects upon the concentration of the soil solution.

(b) effects upon the composition of the dissolved and adsorbed constituents.

Concentration of the Soil Solutions

The relation between the concentration of the total dissolved constituents in the irrigation water and that in the soil solution of the root zone, is determined primarily by the fraction of the applied water which passes through the root zone, and the water content of the soil (8). Both of the latter two are in turn influenced by the frequency and amount of water application in relation to that lost to the atmosphere by evapotranspiration, the position of the ground water table, and the permeability of the soil. A water of good quality may cause trouble when improperly used or when applied to a very impermeable soil, while a water of relatively poor quality may produce good results when properly used on a permeable, well-drained soil (4). Thus, for a given irrigation water, the concentration of the soil solution may vary greatly depending upon water management practices, and soil drainage conditions.

The proper rate of water application is determined by the crop requirement for water and the leaching requirement (4). If the maximum permissible level of soil salinity, in terms of the EC of the saturation extract, is ECdw, and conductivity of the irrigation water, ECiw, then, leaching requirement, LR = $\frac{ECiw}{ECdw}$. Thus, the leaching requirement may be calculated from knowledge of the irrigation water and the permissible concentration of the drainage water which is approximately equal to the concentration of the soil solution. From a theoretical standpoint, Bower (8) states that since the above concept is based on the principles of salt-balance and steady-state water flow rates, the above equation can be used to predict and calculate the effect of irrigation water on the soil solution of a given depth around the root zone.

Composition of Dissolved and Adsorbed Constituents

Bower (8) explains that in predicting the effects of irrigation water on the composition of the dissolved and adsorbed constituents of soils: "It is useful to consider the irrigation of a soil to be a column process involving the adsorption and exchange of constituents during the down flow of water."

Brooks, et al. (10) have successfully applied a cation exchange theory, developed for exchange columns, to a soil in a field situation. Measured values of calcium, magnesium, and sodium in a soil solution

sampled as a function of the depth of water applied, agreed well with the theory. However, the exact solution of the Thomas-Hiester-Vermeulen, which includes the latter, are complex as they contain functions which must be evaluated numerically; moreover, the uses of the equations require values for soil properties that must be obtained by direct determination. For the important case where a high sodium irrigation water is applied to a soil initially present, the equation shows considerable promise. It is well to keep in mind, however, that there is a divergence between the results from field studies and those calculated from theoretical equations (8).

The length of time necessary to establish equilibrium between irrigation water and soil seems to be of importance if data which will actually show changes in chemical and physical characteristics of soils in the field are to be expected. Data of Lewis and Juve (33), in Texas, indicated that in one soil the process of the establishment of equilibrium began only after a two-year period. The result of work at the Safford Experimental Station shows that equilibrium is established in less than two years under conditions of adequate drainage. McGeorge, Breazeale, and Bliss (40) found that two years of irrigation with a water having a conductance of 6 millimhos per centimeter and a sodium percentage of about 83, increased the exchangeable sodium percentage of soil on the Safford farm from about 10 percent to near the equilibrium value of 25 percent. However, the

studies of Longenecker and Lyerly (34), in Texas, showed that one soil approached equilibrium only after a five to seven year period. The workers, however, concluded that under field conditions, the relative relation between water composition and soil properties is unreliable and of little value in predicting the chemical status of irrigated gypsiferous soils of west Texas.

Doneen and Henderson (17) have obtained interesting data that show the effects of irrigation water on soil characteristics. These workers showed that the concentration of electrolytes in the water has a marked effect on the infiltration rate. The bicarbonate waters precipitated out lime, and increased the exchangeable sodium percentages of the soils.

The indirect effects of irrigation are many and varied. Some of the most important effects are: the decreased absorption of water by plant roots as the concentration of the soil solution increases (24, 46, 58). The deterioration of the physical condition of the soils as a consequence of the adsorption of sodium (63), and the specific toxicity of some constituents such as boron to plants (21, 53, 54, 55, 71, 72).

The chief beneficial effects of the application of irrigation waters, other than the supplying of water and some mineral nutrients to plants, are the leaching of accumulated salts and the improvement of soil structure through the replacement of adsorbed sodium by calcium and magnesium contained in the water (4, 23).

Plants in Relation to Salt-Affected Soils

It is commonly accepted that excessive salt concentration is detrimental to plant growth. It is also accepted that some salts are more toxic than others and that certain plants are able to tolerate high concentrations of salts while others are sensitive to low concentrations. In 1877, Pfeffer reported that salts in solution around roots would reduce or prevent water uptake by plants (58). This concept has been widely accepted for some time, but the general application of the principle, along with other effects of salt on plants and soils, had not been extensively studied until work on this subject became intense at the U. S. Salinity Laboratory.

The solution to many of the perplexities imposed by salinity must be based on the differences in soil characteristics. Saline soils with excessive salt in the soil solution around the root zone differ fundamentally from the sodic soil with high exchangeable sodium, poor physical conditions and frequently the high exchangeable sodium is in addition affected by excessive salts (46, 58).

High Salt Concentration

Salts in the soil solution may adversely affect plants in several ways: (a) by osmotic inhibition of the water intake into the

roots; (b) by direct chemical effects of the salts in disturbing the nutrition and metabolism of plants.

Osmotic Inhibition of Water Intake

It is generally recognized that plant growth bears a definite relationship to the osmotic pressure of the root medium and that different species, and sometimes even varieties, exhibit different sensitivities to increases in the osmotic pressure (29, 46). Gingrich and Russell (24) compared the growth of corn roots in osmotic media at seven levels of osmotic pressure, and soils adjusted to equivalent soil moisture tensions. Root elongation was affected more in the soil than at equivalent osmotic stresses, indicating that restricted moisture transmission in the soil, especially at suctions in the range of 1 to 3 atmospheres, was limiting root growth. Salt has also been found to delay germination of seeds. This might be expected because of the reduced availability of water (29, 46).

Specific Ion Effects

Specific ion effects (toxicities and nutritional disturbances) may be superimposed on the general osmotic effect, depressing the yield further (46). Many of the fruit crops, including citrus, stone fruits, and avocado, have been shown to be specifically sensitive to chlorides (4, 6). The nutritional upset may be a result of the

insolubility or competitive adsorption of ions. Any one of these effects may be associated with enzyme activity in the plant or with morphological changes (46). Lundegardh (35) has presented a theory of an ion respiration in which he expresses a belief that the activity of the cytochrome system is controlled by the concentration of movable salt anions. He has shown that in living wheat roots, the oxidation reduction balance of the cytochromes is raised toward a higher state of oxidation by a change of medium from water to salt solutions. Miller and Evans (42) made a study of the influence of various concentrations and kinds of salt on the activity of cytochrome oxidase from certain higher plants. They showed that monobasic cations were more stimulating at low concentrations than dibasic, and less depressing at higher concentrations. When anions were varied, they found that chloride, nitrate, sulphate, bromide, and iodine were about equal in their influence. The $H_2PO_4^-$ and $HPO_4^=$ were best while $NaHCO_3$ was most inhibitory. No explanation for the beneficial effects of high salt was offered nor did these workers indicate how the enzyme systems of some plants were protected from the influence of high concentrations of salt. Such data on enzyme activity are not conclusive but they suggest ways in which salts may adversely influence plant growth.

Exchangeable Sodium

Not a great deal of concrete information is available on the influence of exchangeable sodium on plant behavior, nor on the basis of tolerance to alkaline conditions. There is also no assurance that salt tolerant plants also have tolerance to excessive amounts of exchangeable sodium. Tolerance to excessive amounts of exchangeable sodium varies with such conditions as: (a) high sodium plus natural salts; (b) high sodium and high pH; and (c) high sodium carbonate content in the soil solution (46).

The adverse effects on plants under these various conditions may result from (a) high concentrations of sodium; (b) low calcium, magnesium, and potassium availability; and (c) the dispersion of soil with resulting poor aeration.

High Concentration of Sodium

Excessive sodium in the plant causes characteristic leaf-burn symptoms when leaf content of sodium or chloride reaches critical values in fruit crops, including citrus, and avocado (4, 7, 29). In contrast, crops such as field forage and vegetable crops are not affected as much by sodium as by excessive calcium because the accumulation of sodium is usually much more restricted, especially in plant tops, than is calcium accumulation (4, 7, 11, 29, 45).

Grain or forage plants are frequently the first crops planted on reclaimed sodic soils, and the tolerance of such crops to exchangeable sodium (ES), is, therefore, of particular interest. Pearson and Bernstein (45) found that the ES percentage at which yields were reduced by 50 percent for six such crops were: 30 percent for oats; 34 percent for tall fescue; 38 percent for rice; 43 percent for wheat; 49 percent for barley; and 64 percent for tall wheat grass. Thus, while some species are outstanding, almost all can tolerate the levels of ES that may be encountered on moderately affected or partially reclaimed sodic soils.

Low Calcium, Magnesium, and Potassium

Chang and Dregne (11) have suggested the unique symptoms they call sodium-induced calcium deficiencies. For alfalfa they take the form of reddish coloration of the lower leaves followed by a collapse of the petioles.

Martin, Bitters, and Ervin (39) in working with trifoliate orange trees found that by increasing the ES from 1 percent to 7 or 15 percent, or the exchangeable potassium (EP) to 23 percent of the cation exchange capacity, they decreased the seedling growth. The harmful effects of ES and EP tended to be additive. Increasing the ES decreased leaf calcium and magnesium and tended to increase leaf potassium, the

latter is a frequently observed phenomenon with species that restrict sodium uptake.

Bernstein and Ayer (5) showed that several varieties of carrots achieved an increase in the absorption of calcium and a depression in the absorption of potassium by the addition of calcium and sodium chloride to the soil. Those varieties which tended to absorb more calcium and less potassium of a given level of salinity gave relatively poorer yields than others.

The Dispersion of Soil

Except for those crops most sensitive to exchangeable sodium, such as the bean, the poor physical condition of sodic soils restricts growth of most crops long before any nutritional effects due to decreased calcium or magnesium in sodic soils begins to be felt (46). Fruit crops, which are specifically sensitive to sodium accumulation in the leaves, are also usually affected at levels of exchangeable sodium lower than those associated with deterioration of the soil structure (4).

Reclamation and Improvement of Salt-Affected Land

Fuller (23) has recently reviewed the most prominent methods employed in the reclamation and improvement of saline and sodic soils. These are: (a) drainage to lower water table when needed; (b) leaching to transport salts from root zone; (c) chemicals to supply or make

available soil calcium to replace sodium; (d) tillage to break up soil stratifications, compact layers, hard pans, pressure pans; (e) soil structure improvement; and (f) crop management.

Drainage

In general, reclamation involves the removal of excess soluble salts and exchange sodium. The first consideration in soil reclamation must be the provision of adequate drainage, if this does not already exist, because the soluble salts and the replaced sodium must be leached out of the soil (16, 23).

Leaching

Leaching is the second step in reclamation following drainage. The pertinent question is, therefore: What depth of irrigation water used for reclamation purposes, having a given salt concentration, should be applied to keep a favorable balance between the amount of salt brought into an area and the amount of water removed from the root zone by drainage? The leaching requirement (LR) concept is useful in this regard. The concept is based on the principle that after dynamic equilibrium is established, the salt coming out of a system will equal the salt applied. The salt balance concept is useful in determining in what direction an equilibrium is being shifted, whether towards increased or decreased salinity (29, 52).

Chemical Amendments

The control of sodium in the soil is more difficult. Leaching is not enough because it cannot correct the adverse conditions of soil dispersion. Agricultural chemical amendments are necessary. The exchangeable sodium is displaced by calcium added as a soluble calcium salt either directly or indirectly in the irrigation water or provided by acidification to solubilize lime already present in the soil (23).

Tillage

Often, the physical condition of the soil must also be improved before drainage and leaching can be effective. Special tillage practices as deep plowing and chiseling and ripping have been used effectively to relieve soil compaction and improve water penetration (23, 40).

Soil Structure Improvement

Soil structure improvement is important because structure influences the rate of water infiltration into the soil and consequently leaching of salts from the root zone (23, 39, 40). Practices which are known to improve soil structure on salt-affected soils include the following: (a) alternate wetting and drying of the soil; (b) the addition of organic matter; and (c) the use of manure and sulfur.

Crop Management Practices

Crop management practices (16, 23, 40, 44, 52) which have been suggested for reclaimed and saline soils include: (a) selection of a salt-tolerant crop; (b) special planting and bedding practices; (c) continued soil treatments with agricultural chemicals and organic residues; and (d) special crop-sequence program which includes a deep-rooted legume such as alfalfa.

Soil Methodology

Because large numbers of samples are often necessary in analyzing a given soil situation, simple tests are sought after. The reliability of pH as a guide to ESP is still nebulous in many respects. However, the use of instruments to measure pH in soils has become a standard tool for soil investigators. Chang, et al. (12, 13) found that ammonium acetate added at four-tenths of the cation exchange capacity in making 1:5 soil-water suspensions gave better relationship of pH to ESP than plain water suspensions. The coefficient of correlation rose from 0.690 to 0.843. Correlation between pH and ESP is better when the relationship is developed for a particular area, in agreement with findings of previous investigators.

The procedure of using a dilute soil extract, commonly one part soil to five parts water in determining salinity, is not only quicker

but also reduces the sample required. However, such constant soil-water ratios do not take into account the different moisture-holding capacities of soils, and so yield very unreliable estimates of the salinity in the soil solution. Further, the dilution of the soil solution may dissolve sparingly soluble salts, such as gypsum, which were present as precipitates in the soil moisture range. This could be a main source of error (4, 41). Increasing the moisture content of the soil, even to the saturation percentage, will, of course, also dissolve the soluble salts with which the soil solution was already saturated. Bernstein (4) states that on the average, a gypsiferous soil will read about 2 millimhos higher than a non-gypsiferous soil having the same conductivity in the field moisture range.

McNaught and Houston (41) studying soils from normal and salt-affected greenhouse tomatoes, showed that the relationship of conductivity of saturation extract provides a more reliable estimate of osmotic effects than weight of salts from soil extract. The misleading effects caused by fixed soil-water ratios and dilution of the extracts were again noted. The effect of increasing dilution of the soil extracts was also found to change the proportion of cations, indicating a replacement of exchangeable cations by the calcium ion derived from solution of the gypsum.

Although Na and K determination by flame photometry has now replaced the more tedious chemical methods, another facile

method has been proposed. Glass electrodes have been produced which are sensitive to sodium and potassium as well as hydrogen. Bower has developed a procedure for the quantitative estimation of sodium by precipitating potassium with calcium tetraphenylboron and adjusting the pH. The EMF of the unknown, using the glass electrode and calomel half-cell in conjunction with the Beckman pH meter, is then compared to that of a series of sodium standards. The method promises even greater convenience than flame photometry, with less specialized equipment required (4).

EXPERIMENTAL MATERIALS AND METHODS

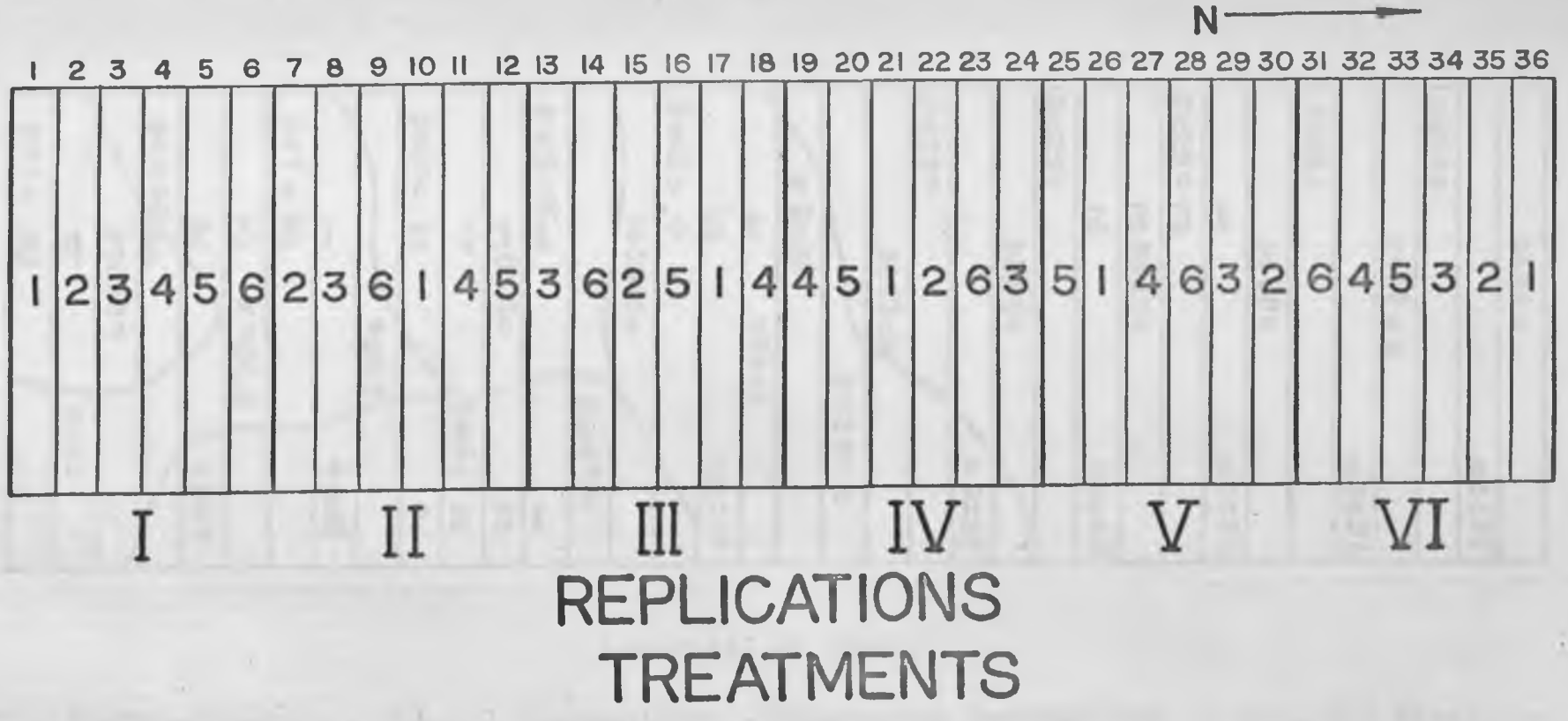
Field Survey

In 1954, Field D, shown in Figure 3, was surveyed and sampled to a depth of four feet for texture determination. The original sampling sites and textural classifications are shown in Figure 4 and Table 1. In addition, the total soluble salts and complete particle size distribution were determined on master samples taken in areas where variations in soil texture were prominent on Field D, and these results are summarized in Table 2.

In the spring of 1961 the Soil Conservation Service reclassified the soils within Field D from Cajon Clay Loam to the following three: Anthony Loam, Anthony Silty Loam, and Cajon Clay Loam. The approximate boundary of each of the above soils is shown in Figure 6, while the descriptions of each of the latter soils are given in the following section on soil characteristics.

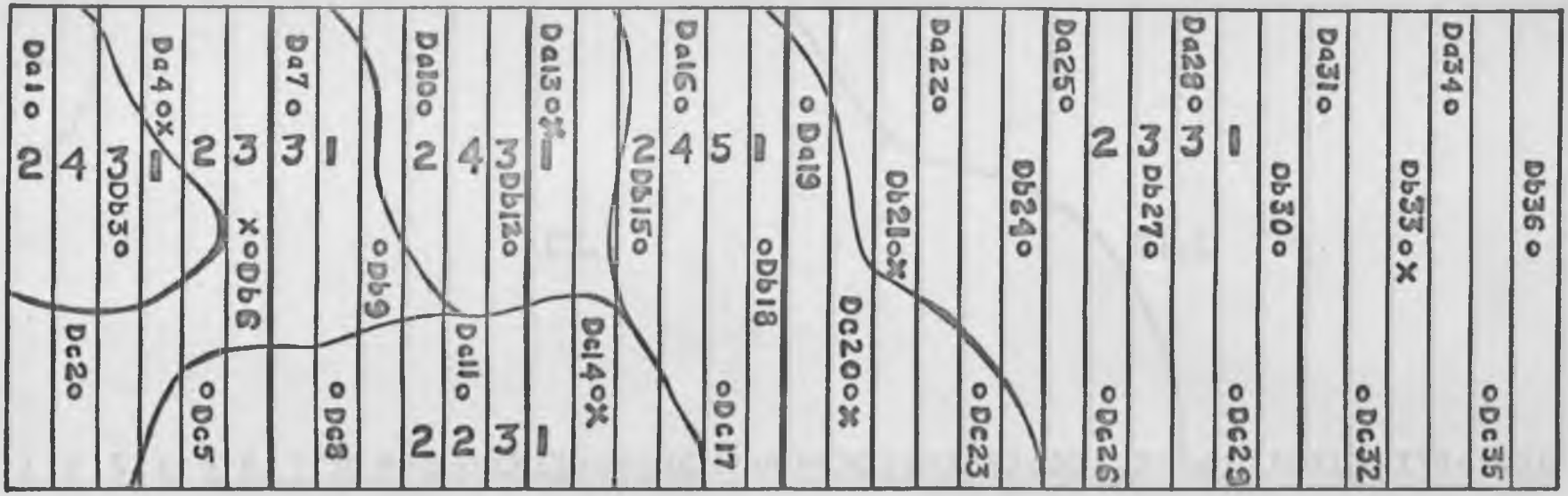
Soil Characteristics

Poulson and Young (48), in their survey of the soils throughout the Safford Valley, classified the soils into three major groups



Treatment number	Leaching water source	Number of leachings		Irrigation water source
		Preplant	Post harvest	
1	river	1	0	river
2	river	1	1	river
3	well	1	0	well
4	well	1	1	well
5	river	1	0	well
6	river	1	1	well

Figure 3. Design showing the layout and irrigation and leaching practices on field D of the University of Arizona, Agricultural Experimental Station Farm at Safford.



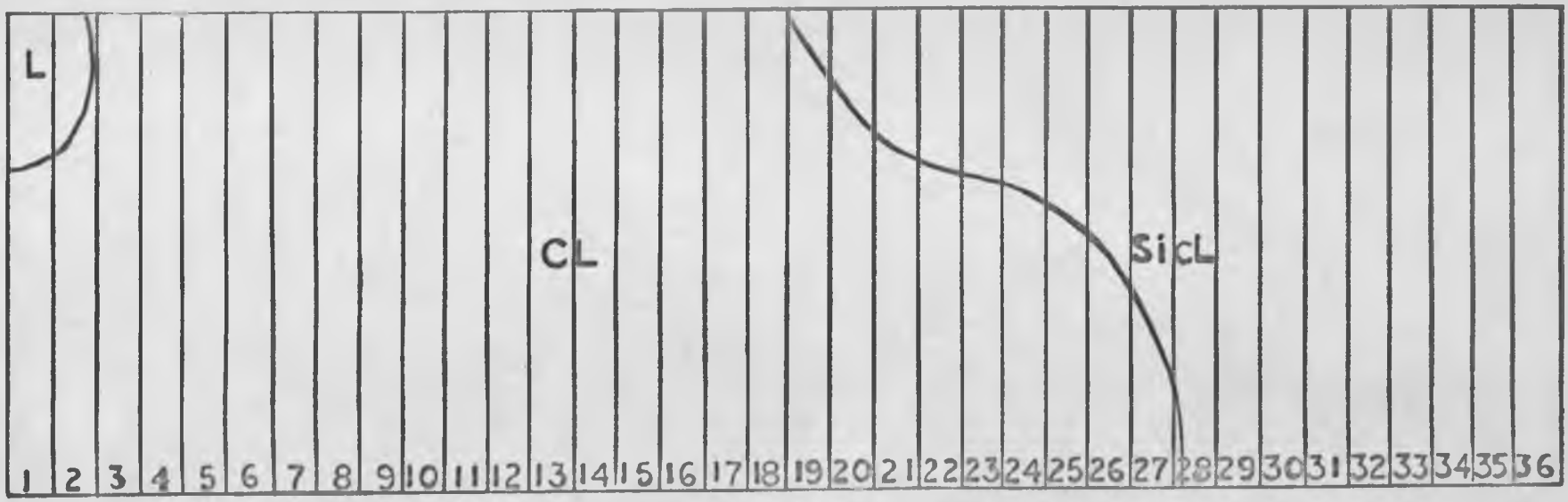
Conservation Symbol

1221 - Surface Texture - Subsoil Permeability - Substratum Permeability or Geologic Materials — Depth

A-2 Slope ------ Erosion

Numeral	Texture	Subsoil Permeability	Substratum Permeability.	Depth to Inhibiting Layer
1	Heavy	Very slowly permeable	Very slowly permeable	Deep - 36" Plus
2	Moderately heavy	Slowly permeable	Slowly permeable	Mod. deep - 20" - 36"
3	Medium	Moderately permeable	Moderately permeable	Shallow - 10" - 20"
4	Light	Rapidly permeable	Rapidly permeable	-- -- --
5	Very light	Very rapidly permeable	Very rapidly permeable	-- -- --
6	Undifferentiated	-- -- -- --	-- -- -- --	-- -- --

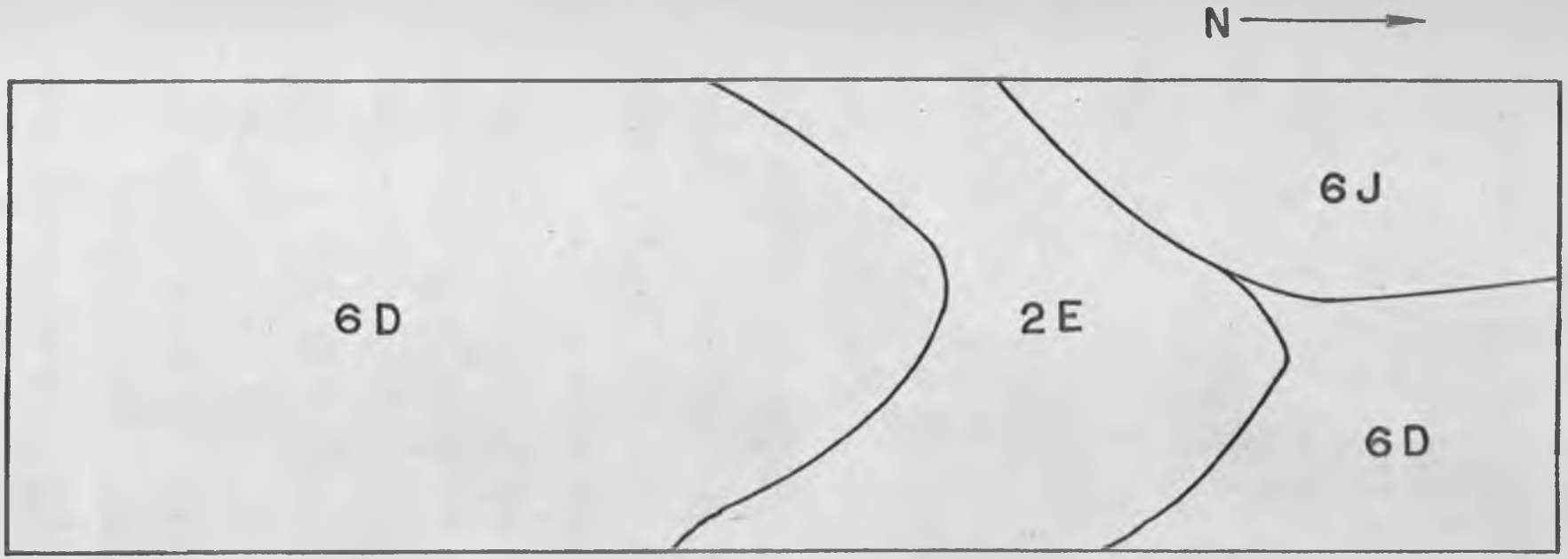
Figure 4. A map prepared in 1954 showing the classification and textures of soils before deep plowing in field D at the Safford Experimental Station.



SYMBOLS

L — Loam
CL — Clay Loam
SiCL — Silty Clay Loam

Figure 5. A map showing the main surface texture on field D on the Safford Experimental Station before deep plowing in 1954.



SYMBOLS

6D — Anthony Silty Clay Loam
2E — Cajon Clay Loam
6J — Anthony Loam

Figure 6. The approximate boundary of Anthony Loam, Cajon Clay Loam, and Anthony Silty Loam on field D made by the Soil Conservation Service in 1961.

as follows: (1) soils without definite accumulation of lime in the subsoils; (2) soils having moderate accumulation in the subsoils; and (3) soils of high lime accumulation. In the first group are the Gila, Pima, Cajon, Imperial, and Land soils; in the second are the Anthony and Mohave soils; and in the third are the Laveen and Cave soils.

Cajon Soils

The Cajon soils in their virgin state are usually dull yellowish or dull light brown in color and are lighter in color, due to low organic matter content, than other soils like those of the Pima and Gila series which are darker in color. In the Safford Valley these soils under irrigation agriculture, in many cases, have been obscured by silting and many such soils now in crop production are darker in color much like the Pima soils, which are usually darker grayish brown or dark chocolate brown in color.

According to Poulsen and Youngs (48), the Cajon soils were developed from granitic materials carried into the valley floor in out washes from the mountains to the south and to the west. These soils dominate a fair portion of the agricultural lands particularly in the upper part of the Safford Valley. No serious internal drainage problems have been observed; nor is the surface drainage a problem because the Cajon soils usually have sloping reliefs that insure good surface drainage.

The Cajon soils are calcareous in nature (qualitative test--two drops of 10 percent HCl produce moderate to strong effervescence).

Poulsen and Youngs (48) included the Cajon soils with those soils that have lime content uniformly distributed or disseminated throughout the soil profile with very little downward leaching or accumulating.

The University of Arizona Agricultural Experimental Station Farm, situated at Lone Star, Arizona, two miles due east of Safford, sits in the heart of Cajon soils, Cajon loam, according to the survey map published in 1933 by Poulsen and Youngs (48).

Anthony Soils

The Anthony soils are pale reddish brown or dull reddish brown, but in most cases under irrigation agriculture, most of these soils have been obscured by silting. These soils are extensively and widely distributed in small areas throughout the valley. The surface soils are fine textured, but the subsoils everywhere are gravelly and in places stony in the lower part, or substratum. Because of the latter factor, these soils have excellent surface drainage. The Anthony soils are calcareous and they are classified under soils having moderate accumulation of lime in the subsoils (48).

Soil Texture

In the preceding discussion, it was mentioned that in 1954 before deep plowing, Field D on the Safford Experimental Farm was surveyed and samples taken to 48 inches or more (54 inches), depending on the soil texture variation with depth at each sampling site. The two

different sampling sites are marked near the original spot where soil samples were taken as shown in Figure 4. In this figure, the symbols X and O are used as the notation to designate the difference between the two sites on the field.

The sampling sites marked by X are sampling spots near which key samples, D4a, D6b, D13a, D14c, D20c, D21b, and D33b, were taken to characterize completely the particle size distribution at each site at designated depths into the profile. The symbols above, used for each sampling site, separated the soil sample from others as well as designated the location within a given border on the field. The symbol D, the number, the letters a, b, and c, stand for Field D, the plot number, and the exact site of sampling, respectively. The exact site is noted by the letters a, b, and c, as follows: a for the west site, b for the center site, and c for the site located on the east. The analyses of the key samples, the soil separate percentages, along with the total soluble salts from the corresponding depths, are recorded and shown in Table 2. These analyses show a textural change in the soil surface from south to north, from sandy clay loam to clay, with clay loam being the prominent surface texture, and at each sampling site the soil texture change with depth into the profile from the surface texture to sandy clay loam, to sandy loam and finally to sand at one site. The salt content showed a corresponding increase from south to north and from west to east with the exception of one sample, D13a, which is on the west; and it has a higher concentration of salts than other samples from the east side of the field.

At the other sampling sites marked by O, also shown in Figure 4, the soils were characterized by sampling the soil with a soil auger and then the texture determined by the "feel" method, which consists of looking at the appearance and feeling the soil sample with the fingers. As in the preceding case, the symbol D stands for Field D, a, b, and c stand for the sites on the west side, the center, and the east side of the field, and, of course, the number after each letter represents the plot number.

The data of the textural determinations, by the feel method, are shown in Table 1. In the table, the individual borders are listed in their respective assigned treatment and replicate, which will be mentioned in the section under Water Quality Treatments. The accumulated data gathered showed that the soil textures varied from the surface, clay loam in the most part to sandy loam at the lowest depth at which samples were taken. Silt loam and sandy loam were the two soil stratum most observed with depth into the profile. Evidences of gypsum dissemination throughout the profile were noted (see plate 1).

In characterizing the subsoil permeability, substratum permeability, and the depth to the inhibiting layer on the experimental field, Field D, the U. S. D. A. Soil Conservation Service in 1954 showed the results which appear in Figure 5 with the soil conservation symbol at the bottom. Four different descriptions were given, and these were 2331, 2451, 2431, and 2231, which are shown in Figure 4. The largest

Plate 1. A picture showing the deep plowing on Field D in 1954.

Plate 2. A picture showing the dispersion of lime in the soil profile on Field D.

section of the field was occupied by 2331 while the smallest section of Field D was occupied by 2231. Two areas in the above, 2451 and 2431, showed a rapidly permeable subsoil while 2331 had a moderately permeable subsoil and 2231 showed a slowly permeable subsoil. The substratum permeability observed on Field D showed that all the above sections were moderately permeable with one exception. The 2451 section in the center showed a very rapid permeable substratum. With respect to the inhibiting layer depth, all the above sections showed the depth to be more than 36 inches.

The results of the soil survey in 1954 showed three prominent textures represented on Field D at the surface. These textural classes, loam, clay loam, and silty clay loam, are shown in Figure 6 as they are distributed over Field D.

In 1960, the U. S. D. A. Soil Conservation Service reclassified the field above, Field D, into three distinctive groups. These soils groups are shown in Figure 6. In size, the Anthony silty clay loam-6D is the largest, while the Cajon clay loam-2E is midway in between, and Anthony loam-6J the smallest, respectively. These soils on Field D of the University of Arizona Agricultural Experimental Station Farm at Safford were surveyed and classified by the U. S. D. A. Soil Conservation Service as follows:

Anthony Loam-6J

The soil is very deep with medium texture surface that takes water readily. It is an excellent soil with few, if any, limiting features.

This soil has medium fertility and can be easily maintained in a good tilth.

Texture by depth:

0 - 12 inches = loam
12 - 36 inches = loam
36 - 60 inches = loam (coarse)

Cajon Clay Loam-2E

The soil is very deep with a clayey surface which restricts water intake. The internal drainage is fairly rapid but the surface takes water slowly and tends to crust upon drying.

Texture by depth:

0 - 12 inches = clay loam
12 - 60 inches = sandy loam

Anthony Silty Clay Loam-6D

The soil is very deep with clayey surface which takes water slowly and may crack on drying. Internal drainage is good.

Texture by depth:

0 - 12 inches = silty clay loam
12 - 36 inches = loam
36 - 60 inches = loam (coarse)

Field Preparation

On January 25 and 26, 1955, Field D was plowed to a depth of about 30 inches to disrupt the horizontal soil stratification of different textures (see plates 1 and 2). After the soil had dried fairly well and the field had been leveled and the borders constructed, one foot of water

was applied for leaching. Cotton was then planted in each of the 36 borders or plots in the six-acre field according to the usual field practices of the area. The individual plot measured 220 feet long by 27 feet wide.

Water Quality Treatments

The six treatments used in this experiment consisted of the following:

Treatment 1 - one preplant leaching with river water and river water as a source of crop irrigation.

Treatment 2 - river water was used both as a leaching and crop irrigation source. However, in this case, two leachings, one at the beginning and one at the end of the cropping season, were conducted.

Treatment 3 - well water was used both for preplant leaching and crop irrigation.

Treatment 4 - well water was used throughout the summer with two leachings, one at the beginning and one at the end of the cropping season.

Treatment 5 - one preplant leaching with river water and well water for irrigation source.

Treatment 6 - two leachings with river water, one at the beginning and one at the end of the season, with well water as the sole source of crop irrigation water.

Water Quality

Beginning in 1954, the irrigation water sources from both the Gila River and the Safford Station well were periodically analyzed. A number of such analyses, for the 1954 to 1962 period, shown in Tables

11 and 12, illustrate the annual variations occuring in the chemical composition of both water sources. In both tables, only the cationic constituents are listed; because only the cations, calcium, magnesium, and sodium content and their changes in the water have been interpreted on the basis of the effect they have on the physical condition of the soil.

Gila River Water

McGeorge, et al. (40) summarized the total composition of the Gila River water source used for irrigation on the Safford Experimental Farm from 1945 to 1952, year by year. These workers showed the predominate salt present, as sodium chloride, while during this same period the amounts of sulfate, carbonate, and bicarbonate ions were non-significant to be problems. The calculated values, the sodium:calcium ratio varied from 0.3 to 2.4 with a mean of 1.6, and the calculated sodium absorption ratio, SAR, showed a mean value of 3.1. During the same period, the conductivity of the Gila River water varied from 0.4 to 1.6 mmhos./cm. (278 to 1131 p.p.m. total soluble salt with a mean value of 739 p.p.m.), which represents 0.4 to 1.5 tons of salts per acre-foot of water with a mean value equal to 1.0 ton of salts per acre-foot of water. The sodium percentage during this same period varied from 21 to 81 percent with a mean of 51 percent sodium. Using the average values, the electrical conductivity, 1.1 mmhos./cm., and the SAR mean, 3.1, the Gila River water used for irrigation purposes during the 1945 to 1952 period can be separated into a water class,

C3-S1, which describes its characteristics as being a high salinity-low sodium irrigation water.

The Gila River water used for irrigation on the Safford Experimental Farm during the 1954 to 1962 period shows considerable variations in chemical composition (see Figures 7, 8, and 9). The sulfates, carbonates, and bicarbonates content of the Gila River water increased over the previous study by McGeorge, et al. (40); however, the increase is not significant enough to warrant special consideration. The chlorides continue to be the major salt in the Gila River water used for irrigation purposes. The calculated factors, the sodium:calcium ratio, varied from 0.5 to 9.1 with a mean of 4.0, while the SAR values varied from 0.5 to 17.1 with 7.4 as a mean value. The electrical conductivity, during the 1954 to 1962 period, ranged from 0.5 to 3.4 mmhos./cm. (360 to 2406 p.p.m. total soluble salts with a mean value equal to 1,099 p.p.m.), which represents 0.5 to 3.3 tons of salts per acre-foot of water with a mean value equal to 1.5 tons of salts per acre-foot of water. During the same period, the sodium percentage varied from 13 to 84 percent with an average value equal to 66 percent. Using average values, the electrical conductivity mean, 1.6 mmhos./cm., and the SAR mean, 7.4, the water used for irrigation purposes during the above period represents a C3-S2 water class, a high salinity-medium sodium irrigation water.

Correlation analyses made between the following factors: time, sodium percentage, sodium-absorption ratio, and the total soluble salt,

during the 1955 to 1962 period, with respect to the Gila River water, showed that there was no correlation with time. However, correlations were noted between the sodium-absorption ratio and the sodium percentage, the total soluble salt and the sodium percentage, and between the total soluble salt and the sodium-absorption-ratio. The following correlation coefficients were noted: $r = 0.85$, $r = 0.59$, and $r = 0.70$ for the above, respectively.

In Figures 7, 8, and 9, the mean values for the Gila River water are as follows: the total soluble salt mean = 1100 p.p.m., the sodium-absorption-ratio mean = 7.4, and the sodium percentage mean = 66.

Safford Farm Station Well

The well is located on the southwest end of the field boundary of the Safford Experimental Station. It was drilled in 1939 to a depth of 98 feet, and the pipe casing is 16 inches in diameter. The water drawn from the above well for irrigation purposes during the 1945 to 1952 period shows the following variations in the chemical composition: the sodium:calcium ratio varied from 2.2 to 6.6 with a mean equal to 4.5, while the SAR value varied from 14.1 to 19.4 with a mean value equal to 12.7, the electrical conductivity varied from 3.1 to 5.8 mmhos./cm. (2148 to 4085 p.p.m. total soluble salts with 3396 p.p.m. as an average value), which represents 2.9 to 5.6 tons of salts per acre-foot of water with 4.6 tons per acre-foot of

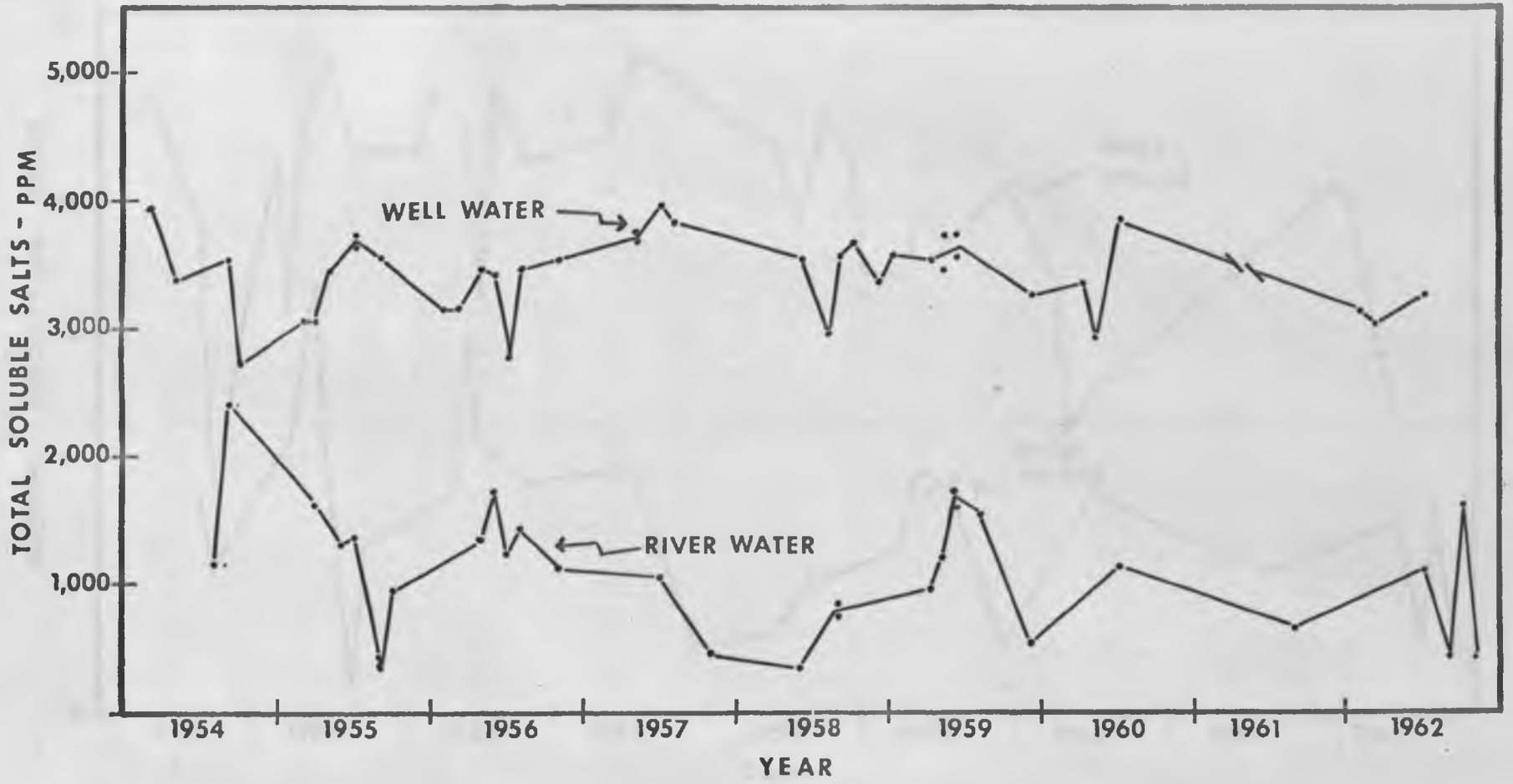


Figure 7. The annual change in the total soluble salts of river and well water used for irrigation on the University of Arizona Farm at Safford from 1954 through 1962.

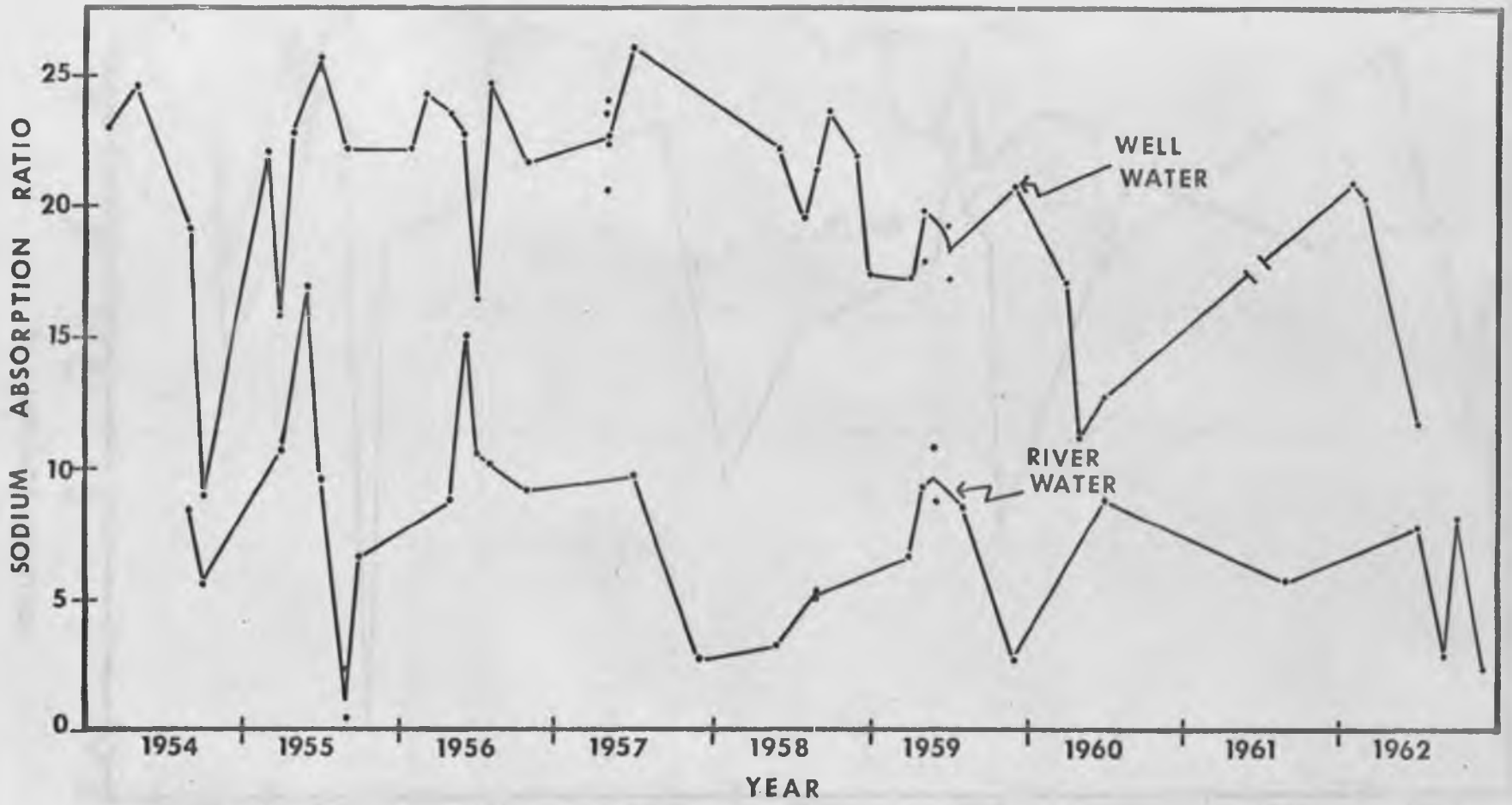


Figure 8. The annual change in the sodium-absorption ratio of well and river water used for irrigation on the University of Arizona Farm at Safford from 1954 through 1962.

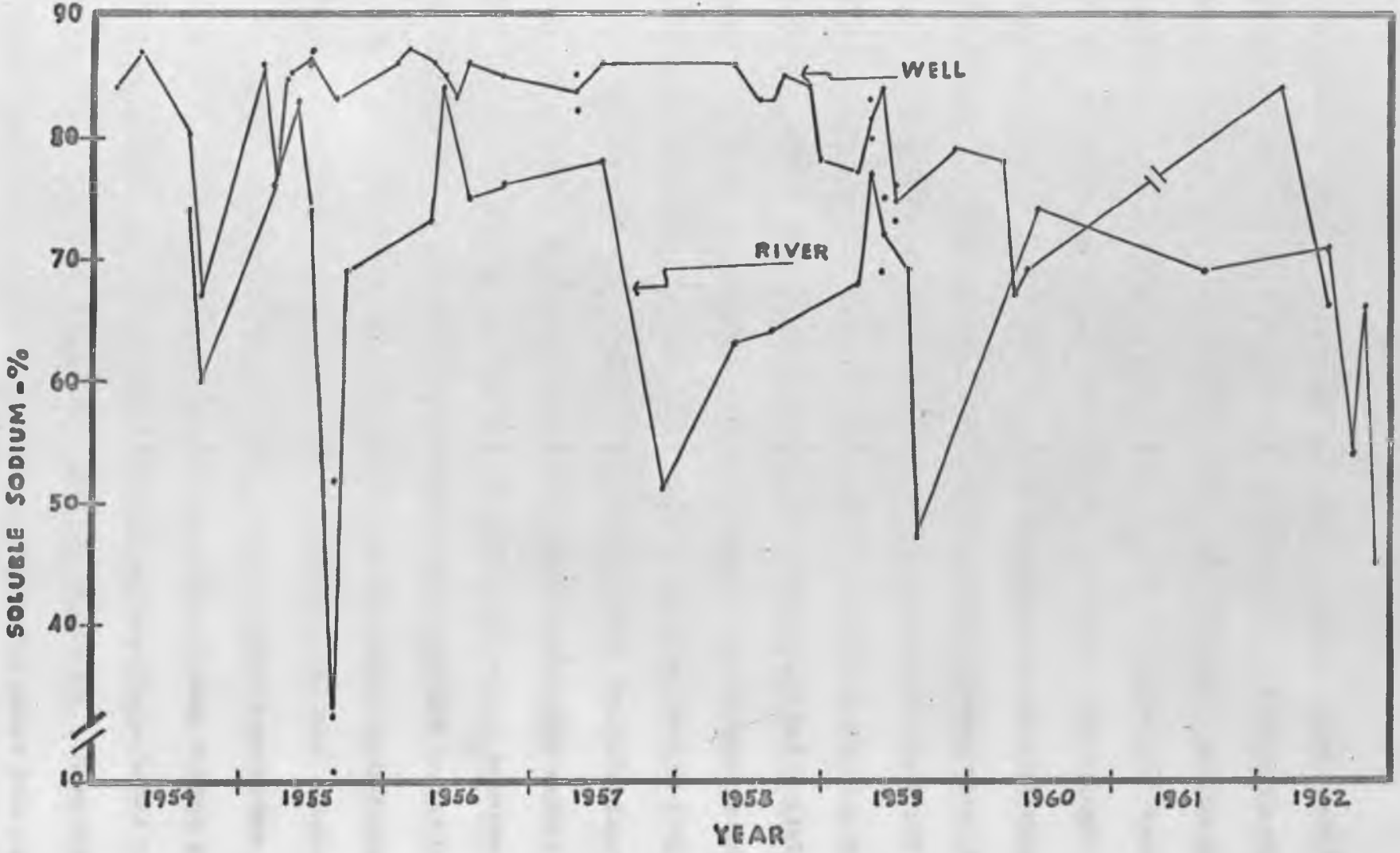


Figure 9. The annual change in the soluble sodium percentage of well and river water used for irrigation on the University of Arizona Farm at Safford from 1954 through 1962.

water as the mean value, and the sodium percentage varied from 67 to 85 percent with the mean value equal to 78 percent. Taking the average value of the electrical conductivity of 4.8 mmhos./cm., and the SAR mean value, 12.7, the average water class for the above well water is C4-S4, a very high salinity-very high sodium water. The anionic constituents in the well water are definitely higher in the well water as compared to the river water. The anions in the irrigation water during the above period show the following: the sulfates varied from 197 to 826 p.p.m., while the bicarbonates ranged from 268 to 641 p.p.m., and the chlorides, the most predominate, varied from 643 to 1367 p.p.m. McGeorge, et al. (40) show the absence of residual sodium carbonates with the exception of two years during the 1945 to 1952 period.

During the period from 1954 through 1962, the following variations in the chemical composition of the Farm Station well waters were noted. The calculated ratios, the sodium:calcium varied between 3.0 to 14.9 with 8.0 as an average, while the calculated SAR varied from 9 to 26 with a mean value equal to 20.4. The electrical conductivity ranged from 3.88 to 5.70 mmhos./cm. (2721 to 3995 p.p.m. total soluble salts with a mean value equal to 3369 p.p.m.), which represents 3.7 to 5.4 tons of salts per acre-foot of water with 4.5 tons of salts per acre-foot of water as the mean. The sodium percentage varied from 66 to 87 percent with a mean value equal to 82 percent. Using the mean values of electrical conductivity and SAR, the above well water

rates a C4-S4, a very high salinity-very high sodium water. The anions were not characterized for the 1954 to 1962 period, but it was assumed that they increased proportionately over that of the period reported by McGeorge, et al. (40).

Only one correlation was noted on the well water during the 1955 to 1962 period. There is a close correlation between the sodium-absorption-ratio and the sodium percentage. The correlation coefficient, r = 0.954.

In Figures 7, 8, and 9, the mean values for the well water are as follows: total soluble salt mean = 3425.0, the sodium-absorption-ratio mean = 20.9, and the sodium percentage mean = 82.0.

Field Plot Design

The experimental design, a randomized complete block, was imposed on Field D in which the experimental area, Field D, was divided into six replications with six treatments per each replicate. The six treatments were assigned randomly to each of the six plots within a replicate.

Data from the various experiments, reported in this manuscript, were analyzed statistically by the method outlined in the text, Procedures of Statistics, written by Steel and Torrie (57). Treatment means were separated by the new Duncan Multiple Range Test according

to the above text. The five percent level of significance was used in all cases unless otherwise stated.

Indicator Crops

Past data from the Experimental Station at Safford showed that Field D had been under cultivation for a number of years. For instance, in 1951 and 1952, the different alfalfa varieties, already growing on Field D, were tested in connection with water applications and seed production. In 1953, sudan grass was planted on Field D, borders 1 through 21, and later the crop was plowed under to aid in increasing the fertility and to improve the physical structure of the soil. In 1954, soybeans were grown on Field D to determine the proper seedling rate and the date of planting. During the same year, cotton was also planted to test the proper planting methods to get the maximum seedling stand. In the fall, field borders 22 through 36 were planted to sudan grass and later the crop was plowed under to aid in fertility and to improve the physical structure of the soil.

Cotton and barley were the indicator crops grown during the 1955 to 1962 period on Field D. The crop yields obtained were analyzed statistically. These results are shown, along with the yield data from each plot within a given year, in Tables 7, 8, 9, 10, 11, and 12. In 1959, cotton seedling stand counts, four per each border, each 50

feet long, were taken on two dates, July 31 and August 25, and the results statistically analyzed as shown in Tables 13 and 14.

Soil Sampling and Preparation

Because salt-affected soils vary tremendously in chemical and sometimes in their physical characteristics, the sampling procedure has always been a major problem. Sayegh, et al. (50) analyzed statistically the variation in electrical conductivity and ESP between soil mapping units and between locations within a mapping unit. The variation in electrical conductivity within a unit was not large but ESP variation was, especially the individual sample variation. It was found that the subsamples taken at a given location for compositing into a given location may vary more than the samples taken over an area to represent the soil mapping unit. However, increasing the number of sampling locations increased the reliability of the mean more rapidly than increasing the number of samples per location. Chapman and Pratt (15) point out the following procedures in soil sampling: (1) take a series of cores according to some systematic grid layout of equal size and those of comparable depth (volume) should be composited; (2) separate soil cores should be analyzed or replicate set of composite made to determine statistical significance of results on the final composite; (3) the number of soil cores to be composited will depend on the variability of the soils, the degree of accuracy desired, the particular

element or elements to be determined, and the general over-all purpose; (4) cultivated soils are generally more variable than virgin soils, and saline and sodic soils are extremely variable; (5) separate composite representing different segments of the soil profile or root zone should be taken; (6) contamination from soil surface materials should be avoided, also contamination of one soil depth with that of another depth; and (7) in areas to be sampled at successive intervals, it is important to make a map showing initial sampling points and take subsequent samples at points a small but definite distance away from the preceding sampling point.

In the preceding discussion, it has been mentioned that the first samples were taken in 1954 in connection with the soil survey, and these samples are characterized in Tables 1 and 2. During the summer months of 1955, each of the 36 borders within Field D were sampled in the following manner: first, three spots per border, equal distance from each other, were chosen as sampling sites. At each site soil samples from depths of one, two, and three feet were taken. This procedure was repeated for each of the other 35 borders.

About a year later in 1956, the field was sampled again in the same manner with one addition. A two-inch depth soil sample was added for analysis.

In 1961 the writer took soil samples on Field D on two dates, September 27 and October 1. The samples were taken six and 10 days,

respectively, after irrigation. The first 18 borders were sampled on the first date and the rest of the 18 borders on October 1, 1961. Each of the 36 borders were sampled in the following manner: first six sites, two in the center of each border with two sites equal distance on each side of the center, were chosen. At each of the six sites, soil cores were taken from depths of one, two, and three feet. The soil cores were composite with their respective depths.

The soil samples in each case were set out to air dry, rolled, and passed through a 2 mm. sieve and prepared for chemical analysis.

Chemical Procedures

Water Analysis

Water samples were collected and shipped to the University of Arizona where analyses were made according to the following procedures: calcium was determined by titrating with .01N EDTA (ethylenediaminetetraacetic acid), using Calver II indicator with 4N NaOH. Calcium and magnesium was determined by titrating with 0.01N EDTA, using Eriochrome Black T indicator and alkaline ammonium chloride buffer. Magnesium was calculated as the difference between the calcium magnesium and calcium values. Sodium was calculated as the difference between the milliequivalents of the anions chloride, sulfate, carbonate, and bicarbonate, and the milliequivalents of calcium and magnesium. Total soluble salts, TSS, were determined by adding the total ions found. Sodium-

adsorption-ratio, SAR, was calculated by the formula (concentration in meq./L):

$$SAR = \frac{Na^{+}}{\sqrt{\frac{Ca^{++}\ Mg^{++}}{2}}}$$

Soil Analysis

The soil samples used in this work were all air-dried and passed through a 2 mm. sieve screen. Subsamples of the air-dried samples were oven-dried for 24 hours at a temperature of about 105° C. to determine the moisture percentage. The moisture content is taken into account in all of the following soil analyses:

Saturated soil paste. The saturated soil pastes were prepared by the method described by the U. S. Salinity Staff (63).

Saturated soil pH. The saturated soil pastes prepared were allowed to stand about one hour before pH measurements were made on the Beckman pH meter Model N.

Electrical conductance. A fairly quantitative estimate of the salt content of solutions extracted from soils can be made from their electrical conductance by the following equation proposed by the U. S. Salinity Staff (63): $p.p.m. = 0.64 \times EC \times 10^{6}$

The Soil and Water Testing Laboratory at the University of Arizona uses the factor 0.70 instead of 0.64 in the above equation because this factor seems to give a closer estimate of the total soluble salts. Another equation suggested by Jackson (30) which gives a close estimate

of the salt toxicity, shown below, takes into account the soil saturation percentage.

$$\% \text{ salt in soil} = 0.064 \times EC \times 10^3 \times \frac{\% \text{ water in soil at extraction}}{100}$$

However, due to the fact that there were no data available of the soil saturation percentages from past research on soil samples taken in 1954, 1955, and 1956, the latter equation was not used. Calculations reported in this manuscript are based on the University of Arizona Soil and Water Testing Laboratory equation.

Saturation extracts were obtained by the procedure described in the U. S. D. A. Handbook 60 (63). The electrical conductivities of the soil paste extracts were determined on a standard solubridge RD-26 with A. C. galvanometer.

1:5 (soil-water) pH. The suspensions were made according to the method described by the U. S. Salinity Staff (63). The prepared suspensions were allowed to stand at least an hour, agitated again for five minutes, and the pH immediately measured on the Beckman pH meter.

Ammonium acetate pH. Air-dried soils, 40 g., were put in glass bottles and 0. 13N ammonium acetate solution was added to bring the soil nearly to saturation. Ammonium acetate solution was then added dropwise until the mixture had the characteristics of a saturated soil paste. After a few minutes' standing, the criteria for saturation was

again determined (free ammonium should not collect on the soil surface, nor should the paste stiffen markedly or lose its glistering appearance on standing.) To each of the samples, sufficient amount of distilled water was added to make a 1:5 suspension. The bottles were then stoppered and shaken for 30 minutes on a mechanical shaker. The pH of the suspension was then determined immediately on the Beckman pH meter. The estimate of the exchangeable sodium percentage was made from a regression line developed by Chang, et al. (12) and these values recorded as part of the calculations in Table 24.

Cation exchange capacity. Two methods were employed in determining the cation exchange capacity. However, in both cases, the principle involved was the same in that of occupying all the cation exchange positions in the soil with one type of cation. These cations then can either be distilled and titrated or replaced with another cation and the displaced cation analyzed. The first method consisted of replacing all of the exchange positions in the soil with the ammonium ion. Ten gm. of air-dried soil was placed in 500 ml. erlenmeyer flash and 250 ml. of neutral N ammonium acetate (pH 7.00) was added to each sample. The flasks were stoppered and shaken thoroughly and allowed to stand overnight. The samples were then filtered through a Buchner funnel with light suction. The soils were leached with ammonium acetate until no test for calcium could be obtained in the leachings. The leachates were saved

for the determination of exchangeable cations. The soils were then leached with 25 percent alcohol to wash out the excessive salts. The soil samples from the Buchner funnels were then transferred into 500 ml. Kjeldahl flasks and diluted to approximately 200 ml. with distilled water. The flasks were then assembled to the distillation apparatus and the ammonia distilled over into receiving flasks containing saturated boric acid. The ammonia was determined by titrating with 0.2N HCl solution, using the double indicator methyl-red-methylene-blue. The milliequivalent of ammonia per 100 gm. of soil determined represents the base exchange capacity.

The writer determined the cation exchange capacity by the method described by Chapman and Pratt (15) with a few modifications. The soil samples were leached through porcelain Gooch crucibles under vacuum suction instead of using the centrifuge apparatus. Soil samples, weighing 4, 5, and 6 gms., were used depending on the texture. The soil in the Gooch crucible was leached with four 33 ml. portions of N sodium acetate (pH 8.2) to saturate the exchange sites. The excess salts were then removed with 100 ml. of 95 percent ethyl alcohol. The absorbed sodium cations were then displaced with three 33 ml. portions of N ammonium acetate solution (pH 7.00) and the leachate saved for analysis. The solutions were diluted to volume and mixed thoroughly before aliquot portions were taken for the determination of sodium on the flame photometer according to the method described by the U.S.

Salinity Staff (63). The milliequivalents of sodium, expressed on oven-dry soil basis, is the base exchange capacity.

Water soluble constituents. The water-soluble sodium and potassium were determined in the saturated extracts on the flame photometer. H_2O soluble calcium and magnesium were also determined in the saturation extract by the procedures used in determining the calcium and magnesium in the water analysis.

Total extractable constituents. The leachates from the ammonium extraction in determining the cation exchange capacity were used in determining the total extractable sodium, potassium, calcium, and magnesium according to methods described in the U. S. D. A. Handbook 60 (63).

Exchangeable sodium. Three methods were employed to estimate the exchangeable sodium. The first method is a calculation in which the soluble sodium found in the saturation extract is subtracted from the total sodium removed in the ammonium acetate solution. The second method described by Piper (47) was employed by the writer with a few modifications. Two duplicate 10 gm. soil samples were weighed out and transferred to 100 ml. centrifuge tubes. The writer added 50 ml. of 60 percent ethyl alcohol to each centrifuge tube. The tubes were stoppered and shaken on a mechanical shaker for five minutes. The tubes were then put into a water bath with a temperature of 50° C. for

ten minutes. The tubes were then put into an International centrifuge size 2, No. E1004, and centrifuged for about ten minutes. The clarified supernatant liquids were then decanted. The samples were then stirred with two additions of 50 ml. of 80 and 90 percent ethyl alcohol respectively. The washings were discarded. After the soluble salts were removed, the soil samples were treated with four successive 50 ml. aliquots of N ammonium acetate and centrifuged and handled as above. The replaced solutions were then made up to 200 milliliter volume, thoroughly mixed and an aliquot portion taken for the determination of exchangeable sodium and potassium on the flame photometer as described by Chapman and Pratt (15). The third procedure used in estimating the exchangeable sodium percentage, centers around two regression equations, $y = 51.24x - 397.87$ with $r = 0.843$, and $y = 23.22x - 184.99$ with $r = 0.666$. These two equations are both described and discussed by Chang, et al. (12). The former equation actually produced higher values than the latter equation, but because of missing data, ammonium acetate pH values, the latter equation was necessary.

EXPERIMENTAL RESULTS AND DISCUSSION

Throughout the course of this experimentation from 1954 to 1961, soil samples were taken and analyzed in the laboratory for the following: the total soluble salt, the exchangeable sodium percentage, the exchangeable sodium, the exchangeable potassium, the soil pH value, and the total cation exchange capacity. The justification for these chemical analyses was based upon the belief that a knowledge of soil changes accompanying soil management and crop cultural practices would provide a foundation for future recommendations in farm practices.

The waters used for irrigation purposes from 1954 to 1961 were all analyzed and compiled for comparative purposes. The total soluble salts, the exchangeable sodium percentage, and the sodium-absorption-ratio were particularly noted. The irrigation waters used in the 1954 to 1962 study were analyzed periodically not to provide a solution to the problem of growing crops, but to provide a reason for the existence and worsening of the salt and particularly the sodium problem.

Crop yield and stand count data were collected and statistically analyzed.

Soil pH Values

No pH data were obtained on soil samples collected from Field D in 1954 and 1955. In 1956, pH values were determined on the saturated soil paste, the 1:5 soil-water ratio, and the saturated ammonium acetate soil paste. In 1961, however, only pH values for the saturated soil paste were obtained on soil samples collected that year. The mean pH values for 1956 and 1961 are summarized in Tables 19 and 20.

For all treatments the overall trend, noted in the 1956 summary, consistently showed that the surface two inch-depth samples were not highly alkaline. The pH values decreased with depth to the second foot. Samples taken from the third-foot depth were higher in pH value than the second-foot depth samples by at least 0.2 of a unit. These trends were noted in all the data on the saturated soil paste, the 1:5 soil-water ratio, and the ammonium acetate soil paste.

In comparing the 1961 to the 1956 data on the saturated soil paste pH values certain trends were noted. Samples collected from the surface one-foot during these two periods were all similar with essentially no change in pH values. In the next lower depth the average decrease in pH value from 1956 to 1961 was less than 0.1 of a pH unit and the pH decreased about 0.2 of a unit for the 24 to 36 inches depth.

Electrical Conductance, E. C.

In the four summaries made for the years 1954, 1955, 1956, and 1961, the electrical conductance means of the experimental plot soils with different water quality treatments are shown at the different depths in Tables 17, 18, 19, and 20. In the following discussions, these mean values will be considered unless otherwise indicated.

In the summary made for 1954, shown in Table 17, the following results were noted: in general the E. C. decreased with depth into the soil profile, and the highest E. C. values were noted for experimental plot included under both group three and four consisting of plot numbers 3, 8, 13, 24, 29, 31, 4, 11, 18, 19, 27, and 32. These two groups of plots were the only ones consistently receiving the well water or poor quality water.

The summary made for the 1955 period, Table 18, showed very little changes in the salt content of the soils over the previous summary made in 1954. The general trend noted in 1954, that of the decrease in mean values with depth into the profile, was still evident even after one complete year of water treatment. Statistically no significant differences among water quality treatments were noted on the first-foot-depth soil samples taken in 1955 (see Table 3). At the second and third foot levels, the E. C. of soil samples taken under different water quality treatments were still significantly different from each other. There was very little

change in E. C. values over the previous year. Any real differences probably are not due to the treatments but are due instead to the inherent characteristics of the soils in the plots which were chosen for each treatment. For instance, the mean E. C. values for plots chosen for treatments three and four which used well water exclusively were higher before the water treatments were introduced on field D.

In 1956, Table 19, there was a definite increase in salts over most of the values obtained in either 1954 or 1955. The increase in values ranged from a low of 1.22 mmhos./cm. to a high value of 6.19 mmhos./cm. The highest increase over the previous two years in E. C. of the soil extracts was noted under treatment four where the soil was irrigated and leached twice with well water. In treatments one and two, where river water was used exclusively, the mean E. C. values were slightly higher than in treatments three, five, and six where some well water was used. The main difference during this period was the change in trend noted, as in 1954 and 1955. The decrease in E. C. values with depth into the profile no longer was evident in any of the treatments. The highest increase in E. C. values, in comparison to other depth samples, occurred mainly in the second-foot depth samples. Statistically, the water quality treatments were all significantly different for the surface crust (two inch depth) samples, the first-foot depth samples, and the second-foot depth samples. The third-foot samples were not significantly different due to different water treatments (see Table 3). In the

surface two inch depth, treatments one, two, five, and six are significantly different from treatments three and four (see Table 4). The differences are due to the source of water used for preplant and post leaching purposes, and not due to the source of water to irrigate the crop. The river water controlled accumulation of salts better than well water. The two treatment combination, well-water leaching, and well-water irrigation, both are less effective than the other treatments to keep the salts flushed out of the surface two inch depth. The treatment comparison on the first-foot depth samples showed that treatments one, two, five, and six are all significantly different from treatment four (see Table 3). The differences are due to the source of leaching water and not due to irrigation water source. River water was more effective than well water for controlling salt accumulation. The treatment combination of well-water leaching, preplant and post leaching, and well-water irrigation seems to be less effective at this depth to keep the salt leached down than the river water leaching and river or well water irrigation combinations. The difference noted among treatments on the second-foot depth samples, treatments five, six, and one are significantly different from three and four. The differences are due to the same reason given above except that in the latter case the distinctions are not as clearly defined as in the former.

The 1961 summary of E. C. values showed definite increases over the 1956 analyses, particularly in the third-foot depths (see Table

3). In general, the E. C. values in this summary increased with depth into the profile which is just opposite the trends noted in the 1954 and 1955 summaries. The highest increase in E. C. over the previous summary throughout the three-depth levels, were noted in the following treatments: three, five, and six, while the lowest increase in E. C. was noted under treatment two. In the summary, the increase in salts in the surface-foot depth, among different treatments, in all cases are relatively low in comparison to the two lower depths. The increases ranged from an E. C. of 0. 52 to 3. 36 mmhos. /cm. with a decrease under treatment one from 5. 53 to 4. 92 mmhos. /cm. Statistically, treatment one was significantly different from treatments five, four, three, and six in the surface foot (see Table 3). The differences are due not to the source of water used for pre- or post-leaching, but rather due to the source of water used for irrigating the crop.

On the second-foot depth samples, the following was noted: treatments one, two, six, and five are all significantly different from treatment three (see Table 3). The differences are due to the source of water used for leaching and not due to water source used during crop growth. The least amount of salts was leached from the second-foot depth where only well water was used.

In the third-foot depths, treatments two and one were significantly different from treatments five and three (see Table 3). The

difference is due to the source of irrigation water used for leaching. River water permitted less salt accumulation than well water.

In nearly all cases, river-water leaching and river-water irrigation was definitely a better combination to keep the salts flushed down out of the soil-root zone than all other combinations. On the other extreme, the combination of well-water leaching and well-water irrigation was least effective in keeping salt from accumulating.

Exchangeable-Sodium-Percentages, ESP

Each value included in each of the 1954, 1955, 1956, and 1961 summaries is a mean of a group of soil samples taken at different depths from the experimental plots listed in the right hand margin under plot number, Tables 17, 18, 19, and 20. These mean values will be considered as guides, reflecting the general trend of the six plots together, in the following discussions unless otherwise indicated.

In general, during the 1954 period, the exchangeable-sodium-percentages, ESP, summarized in Table 17, showed an increase with depth. The third-foot depth samples, in all cases, had higher ESP values than the top two-foot depth samples. There was considerable variation among plots with respect to ESP values in 1954 even before the experimental irrigation treatments began. No significant general trend appeared.

After a year of differential irrigation and water quality treatments, the 1955 data showed very little change in most cases in the ESP values obtained by depths in comparison to the previous summary made in 1954. The greatest increase in ESP occurred in the third-foot samples under treatment two, which involves the use of river water for one preplant and one post leaching and crop irrigation. The greatest decrease in ESP value was noted, at the same depth, under treatment four, which involves the use of well water for one preplant and one post leaching and for crop irrigation source. The increase in percentage amounted to 8.9 and the decrease in percentage amounted to 5.9 in ESP respectively. The general trend noted in the 1954 summary, the ESP increasing with depth down in the soil profile, was still evident after one completely different water quality treatment.

The ESP values obtained for the 1956 data were calculated from the two regression equations based on the relationship between the 1:5 soil-aqueous solution, and the neutral salt, ammonium acetate paste pH values, as proposed by Chang and co-workers (12). The calculated ESP values produced by the two equations are not the same. This is illustrated nicely by the data in the Appendix in Table 24. The reason the second equation was necessary in the above calculation was due to the fact there were too many missing data in the ammonium acetate pH values. The data listed in the Appendix under ESP were all used in making the statistical analyses during this period. The values produced by

the ammonium acetate pH values and the ESP regression equation probably gave the best indication of the ESP because the values produced were similar to ESP determined in the 1954, 1955, and 1961 soil analyses. The calculated values used in making the 1956 ESP summary are those calculated from the ammonium acetate pH with a few based on the 1:5 soil-water pH and the ESP regression equation.

The ESP values decreased with depth down into the soil profile. The highest ESP values were noted in the surface two-inches under treatment three, 42.8, and treatment four, 45.9. Both treatments are similar in that they both require well water at all times. In the surface two-inch depth, treatments one, two, six, three, and five are all significantly different from treatment four (see Table 5). The latter treatment used well water exclusively. Thus the above difference is definitely due to the source of leaching water. River water is preferred over well water for leaching purposes. The other treatments did not provide significant differences. When the 1955 and 1956 ESP summaries were compared, the following results were noted: ESP increases were noted in the first-foot samples under treatments one, two, three, and four, and decreases in ESP values were noted in both the second- and third-foot samples under treatments one, two, three, four, and six. Treatments one and two featured river water for leaching and crop irrigation source. Treatments three and four both used well water for leaching and crop irrigation source. The highest increase in ESP, 4.2, occurred

under treatment four in the first foot samples. The number of decreases exceeded the increases in ESP in this summary.

In the 1961 summary of ESP values, the following results were noted: in general, the ESP at the second-foot depth increased more than other depths and the highest ESP values were noted under treatments three, four, and five also at the second-foot depth. In general, under treatments one and two, the ESP means decreased throughout the three depths while in treatments three and four the highest increases in ESP were noted throughout the three soil depths. Statistically, in the first-foot (see Table 6), treatments one and two, both featuring river water for leaching and crop irrigation source, were significantly different from treatment six which used river water, one preplant and one post leaching, and well water for crop irrigation source, and treatments three and four, both featuring well water for leaching and crop irrigation source. The difference is due to the source of irrigation water, river water preferred over well water, and not due to the source of leaching water. The other treatments did not provide significant differences.

Cation Exchange Capacity, C.E.C.

In general, in all the summaries, the C.E.C. values decreased with depth down into the soil profile. Over all, the C.E.C. ranged from

10 to 34.4 meq./100 gm. The highest C.E.C. were noted in the 1961 analyses.

Potassium

In general, the 1961 summary showed that the soils all decreased in potassium with depth down into the soil profile. The overall exchangeable potassium content ranged from 0.5 to 1.3 meq./100 gm.

Total Dissolved Solids

These values in p.p.m. were calculated and they follow the same trend as the EC x 10^3 values, because the total dissolved solids values are related by the factor of 700.

Yields

Short staple cotton, variety 1517C, was planted on field D in the spring of 1955; however, due to a very poor seedling stand resulting from cold weather and high winds, the poor yields produced under the different water quality treatments were not recorded.

The lint yields of short staple cotton, variety 1517C, harvested in 1956, were significantly different among the different water quality treatments. Statistically, as shown in Table 7, the yields obtained under different treatments that year were due to the source of water used

for preplant and post leachings and not due to the source of water used for crop irrigation.

In 1957 and 1958, yields of short staple lint cotton, variety 1517C, produced under different water quality treatments were not significantly different (see Tables 8 and 9). From 1956 to 1958, the cotton yields produced in each treatment decreased with time. This trend shows up in the total production year by year as follows: in 1956, 17, 328 pounds of lint cotton were produced, while in 1957, 14, 732 pounds were produced; and in 1955, the yields produced amounted to only 12, 277 pounds, a decrease of 4, 951 pounds as compared with the 1956 yield production.

Stand counts taken on short staple cotton, variety 1517C, seedlings on two different dates, July 31 and August 25, 1959 (see Tables 21 and 22), both showed significant differences among the water quality treatments. The differences, both in yield and stand, shown in Tables 13 and 14, were due to the source of water used for irrigation and not due to the source of water used for preplant and post leaching. The data, in general, indicate that the germination of cotton seeds was adversely affected by the poorer water quality of the well water as compared with the better quality of river water.

In 1960 Arivat barley was planted on Field D. The barley crop was used as a nurse crop for alfalfa, variety Moapa. The barley yields

produced under different water quality treatments were not significantly different from each other (see Table 10).

The yields of alfalfa hay produced in 1961 and 1962 on Field D were not significantly different during a given year for a given irrigation leaching treatment (see Tables 11 and 12). The total yearly yield data were incomplete in 1961 and because of this no clear comparisons can be made between the 1961 and 1962 yields.

SUMMARY AND CONCLUSION

The objective of this research was to learn how to manage and use irrigation waters of relatively poor quality when waters of better quality become limited or become unavailable. Such water problems as these are known to occur through many areas in the Southwest. In Arizona, one such area now exists in the Upper Gila Valley where the amount of supplemental ground water pumped each growing season depends primarily on the Gila River flow available for diversion. Because the ground water has a high salt content and a high sodium content in relation to the other cations, the use of this water during periods of river water shortage increases the probability of salt accumulation and increasing the adsorption of sodium on the soil exchangeable sites. Previous laboratory and field studies have shown that the use of well water from the University of Arizona Agricultural Experimental Station Farm as an irrigation source encourages excessive adsorption of sodium (39, 40).

McGeorge, et al. (40) have shown that the well water increased from 2,148 p.p.m. total salts in 1945 to 4,091 p.p.m. total salts in 1948. Although it has varied since 1948, the salinity remained at this concentration to 1951. In contrast the water samples collected and analyzed during the 1954 to 1962 period showed that the total soluble salts

was slightly less than the 1951 concentration. The total soluble salts varied in concentration from 2, 721 p.p.m. to 3, 995 p.p.m. with 3, 369 p.p.m. as the mean value. The sodium-absorption-ratio shown varied from 9 to 26 with a mean value equal to 20.4, while the soluble sodium percentage varied from 66 to 87 percent with a mean value of 82 percent. Statistically no correlation was noted between the total dissolved solids, the sodium-absorption-ratio, and the soluble sodium percentage with respect to time during the 1954 to 1962 period. Using the average collected values of the electrical conductances and the sodium-absorption-ratios, the water classification of the well water on the Experimental Farm for the 1945 to 1951 and the 1954 to 1962 periods in comparison, were essentially the same, a C4S4 class, a very high salinity-very high sodium irrigation water.

The Gila River water samples analyses for the previous two periods, the 1945 to 1951 and the 1954 to 1962, compared much the same as the Experimental Farm well water. Using average collected values of the electrical conductances and the SAR for the two periods, the Gila River water changed in its classification from its previous class of C3S1, a high salinity-low sodium water, to a C3S3 class, a high salinity-medium sodium irrigation water. The chemical composition, that of the total soluble salts, the SAR, and the soluble sodium percentage with respect to time showed considerable variations during both periods. Most of the variation in the river water's composition

can be accounted by the fact that the Gila River water is supplemented with well water during low flow, and it becomes mixed with water from other sources during its transport to the University of Arizona Agricultural Experimental Station Farm.

The preliminary examination of soil samples collected from Field D in 1954 showed that the majority of these samples had electrical conductances of less than 4 mmhos./cm. The exchangeable-sodium-percentage on the other hand ranged from 31.7 to 45.3 percent with the majority of these percentages being less than 35 percent. According to the U. S. Salinity Laboratory classification the majority of these soils would be classed under non-saline-alkali soils though some of these soils would be included under saline-alkali soils.

The results of the soil survey in 1954 showed that there were three prominent soil surface textures: clay loam, silty clay loam, and loam, on Field D. At each of the sampling sites where soil borings were made, the soil texture changed with depth into the profile from the surface, first to sandy loam and then to fine sand in the majority of the cases. Many of the soil profiles examined were stratified with horizontal soil textural layers, silt loam in most cases. These soil stratifications were noted with a higher frequency at the lower depths in most cases. Some accumulation and dispersion of lime were more noticeable than in others among the soil profiles examined. By simple laboratory tests, most of the soil samples ranged from moderate to strongly

calcareous in nature. The substratum permeability ranged from moderate to highly permeable to water in many areas. In many areas of the field it was noted especially where the surface textures were clay loam and silty loam that the soil surface infiltrated water very slowly and on drying, soil cracking was observed.

It was evident from the preliminary analyses of the soil samples taken from Field D in 1954 that the soil problem was closely related to the poor intake of water at the surface and the substratum permeability, in many cases, and the high exchangeable sodium percentage on the soil exchange complexes.

To solve the problem due to slow intake of water and the substratum permeability, the soils on Field D were plowed to a depth of 30 inches to disrupt the horizontal soil stratifications and to mix the surface soils with the lower soil substratum. In comparison to past performance, deep plowing was very successful in promoting rapid water penetration into the soils on Field D.

In view of the lack of success with economic quantities of gypsum as a soil conditioner to keep the sodium absorption under control, a project was initiated in 1954, on Field D on the University of Arizona Agricultural Experimental Station Farm, to determine if it would be possible to best maintain the soil-water equilibrium by using varying proportions of the infrequent supply of Gila River water in relation to the well water source on the farm in combination with deep plowing and crop management.

Six irrigation management and water quality treatments were imposed on the 36 borders within Field D throughout the seven-year period from 1955 to 1962. The individual treatments have been given previously.

Soil samples were taken from all the 36 borders and analyses for the following years, 1955, 1956, and 1961. These analyses together showed the following results:

1. The saturated soil paste pH values did not increase or decrease appreciably to any degree in the surface depth; however, there were pH value decreases noted in the two lower depths, 12 to 24 inches, and 24 to 36 inches. Statistically, no significant differences were noted among the different treatments with respect to these pH values during these two periods, 1956 and 1961.

2. The electrical conductance studies showed a progressive increase by years. This was noted among all water treatments. The highest increase in electrical conductance values was on soil samples taken from plots treated with well water exclusively both as a leaching and crop irrigation source. In all cases the two lower depth soil samples had the highest E. C. values. In practically all cases the river-river combination of leaching and irrigation was more effective than the well water-well water combination of leaching and irrigation. However, during the period of this study there was a progressive increase in salt accumulation despite the use of river water when it was available.

3. There were a number of substantial increases in the exchangeable sodium percentage among the different water treatments. The increase in ESP varied somewhat among the different treatments but overall the river-river combination of leaching and irrigation was more effective in keeping the exchangeable sodium percentage down as compared to the well water-well water combination of leaching and irrigation.

4. The use of river-river water combinations with leaching treatments was most effective in reducing the surface salt accumulation.

5. The yields produced under the river preleaching were the highest in most cases. This appeared to be related to the plant stand produced initially.

6. The yield of cotton decreased as time progressed even though in most cases there was no significant difference among the different water treatments.

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APPENDIX

Table 1. Soil Texture Survey* made in December, 1954, before Water Quality Treatments were introduced on Field D on the University of Arizona Safford Experimental Farm.

LEGEND

C - Clay	Sicl - Silty Clay Loam
Cl - Clay Loam	Sil - Silt Loam
L - Loam	Sl - Sandy Loam
Fsl - Fine Sandy Loam	Vfs - Very Fine Sand
Ls - Loamy Sand	Vfsl - Very Fine Sandy Loam
Scl - Sandy Clay Loam	

Assigned Treatments	Assigned Replications	Plot Number and Hole	Depth: Inches	Texture
1	1	Da1	0-10	L, mod. sandy
			10-16	L, fine sand fract. tendency toward strat.
			16-24	Ls, med.
			24-30	L, med. S
			30-36	Heavy Vfsl
			36-42	Heavy Sil
			42-48	Sl or heavy Vfsl
1	2	Da10	0- 6	Cl
			6-12	Cl
			12-18	Light Sl
			18-24	Light Sl or Ls with considerable silt included
			24-30	Light Sl
			30-36	Vfsl
			36-42	Sl
			42-48	Light Sl

Table 1. (Continued)

Assigned Treatments	Assigned Replications	Plot Number and Hole	Depth: Inches	Texture
1	3	Dc17	0- 6	Cl
			6-12	Cl
			12-18	Light Cl
			18-24	Sl
			24-30	Sl
			30-36	Vfsl with some thin silt strata
			36-42	Vfsl with some thin silt strata
			42-48	Vfsl
1	4	Db21	0- 6	Cl
			6-12	Cl, with more sand
			12-18	Vfsl
			18-24	Fsl, thinly strat. with Sil
			24-30	Vfsl
			30-36	Vfsl strat. with Sil
			36-42	Vfsl
			42-48	Vfsl
1	5	Dc26	0- 6	Cl
			6-12	Cl
			12-15	Cl
			15-18	Fsl
			18-24	Fsl
			24-30	Vfsl with Sil strata
			30-36	Vfsl with stratum of light Sl
			36-42	Sil (or Vfsl with thick Sil strata)
			42-48	Vfsl

Table 1. (Continued)

Assigned Treatments	Assigned Replications	Plot Number and Hole	Depth: Inches	Texture
1	6	Db36	0- 6	Sicl
			6-12	Sicl
			12-18	Scl
			18-24	Fsl with considerable amounts of silt and Vfs
			24-30	Fsl
			30-34	Fsl
			34-36	Sl
			36-42	Light Sl
			42-48	Light Sl, strat. with Sil
			48-54	Fsl - Vfsl
2	1	Dc2	0- 6	Cl
			6-12	Light Cl
			12-18	Heavy L
			18-24	Heavy L
			24-30	L
			30-36	Vfsl
			36-42	Vfsl to Sil
			42-48	Vfsl
2	2	Da7	0- 6	Cl - Vfs fraction
			6-12	Cl
			12-16	Heavy Sl
			16-36	Fsl, close to Vfsl
			36-40	Same with 1" stratum of Sil
			40-48	Light Sl

Table 1. (Continued)

Assigned Treatments	Assigned Replications	Plot Number and Hole	Depth: Inches	Texture
2	3	Db15	0- 6	Cl
			6-12	Cl
			12-18	Scl
			18-24	Sl
			24-30	Vfsl
			30-36	Vfsl
			36-42	Vfsl
			42-48	Vfsl
2	4	Da22	0- 6	Sicl
			6-12	Sicl
			12-18	Fsl
			18-24	Fsl
			24-30	Fsl, nearly Vfsl
			30-36	Fsl
			36-42	Fsl, nearly Vfsl
			42-48	Fsl, nearly Vfsl, very thinly strat. with Sil
2	5	Db30	0- 6	Sicl
			6-12	Cl
			12-18	Scl
			18-24	L with slight predominance of S
			24-30	Sl
			30-36	Sl with coarse sand fraction
			36-42	Sl with coarse sand fraction, strat. with Sil and Vfsl
			42-48	Vfsl strat. with Sil
			48-54	Vfsl strat. with Sil

Table 1. (Continued)

Assigned Treatments	Assigned Replications	Plot Number and Hole	Depth: Inches	Texture
2	6	Dc35	0- 6	Sicl
			6-12	Cl
			12-18	Cl
			18-24	Vfsl
			24-30	Vfsl
			30-36	Fsl
			36-42	Fsl
			42-48	Vfsl
3	1	Db3	0- 6	Light Cl
			6-12	Light Cl
			12-21	Scl
			21-24	Light Sl
			24-30	Sl
			30-36	Vfsl with Sil strat.
			36-42	Fsl
			42-48	Fsl, contains some med. sand
3	2	Dc8	0- 6	Cl
			6-12	Cl
			12-18	Light Cl
			18-24	Sicl
			24-32	Heavy L
			32-36	Vfsl
			36-42	Vfsl with Sil strat.
			42-48	Vfsl

Table 1, (Continued)

Assigned Treatments	Assigned Replications	Plot Number and Hole	Depth: Inches	Texture
3	3	Da13	0- 6	Cl, somewhat silty
			6-12	Cl
			12-18	Sl
			18-24	Sl
			24-30	Sl to Vfsl
			30-36	Vfsl
			36-42	Sil
			42-48	Vfsl
3	4	Db24	0- 6	Cl
			6-12	Cl
			12-18	L
			18-24	Fsl
			24-30	Vfsl
			30-36	Vfsl
			36-42	Vfsl with Sil strat.
			42-48	Vfsl, well strat. with Sil
3	5	Dc29	0- 6	Sicl
			6-12	Cl
			12-18	Fsl
			18-24	Fsl
			24-30	Sl
			30-36	Ls
			36-44	Ls
			44-48	Vfsl with Sil strata

Table 1. (Continued)

Assigned Treatments	Assigned Replications	Plot Number and Hole	Depth: Inches	Texture
3	6	Da34	0- 6	Sicl
			6-12	Sicl
			12-15	Sicl
			15-18	Fsl
			18-24	Fsl
			24-30	Fsl, thinly strat. with Sil
			30-36	Fsl, close to Sl
			36-42	Fsl strat. with Sil
4	1	Da4	0-10	Light Cl
			10-18	Heavy L
			18-24	Fsl
			24-30	Fsl with a little more silt
			30-36	Sil - Vfsl
			36-42	Sil - Vfsl
			42-48	Sil, thinly strat. with Vfsl
4	2	Dc11	0- 6	Cl
			6-12	Cl
			12-18	Cl
			18-24	Cl
			24-30	Heavy Sl
			30-36	Fsl
			36-42	Fsl, nearly Vfsl
			42-48	Vfsl

Table 1. (Continued)

Assigned Treatments	Assigned Replications	Plot Number and Hole	Depth: Inches	Texture
4	3	Db18	0- 6	Light Cl
			6-12	Light Cl
			12-18	Light Cl or heavy L
			18-24	Fsl, with Sil strat.
			24-30	Sl, fairly light
			30-36	Sl, fairly light
			36-42	Light Sl
			42-48	Ls
			48-54	Ls
4	4	Da19	0- 6	Cl
			6-12	Light Cl, Vfs fraction
			12-15	Light Cl
			15-18	Sl
			18-24	Sl with 2" of Sil strat.
			24-30	Fsl to Vfsl with 1" Sil stratum
			30-36	Fsl - Vfsl
			36-42	Light Sl
			42-48	Light Sl, med. sand
4	5	Db27	0- 6	Sicl
			6-12	Cl
			12-18	Cl with Sicl strat.
			18-24	Trans. zone, gypsum in upper 2", sandier below
			24-30	Cl

Table 1. (Continued)

Assigned Treatments	Assigned Replications	Plot Number and Hole	Depth: Inches	Texture
			30-36	Fsl - Vfsl
			36-42	Vfsl
			42-48	Vfsl
			48-54	Vfsl, Sil stratified
4	6	Dc32	0- 6	Cl
			6-12	Cl
			12-18	Scl
			18-24	Fsl
			24-30	Fsl
			30-36	Fsl
			36-42	Vfsl, Sil strata
			42-48	Vfsl, thinly strat. with Sil
5	1	Dc5	0- 6	Light Cl
			6-12	Light Cl
			12-18	Light Cl, rather silty
			18-24	Light Cl, rather silty
			24-30	Light Cl, more sand
			30-36	Vfsl
			36-42	Vfsl, with Sil strat.
			42-48	Same

Table 1. (Continued)

Assigned Treatments	Assigned Replications	Plot Number and Hole	Depth: Inches	Texture
5	2	Db12	0- 6	Cl
			6-12	Cl
			12-18	Scl
			18-24	Sl
			24-30	Sl
			30-36	Vfsl and Sil strat.
			36-42	Sil
			42-48	Vfsl
5	3	Da16	0- 6	Cl
			6-12	Cl with a little more sand
			12-18	Light Scl
			18-24	Heavy Sl
			24-30	L
			30-33	Vfsl
			33-36	Sl
			36-42	Ls
			42-48	Ls
5	4	Dc20	0- 6	Cl
			6-12	Light Cl
			12-18	Light Cl
			18-24	Fsl
			24-30	Sl
			30-36	Sl
			36-39	Sl
			39-42	Ls
			42-48	Ls

Table 1. (Continued)

Assigned Treatments	Assigned Replications	Plot Number and Hole	Depth: Inches	Texture
5	5	Da25	0- 6	Sicl, fairly heavy
			6-12	Sicl, fairly heavy, contains scattered gypsum
			12-18	Sicl
			18-24	Sicl
			24-30	Fsl
			30-36	Fsl
			36-42	Fsl, thinly strat. with Sil
			42-48	Fsl, bordering on Vfsl
5	6	Db33	0- 6	Sicl
			6-12	Sicl
			12-18	Scl, fine sand fraction
			18-24	Fsl, bordering on Vfsl
			24-30	Fsl, bordering on Vfsl
			30-36	Fsl
			36-42	Vfsl strat. with Sil
			42-48	Vfsl strat. with Sil
6	1	Db6	0- 6	Cl
			6-12	Cl
			12-18	Cl
			18-24	Vfsl
			24-30	Vfsl
			30-36	Vfsl, slightly coarse
			36-42	Fsl strat. with Sil
			42-48	Vfsl strat. with Sil

Table 1. (Continued)

Assigned Treatments	Assigned Replications	Plot Number and Hole	Depth: Inches	Texture
6	2	Db9	0- 6	Cl
			6-12	Cl
			12-18	Cl
			18-24	Scl
			24-30	Fsl
			30-36	Vfsl
			36-42	Fsl
			42-48	Fsl
6	3	Dc14	0- 6	Cl
			6-12	Cl
			12-18	Cl
			18-24	Scl
			24-30	Scl, more sandy
			30-36	Vfsl
			36-42	Fsl
			42-48	Vfsl with some silt strat.
6	4	Dc23	0- 6	Cl, gypsum
			6-12	Cl
			12-18	Cl
			18-24	Sl
			24-30	Sl
			30-36	Sil
			36-42	Vfsl
			42-48	Vfsl with Sil strata

Table 1. (Continued)

Assigned Treatments	Assigned Replications	Plot Number and Hole	Depth: Inches	Texture
6	5	Da28	0- 6	Sicl
			6-12	Sicl)
			12-18	Sicl) gypsum
			18-24	Cl
			24-30	Fsl, approaching Vfsl
			30-36	Fsl
			36-42	Fsl
			42-45	Fsl
			45-48	Sil
			48-52	Fsl
6	6	Da31	0- 6	Sicl
			6-12	Cl
			12-18	Sl
			18-24	Fsl
			24-30	Fsl
			30-36	Sl
			36-42	Sl strat. with Sil
			42-48	Vfsl strat. with Sil

*Soil Survey made by the U. S. D. A. Soil Conservation Service.

Table 2. Summary of Soil Textures and Total Soluble Salts of Soils on Field D before Deep Flowing in 1954.

Field Number	Soil Depth	Particle Size Distribution					
		Sand 2.0-.05mm.	Silt .05-.002mm.	Clay .005-.000mm.	Fine Clay .002-.000mm.	Colloid	TSS
	inches	Percent					ppm
D 4a	0-10	49.1	26.8	28.5	24.1	15.9	1483
	10-18	53.6	24.8	25.5	21.6	13.9	1308
	18-30	63.6	21.3	16.5	15.1	9.9	960
	30-48	56.6	27.3	19.5	16.1	9.9	1244
D 12a	0-12	46.6	30.3	32.5	23.1	16.9	2375
	12-30	70.6	14.8	16.1	14.6	9.4	1316
	30-48	61.0	24.9	16.6	14.1	8.9	1050
D 6b	0-18	44.0	22.4	37.1	33.6	21.4	1962
	18-30	56.9	20.3	21.6	23.7	14.4	1149
	30-42	59.5	22.8	19.7	17.7	12.4	1142
	42-48	66.9	16.8	18.7	16.3	10.1	1149

Table 2. (Continued)

Field Number	Soil Depth	Particle Size Distribution					
		Sand 2.0-.05mm.	Silt .05-.002mm.	Clay .005-.000mm.	Fine Clay .002-.000mm.	Colloid	TSS
	inches	Percent					ppm
D 21b	0-12	51.7	19.9	31.8	28.4	17.3	652
	12-30	66.7	19.0	17.8	14.3	8.8	996
	30-48	55.7	27.6	19.2	16.7	10.1	1700
D 33b	0-12	35.9	22.4	46.1	41.7	25.5	3702
	12-18	45.9	19.9	38.1	34.2	19.5	4968
	18-36	66.4	19.9	16.1	13.7	8.9	4038
	36-48	56.9	27.0	19.1	16.1	9.4	4968
D 14c	0-18	44.9	21.5	37.6	33.6	20.4	1685
	18-30	54.4	18.0	30.6	27.6	16.4	1494
	30-48	59.4	23.5	19.6	17.1	9.9	1887
D 20c	0- 6	41.9	26.5	36.6	31.6	17.9	1981
	6-18	43.4	25.0	36.1	31.6	18.9	1332
	18-24	66.9	16.0	19.6	17.1	10.9	1128
	24-39	77.1	12.0	11.9	10.9	7.9	1050
	39-48	89.6	5.0	5.4	5.4	3.4	636

Table 3.. The Electrical Conductivity Mean Comparisons Between Six Different Water Quality Treatments on the Different Depth Samples of Cajon Clay Loam Taken in 1955, 1956, 1961.

Treatments	Depth Samples								
	0 to 12 inches			12 to 24 inches			24 to 36 inches		
	Year			Year			Year		
	1955	1956	1961	1955	1956	1961	1955	1956	1961
	E.C. x 10^3 (mmhos./cm)								
1	3.9ab	5.6a*	4.9a	3.6ab	7.3ab	9.1a	3.2a	5.8a	11.5a
2	3.3a	5.5a	6.5ab	3.3a	8.1abc	10.8ab	3.2a	5.3a	10.1a
3	4.4b	6.4ab	8.3b	4.7c	8.9bc	16.3c	4.4b	6.2a	14.1b
4	4.4b	7.3b	8.0b	4.1bc	10.3c	13.6bc	4.2b	6.8a	12.3ab
5	3.6ab	5.1a	7.3b	3.5ab	6.1a	13.1b	3.4a	5.4a	14.0b
6	3.8ab	5.0a	8.4b	3.4ab	7.3ab	12.0ab	3.7ab	5.2a	12.6b
Standard error	N.S.	0.4	0.6	0.2	0.8	1.0	0.3	N.S.	0.8

*Those mean with the same letter belong to the same population.

Table 4. The Electrical Conductivity Mean Comparison between Six Different Water Quality Treatments on the Surface Two Inch Samples of Cajon Clay Loam taken in 1956.

Replications	Water Quality Treatments					
	1	2	3	4	5	6
	E.C. x 10^3 (mmhos./cm.)					
1	3.97	4.15	2.83	8.30	3.40	3.43
2	4.77	3.13	5.90	9.23	3.60	4.73
3	3.45	3.97	4.43	8.07	3.60	3.77
4	3.30*	3.17	6.80	6.75	2.70	3.65
5	3.63	3.40	7.93	9.23	2.97	3.03
6	2.60	4.75	10.26	10.37	3.62	3.40
Sum	21.72	22.57	38.15	51.95	19.89	22.01
Means	3.62	3.76	6.36	8.66	3.32	3.67
EMS =	1.56	$s_{\bar{x}}$ = 0.51				

Comparison of Individual Means - New Duncan Multiple Range.

Water Quality Treatments					
5	1	6	2	3	4
3.32	3.62	3.67	3.76	6.36	8.66

*Calculated value (missing data).

Table 5. The Exchangeable-Sodium-Percentage Mean Comparisons Between Six Different Water Quality Treatments on the Different Depth Samples of Cajon Clay Loam Taken in 1955, 1956, and 1961.

Treatments	Depth Samples								
	0 to 12 inches			12 to 24 inches			24 to 36 inches		
	Year			Year			Year		
	Exchangeable-Sodium-Percentage								
1	32.5a*	31.8a	30.2a	33.8ab	32.3a	34.0a	33.9a	33.7a	32.0a
2	33.7a	34.1a	30.8a	31.5a	34.1a	37.1ab	40.1a	32.6a	33.2ab
3	31.5a	31.7a	36.1b	33.1ab	31.7a	40.2b	35.0a	26.5a	36.9ab
4	33.3a	30.4a	37.2b	34.5ab	26.2a	41.9b	37.6a	29.4a	35.8ab
5	35.4a	39.0b	34.0ab	33.2ab	29.6a	39.2ab	39.0a	30.4a	40.5b
6	36.2a	27.8a	35.7b	35.7b	30.2a	41.2b	39.4a	29.6a	37.1ab
Standard error	2.6	2.5	1.2	1.1	2.6	2.0	2.4	2.8	2.2

*Those mean with the same letter belong to the same population.

Table 6. The Exchangeable-Sodium-Percentage Mean Comparisons Between Six Different Water Quality Treatments on the Surface Two Inch Samples of Cajon Clay Loam Taken in 1956.

Replications	Calculated Exchangeable-Sodium-Percentage					
	1	2	3	4	5	6
			%			
1	39.2	36.1	32.1	46.9	37.7	42.8
2.	36.6	37.7	42.8	44.3	37.7	37.7
3.	39.2	37.7	44.3	43.8	41.8	37.7
4	29.0	37.7	46.1	45.4	33.6	35.1
5	41.8	26.3	47.9	43.8	37.7	40.2
6	30.0	44.3	28.6	52.0	45.4	37.7
Sum	215.8	219.8	231.8	276.2	233.9	231.2
Mean	35.97	36.63	38.63	46.03	38.98	38.53
EMS =	27.54	$s_{\bar{x}}$ = 2.14				

Comparison of Individual Means - New Duncan Multiple Range.

	Water Quality Treatments					
	1	2	6	3	5	4
Individual mean	35.97	36.63	38.53	38.63	38.98	46.03

Table 7. Yield of Cotton Produce Under Six Different Water Quality Treatments in 1956.

Replications	Water Quality Treatments					
	1	2	3	4	5	6
	lbs/plot *					
1	515	513	408	401	514	495
2	531	526	435	456	558	499
3	478	529	452	376	458	541
4	575	530	540	449	524	550
5	505	426	487	411	506	501
6	388	433	422	430	483	483
Sum	2992	2957	2744	2523	3043	3069
Means	498.66	492.83	457.33	420.50	507.16	511.50
EMS =	1253.60	$s_{\bar{x}}$ = 14.45				

Comparison of Individual Means - New Duncan Multiple Range.

	Water Quality Treatments					
	4	3	2	1	5	6
Individual means	420.50	457.33	492.83	498.66	507.16	511.50

*plot size. The individual plot measured 220 feet long by 27 feet wide.

Table 8. Yield of Cotton Produce Under Six Different Water Quality Treatments in 1957.

Replications	Water Quality Treatments					
	1	2	3	4	5	6
	lbs/plot *					
1	411	423	318	333	307	416
2	455	415	338	386	480	435
3	404	458	384	405	423	426
4	526	453	693	417	457	703
5	536	442	320	409	485	352
6	313	339	148	325	329	268
Sum	2645	2530	2201	2275	2481	2600
Means	440.83	421.66	366.83	379.17	413.50	433.33

EMS = 5714.6 $s_{\bar{x}}$ = 30.86

Comparison of Individual Means - New Duncan Multiple Range.

	Water Quality Treatments					
	3	4	5	2	6	1
Means	366.83	379.17	413.50	421.66	433.33	440.83

*plot size. The individual plot measured 220 feet long by 27 feet wide.

Table 9. Yield of Cotton Produce Under Six Different Water Quality Treatments in 1958.

Replications	Water Quality Treatments					
	1	2	3	4	5	6
	lbs/plot *					
1	365	366	250	307	304	280
2	378	231	351	352	402	321
3	420	462	374	276	330	387
4	512	480	288	334	430	314
5	384	283	369	382	319	351
6	250	287	303	284	291	260
Sum	2309	2109	1935	1935	2076	1913
Means	384.83	351.50	322.50	322.50	346.00	318.83
EMS =	3378.7	$s_{\bar{x}}$ = 23.73				

Comparison of Individual Means - New Duncan Multiple Range.

	Water Quality Treatments					
	6	3	4	5	2	1
Individual means	318.83	322.50	322.50	346.00	351.50	384.83

*plot size. The individual plot measured 220 feet long by 27 feet wide.

Table 10. Yield of Barley Grain Under Six Different Water Quality Treatments in 1960.

Replications	Water Quality Treatments					
	1	2	3	4	5	6
	lbs/plot*					
1	310	327	332	322	197	273
2	294	310	314	350	324	270
3	227	319	310	211	343	335
4	327	297	257	260	276	236
5	244	118	264	237	208	247
6	176	290	195	250	191	191
Sum	1578	1661	1672	1630	1539	1552
Means	263.00	276.83	278.67	271.67	256.50	258.67

EMS = 2579.42 $s_{\bar{x}}$ = 20.73

Comparison of Individual Means - New Duncan Multiple Range.

	Water Quality Treatments					
	5	6	1	4	2	3
Individual means	256.50	258.67	263.00	271.67	276.83	278.67

*plot size. The individual plot measured 220 feet long by 27 feet wide.

Table 11. Yield of Alfalfa Hay Under Six Different Water Quality Treatments in 1961.

Replications	Water Quality Treatments					
	1	2	3	4	5	6
	lbs/plot *					
1	344	505	489	424	363	410
2	456	427	285	387	228	276
3	332	534	367	345	420	285
4	490	401	420	388	395	339
5	282	389	276	281	397	381
6	509	480	428	377	325	338
Sum	2413	2736	2265	2202	2128	2029
Means	402.17	456.00	377.50	367.00	354.67	338.17

EMS = 4320.4 $s_{\bar{x}}$ = 26.83

Comparison of Individual Means - New Duncan Multiple Range

	Water Quality Treatments					
	6	5	4	3	1	2
Individual means	338.17	354.67	367.00	377.50	402.17	456.00

*plot size. The individual plot measured 220 feet long by 27 feet wide.

Table 12. Yield of Alfalfa Hay Produce Under Six Different Water Quality Treatments in 1962.

Replications	Water Quality Treatments					
	1	2	3	4	5	6
	lbs/plot*					
1	1762	1945	1462	1511	1293	1475
2	1178	1451	1418	1121	1299	1475
3	1080	1046	1180	1117	1357	1470
4	1251	1230	1125	1146	1450	990
5	973	924	1466	1077	1235	1129
6	1054	1307	1225	1445	1284	1198
Sum	7298	7903	7876	7417	7918	7737
Means	1216.33	1317.17	1312.67	1236.17	1319.67	1289.50

EMS = 34,713. - $s_{\bar{x}}$ = 76.06

Comparison of Individual Means - New Duncan Multiple Range.

	Water Quality Treatments					
	1	4	6	3	2	5
Individual means	1216.33	1236.17	1289.50	1312.67	1317.17	1319.67

*plot size. The individual plot measured 220 feet long by 27 feet wide.

Table 13. Stand Count of Cotton Seedling Under Six Different Water Quality Treatments in 1959.

Replications	Water Quality Treatments					
	1	2	3	4	5	6
	Average plant count/50 feet of row					
1	200	211	32	76	18	53
2	256	242	30	93	66	80
3	269	271	60	19	61	203
4	216	274	116	65	72	124
5	188	179	36	151	136	148
6	247	253	38	48	104	60
Sum	1376	1430	312	452	457	668
Means	229.33	238.33	52.0	75.33	76.16	111.33
EMS =	1719.09	$s_{\bar{x}}$ = 16.93				

Comparison of Individual Means - New Duncan Multiple Range.

	Water Quality Treatments					
	4	3	2	1	5	6
Individual means	420.50	457.33	492.83	498.66	507.16	511.50

Table 14. Stand Count of Cotton Seedling Under Six Different Water Quality Treatments in 1959.

Replications	Water Quality Treatments					
	1	2	3	4	5	6
	Averages of Four Count					
1	207	216	38	87	21	66
2	247	227	41	107	114	86
3	219	260	71	53	115	227
4	220	272	138	117	136	161
5	167	194	64	183	176	178
6	231	235	64	76	157	77
Sum	1291	1404	416	623	719	795
Means	215.17	234.00	69.33	103.83	119.83	132.50
EMS =	1736.99	$s_{\bar{x}}$ = 17.01				

Comparison of Individual Means - New Duncan Multiple Range.

	Water Quality Treatments					
	3	4	5	6	1	2
Individual means	69.33	103.83	119.83	132.50	215.17	234.00

Table 15. Some Chemical Constituents Found in the Gila River Water Used for Irrigation Purposes on the University of Arizona Safford Farm from 1954 through 1962.

Month Sampled	Ca	Mg	Na	Na	Na/Ca	SAR*	TSS**
	meq/Liter			%			ppm
			1954				
August	4.2	0.3	12.8	74	3.6	8.5	1164
September	6.0	1.3	11.0	60	2.2	5.7	2406
			1955				
March	4.2	1.9	19	76	5.2	10.9	1636
May	3.8	2.0	29	83	4.5	17.0	1318
June	3.8	1.8	16.2	74	4.9	9.7	1387
August	2.0	0.9	3.2	52	1.9	2.3	430
August	3.8	0.9	0.7	13	0.5	0.5	360
September	3.2	1.2	9.9	69	5.2	6.7	940
			1956				
April	3.0	2.2	14.3	73	5.5	8.9	1332
May	3.0	1.2	21.8	84	8.2	15.1	1711
June	2.6	1.4	15.0	79	6.6	10.6	1217
July	2.1	3.3	16.7	75	9.1	10.2	1413
October	2.7	1.3	13.0	76	5.5	9.2	1103

*SAR means Sodium-Adsorption-Ratio and is calculated from the equation: $SAR = \frac{Na+}{\sqrt{(Ca^{++} + Mg^{++})/2}}$

**TSS means total soluble salts.

Table 15. (Continued)

Month Sampled	Ca	Mg	Na	Na	Na/Ca	SAR	TSS
	--------meq/Liter--------			%			ppm
			1957				
June	2.7	0.8	13.0	78	5.4	9.8	1088
November	2.2	1.0	3.3	51	1.7	2.6	460
			1958				
May	1.3	0.4	3.0	63	2.6	3.2	363
August	3.0	1.4	8.0	64	3.0	5.4	817
August	2.6	1.5	7.2	64	3.1	5.0	760
			1959				
March	3.4	1.3	10.1	68	3.4	6.6	999
April	3.0	1.2	13.6	76	5.1	9.4	1217
May	4.7	1.9	19.6	75	4.7	10.8	1713
May	5.3	2.3	17.1	69	3.7	8.8	1614
July	4.9	2.1	16.0	69	3.8	8.5	1509
November	3.0	1.2	3.8	47	1.4	2.6	547
			1960				
June	3.5	1.2	13.3	74	4.3	8.7	1193
			1961				
August	2.2	0.9	6.9	69	3.6	5.6	691

Table 15. (Continued)

Month Sampled	Ca	Mg	Na	Na	Na/Ca	SAR	TSS
	--------meq/Liter--------			%			ppm
			1962				
June	3.5	1.4	11.9	71	3.9	7.6	1112
August	2.0	0.8	3.3	54	1.9	2.8	433
September	5.6	2.7	16.3	66	3.3	8.0	1610
October	2.7	1.0	3.0	45	1.3	2.2	455

Table 16. Some Chemical Constituents of the University of Arizona Safford Farm Well Used for Irrigation Purposes from 1954 through 1962.

Month Sampled	Ca	Mg	Na	Na	Na/Ca	SAR*	TSS**
	--------meq/Liter--------			%			ppm
			1954				
February	7.9	1.9	51	84	7.4	23.1	3995
April	6.0	1.0	46	87	8.8	24.6	3364
August	10.5	1.0	46	80	5.0	19.2	3534
September	6.3	3.5	20	67	3.7	9.0	2721
			1955				
February	5.0	1.9	41	86	9.3	22.2	3072
March	7.6	3.2	37	77	5.6	15.9	3071
April	5.6	2.6	46	85	9.6	22.8	3469
June	5.5	1.8	49	87	10.3	25.6	3647
August	7.9	1.6	46	83	6.8	22.3	3558
			1956				
January	5.5	1.5	41.3	86	8.7	22.1	3124
February	4.1	2.0	42.4	87	11.9	24.4	3146
April	4.6	2.0	42.6	86	11.9	23.5	3474
May	5.5	2.1	43.4	85	9.1	22.9	3412
June	4.4	1.0	27.0	83	7.0	16.5	1927
July	3.6	3.5	46.8	86	14.9	24.9	3467

*SAR means Sodium-Adsorption-Ratio and is calculated from the equation: $SAR = \frac{Na^{+}}{\sqrt{(Ca^{++} + Mg^{++})/2}}$

**TSS means total soluble salts.

Table 16. (Continued)

Month Sampled	Ca	Mg	Na	Na	Na/Ca	SAR	TSS
	--------meq/Liter-------			%			ppm
			1956				
October	5.5	1.4	41.0	85	8.6	21.6	3530
October*	3.1	2.3	22.5	80	8.3	14.61	1798
			1957				
April	7.4	3.0	47.0	82	7.3	20.6	3698
April	6.2	2.6	49.2	84	9.0	23.5	3735
April	6.3	2.2	49.5	85	9.0	24.0	3702
April	5.8	2.8	46.3	84	9.2	22.4	3788
June	5.8	2.5	52.9	86	10.5	26.0	3955
July	5.6	2.3	51.2	86	10.4	25.8	3811
			1958				
May	5.9	1.5	46.2	86	9.0	22.2	3503
July	5.3	2.3	37.9	83	8.2	19.5	2951
August	5.9	3.4	46.2	83	9.0	21.3	3554
September	6.0	2.7	48.9	85	9.3	23.5	3685
November	5.3	2.8	43.8	84	9.4	21.8	3328
December	9.1	3.2	43.0	78	5.4	17.4	3552

*Mixed-Well and River Water

Table 16. (Continued)

Month Sampled	Ca	Mg	Na	Na	Na/Ca	SAR	TSS
	-------meq/Liter--------			%			ppm
			1959				
March	8.7	3.8	42.7	77	5.6	17.1	3518
April	6.9	2.7	47.9	83	7.9	21.9	3709
April	6.5	2.9	38.6	80	6.8	17.9	3473
May	6.3	2.9	48.3	84	8.8	22.6	3701
May	6.5	2.7	47.0	84	8.3	22.0	3614
May	6.4	3.1	46.8	83	8.4	21.6	3599
June	16.6	3.8	54.6	73	3.8	17.1	4823
June	12.2	5.8	57.3	76	5.4	19.1	4906
November	5.9	2.5	42.2	84	8.4	20.7	3268
			1960				
March	7.8	3.4	40.1	78	5.9	17.0	3334
April	10.3	4.3	30.3	67	3.4	11.2	2903
June	12.4	4.3	36.7	69	3.4	12.7	3877
			1962				
January	4.7	2.9	40.4	83	9.9	20.8	3165
February	4.8	2.7	39.1	84	9.4	20.2	3081
June	12.8	3.9	33.8	66	3.0	11.7	3298

Table 17. Some Chemical Characteristics of Cajon Clay Loam Taken in 1954 before Treatment with Water of Different Quality.

Number	Depth	EC x 10^3	C. E. C.	Exch. Na	Exch. Na	H_2O Soluble Na in the Saturated Paste	Total Soluble Salt
	feet	(mmhos. /cm.)	meq. /100 gm.	meq. /100 gm.	%	%	ppm
1, 10, 17	1	3.93	21.8	7.4	33.7	31.5	2751
21, 26, 36	2	3.57	19.2	6.5	33.9	34.2	2499
	3	3.22	12.5	9.3	34.1	33.9	2254
2, 7, 15	1	3.17	20.9	6.6	31.7	28.3	2219
22, 30, 35	2	3.27	18.3	5.8	31.5	31.5	2289
	3	3.25	10.4	4.2	40.6	40.1	2275
3, 8, 13	1	4.35	21.6	7.1	32.9	31.5	3045
24, 29, 34	2	4.68	18.6	6.2	33.2	33.2	3276
	3	4.43	13.0	4.4	33.9	32.4	3101
4, 11, 18	1	4.83	22.5	7.4	32.8	33.3	3381
19, 27, 32	2	4.12	19.9	6.9	34.5	34.5	2884
	3	4.32	10.9	5.0	45.3	38.9	3024
5, 12, 16	1	3.52	23.2	7.9	34.0	35.4	2464
20, 25, 33	2	3.48	18.3	6.1	33.3	33.2	2436
	3	3.37	11.8	4.6	38.8	39.0	2359
6, 9, 14	1	3.48	23.8	8.6	36.0	36.2	2436
23, 28, 31	2	3.42	17.3	6.1	35.4	35.7	2394
	3	3.67	12.3	4.6	37.7	39.0	2569

Data represent means of two replicated samples. C. E. C. means cation exchange capacity.
EC means electrical conductivity

Table 18. Some Chemical Characteristics of Cajon Clay Loam Taken in 1955 after Partial Water Treatments with Different Quality.

Treatment	Plot Number	Depth	EC x 10^3	C. E. C.	Exch. Na	Exch. Na	Total Soluble Salt
		feet	(mmhos./cm.)	meq./100 gm.	meq./100 gm.	%	ppm
1							
River water source: Irrigation and pre-plant leaching.	1, 10, 17 21, 26, 36	1	3.93	22.5	7.4	32.9	2751
		2	3.53	19.2	6.5	33.9	2471
		3	3.22	12.3	4.2	34.1	2254
2							
River water source: Irrigation and two leachings: one pre-plant and one post leaching.	2, 7, 15 22, 30, 35	1	3.30	20.8	7.0	33.7	2310
		2	3.28	18.3	5.8	31.7	2296
		3	3.22	10.5	5.2	49.5	2254
3							
Well water source: Irrigation and one preplant leaching.	3, 8, 13 24, 29, 34	1	4.36	22.7	7.7	33.9	3052
		2	4.68	18.6	6.1	32.8	3276
		3	4.45	13.3	4.4	33.1	3115
4							
Well water source: Irrigation and two leachings: one pre-plant and one post leaching.	4, 11, 18 19, 27, 32	1	4.44	22.6	7.5	33.0	3108
		2	4.12	19.9	6.8	34.2	2884
		3	4.21	11.1	4.4	39.6	2947

Table 18. (Continued)

Treatment	Plot Number	Depth feet	EC x 10^3 (mmhos./cm.)	C.E.C. meq./100 gm.	Exch. Na meq./100 gm.	Exch. Na %	Total Soluble Salt ppm
5							
Well water source: Irrigation. River water source: one preplant leaching.	5, 12, 16 20, 25, 31	1	3.55	23.2	7.9	34.1	2485
		2	3.47	18.5	6.1	33.0	2429
		3	3.37	12.0	4.6	38.3	2359
6							
Well water source: Irrigation. River water source: one preplant and one post leaching.	6, 9, 14 23, 28, 31	1	3.81	23.6	8.6	36.4	2667
		2	3.42	17.2	6.1	35.5	2394
		3	3.69	12.2	4.5	36.9	2583

Data represent means of three replicated samples.
C.E.C. means cation exchange capacity.
EC means electrical conductivity.

Table 19. Some Chemical Characteristics of Cajon Clay Loam Taken in 1956 after Treatment with Different Water Quality.

Treatment	Plot Number	Depth inches	EC x 10^3 (mmhos. /cm.)	Paste pH	1:5 ratio pH	NH_4AC pH	Calculated Na %	Total Soluble Salt ppm
1								
River water source:	1, 10	2	3.68	8.12	9.41	8.47	36.1	2576
Irrigation and one pre-	17, 21	12	5.58	7.92	9.19	8.46	35.6	3906
plant leaching.	26, 36	24	7.27	7.92	9.26	8.40	32.5	5089
		36	5.82	8.10	9.46	8.41	33.0	4074
2								
River water source:	2, 7	2	3.76	8.11	9.33	8.52	38.7	2732
Irrigation and two	15, 22	12	5.51	7.93	9.22	8.47	36.1	3857
leachings: one pre-	30, 35	24	8.08	7.84	9.10	8.37	31.0	5656
plant and one post		36	5.29	8.04	9.35	8.48	36.6	8703
leaching.								
3								
Well water source:	3, 8	2	6.51	8.12	9.34	8.60	42.8	4557
Irrigation and one pre-	13, 24	12	6.36	8.06	9.07	8.47	36.1	4952
plant leaching.	29, 34	24	8.86	7.84	8.97	8.32	23.3	6202
		36	6.15	7.99	9.07	8.43	34.1	4305
4								
Well water source:	4, 11	2	8.66	8.14	9.41	8.66	45.9	6062
Irrigation and two	18, 19	12	7.48	7.97	9.11	8.49	37.2	5236
leaching, one preplant	27, 32	24	10.31	7.81	8.89	8.36	30.5	7217
and one post leaching.		36	6.85	8.04	9.21	8.39	32.0	4795

Table 19. (Continued)

Treatment	Plot Number	Depth	EC x 10^3	Paste	1:5 ratio	NH_4AC	Calculated Na	Total Soluble Salt
		inches	(mmhos. /cm.)	pH	pH	pH	%	ppm
5								
Well water source:	5, 12	2	3.32	8.11	9.40	8.53	39.2	2324
Irrigation. River	16, 20	12	5.05	7.96	9.07	8.43	34.1	3535
water source: one	25, 33	24	6.09	7.97	9.08	8.43	34.1	4263
preplant leaching		36	5.43	8.09	9.23	8.43	34.1	3801
6								
Well water source:	6, 9	2	3.67	8.07	9.39	8.52	38.7	2569
Irrigation. River	14, 23	12	5.03	8.04	9.00	8.47	36.1	3521
water source: one	28, 31	24	7.26	7.91	9.01	8.41	33.1	5082
preplant and one post leaching.		36	5.21	8.12	9.32	8.40	32.5	3647

Data represent means of triplicated sample.
C. E. C. means cation exchange capacity.
EC means electrical conductivity.
NH_4AC means 0.13N Ammonium acetation solution.
1:5 ratio means 1 part soil to 5 parts water.

Table 20. Some Chemical Characteristics of Cajon Clay Loam taken in 1961 after Six Years of Treatment with Different Water Quality.

Treatment	Plot Number	Depth feet	EC x 10^3 (mmhos. / cm.)	Paste pH	C. E. C. meq. / 100 gm.	Exch. Na meq. / 100 gm.	Exch. Na %	Exch. K meq. / 100 gm.	Total Soluble Salt ppm.
1									
River water source:	1, 10	1	4.92	8.05	28.5	8.6	30.2	1.2	3444
Irrigation and one	17, 21	2	9.12	7.86	21.9	7.4	33.8	1.0	6384
preplant leaching.	26, 36	3	11.48	7.89	12.1	4.5	31.9	0.5	8036
2									
River water source:	2, 7	1	6.54	7.95	27.7	8.4	30.3	1.2	4578
Irrigation and two	15, 22	2	10.78	7.80	20.1	7.4	36.8	1.0	7546
leachings: one pre-	30, 35	3	10.10	7.81	13.0	4.3	33.1	0.5	7070
plant and one post leaching.									
3									
Well water source:	3, 8	1	8.33	8.00	31.4	11.3	36.0	1.3	5831
Irrigation and one	13, 24	2	16.33	7.82	24.8	9.8	39.5	0.9	11431
preplant leaching.	29, 34	3	14.10	7.86	14.1	5.2	36.9	0.5	9870
4									
Well water source:	4, 11	1	8.00	7.99	29.8	11.1	37.2	1.2	5600
Irrigation and two	18, 19	2	13.55	7.84	25.4	10.5	41.3	1.1	9485
leachings: one pre-	27, 32	3	12.27	7.86	14.4	5.1	35.4	0.6	8589
plant and one post leaching.									

Table 20. (Continued)

Treatment	Plot Number	Depth feet	EC x 10^3 (mmhos. / cm.)	Paste pH	C. E. C. meq. / 100 gm.	Exch. Na meq. / 100 gm.	Exch. Na %	Exch. K meq. / 100 gm.	Total Soluble Salt ppm
5									
Well water source:	5, 12	1	7.27	7.98	30.3	10.2	33.7	1.2	5089
Irrigation. River	16, 20	2	13.07	7.79	24.2	9.5	39.3	1.1	9149
water source: one	25, 33	3	14.03	7.80	14.5	5.9	40.7	0.5	9821
preplant leaching.									
6									
Well water source:	6, 9	1	8.40	8.04	31.3	11.2	35.9	1.3	5880
Irrigation. River	14, 23	2	11.97	7.81	25.8	10.4	40.3	1.0	8379
water source: one	28, 31	3	12.62	7.85	14.8	5.5	37.2	0.6	8834
preplant and one post leaching.									

Data represent means of two replicated samples.
C. E. C. means cation exchange capacity.
EC means electrical conductivity.

Table 21. Cotton Seedling Stand Counts Under Six Different Water Quality Treatments in 1959.

	Number of plants per 50-foot row on 7/31/59				
Plot Number	1w*	2w	3e	4e	Average
1	192	227	190	191	200
2	183	225	207	229	211
3	0	92	37	0	32
4	79	75	137	12	76
5	17	33	14	7	18
6	27	47	60	77	53
7	232	246	246	242	242
8	89	6	4	20	30
9	74	92	105	47	80
10	291	237	256	241	256
11	199	81	74	17	93
12	28	50	125	60	66
13	45	36	87	70	60
14	169	263	175	206	203
15	268	275	305	236	271
16	40	14	102	88	61
17	244	230	267	333	269
18	7	4	52	14	19
19	127	109	0	23	65
20	62	66	78	83	72
21	177	247	157	284	216
22	285	269	241	301	274
23	110	133	133	118	124
24	183	63	160	58	116
25	127	85	201	132	136
26	118	120	250	265	188
27	125	99	142	239	151
28	209	48	216	118	148
29	2	9	84	48	36
30	168	105	211	233	179
31	87	102	6	45	60
32	84	17	80	11	48
33	97	120	65	132	104
34	6	10	44	93	38
35	271	218	238	289	253
36	296	267	252	172	247

*w = west side of the border; e = east side of the border

Table 22. Cotton Seedling Stand Counts under Six Different Water Quality Treatments in 1959.

	Number of plants per 50-foot row on 8/25/59				
Plot Number	1w	2w	3e	4e	Average
1	254	196	192	184	207
2	170	224	285	185	216
3	82	2	58	8	38
4	87	63	183	16	87
5	25	35	7	18	21
6	37	71	87	70	66
7	233	207	234	233	227
8	12	79	17	55	41
9	114	49	48	131	86
10	285	235	230	239	247
11	213	109	84	21	107
12	99	88	159	110	114
13	26	75	103	79	71
14	249	267	220	173	227
15	271	264	255	249	260
16	23	150	178	108	115
17	212	186	371	108	219
18	54	5	25	127	53
19	148	235	35	48	117
20	252	72	148	73	136
21	230	171	201	276	220
22	250	280	263	293	272
23	104	247	128	165	161
24	187	69	159	135	138
25	147	129	219	209	176
26	163	159	190	156	167
27	140	164	245	183	183
28	113	215	174	210	178
29	24	18	99	115	64
30	144	223	201	208	194
31	91	124	31	62	77
32	100	30	102	73	76
33	164	207	70	187	157
34	27	16	80	133	64
35	251	256	202	229	235
36	208	284	195	236	231

Table 23. Some Chemical Characteristics of Cajon Clay Loam Taken in 1955.

Plot Number	Depth feet	EC x 10^3 (mmhos. / cm.)	C. E. C. meq. / 100 gm.	Exch. Na meq. / 100 gm.	Exch. Na %	Total Soluble Salt ppm
1	1	5.0	15.1	5.2	34.4	3500
1	1	3.5	9.9	3.5	35.4	2450
1	1	2.4	10.6	2.7	25.5	1680
1	2	4.4	26.1	8.9	34.1	3080
1	2	3.8	19.9	5.2	26.1	2660
1	2	3.1	14.7	6.3	42.9	2170
1	3	3.5	20.0	6.5	32.5	2450
1	3	3.0	10.5	3.9	37.1	2100
1	3	2.6	13.2	3.1	23.5	1820
10	1	4.1	32.1	15.2	47.4	2870
10	1	4.0	26.2	8.1	30.9	2800
10	1	3.9	23.0	9.0	39.1	2730
10	2	4.2	24.0	7.2	30.0	2940
10	2	2.9	15.9	5.1	32.1	2030
10	2	3.0	10.4	4.0	38.5	2100
10	3	4.5	--	--	--	3150
10	3	3.7	--	--	--	2590
10	3	2.9	12.1	4.5	37.2	2030
17	1	4.1	26.9	8.3	30.9	2870
17	1	3.3	26.3	8.6	32.7	2310
17	1	2.5	16.8	4.1	24.4	1750
17	2	3.8	18.2	7.0	38.5	2660
17	2	2.3	24.6	9.2	37.4	1610
17	2	2.6	17.2	4.1	23.8	1820
17	3	4.7	--	--	--	3290
17	3	2.2	--	--	--	1540
17	3	1.5	10.6	3.7	34.9	1050
21	1	4.5	22.3	8.2	36.8	3150
21	1	3.0	20.5	5.4	26.3	2100
21	1	3.0	21.4	8.7	40.7	2100
21	2	3.6	25.0	7.9	31.6	2520
21	2	2.2	21.5	6.1	28.4	1540
21	2	3.9	24.6	8.4	34.1	2730

Table 23. (Continued)

Plot Number	Depth feet	EC x 10^3 (mmhos. / cm.)	C. E. C. meq. / 100 gm.	Exch. Na meq. / 100 gm.	Exch. Na %	Total Soluble Salt ppm
21	3	3.2	--	--	--	2240
21	3	2.5	--	--	--	1750
21	3	2.9	15.1	5.0	33.1	2030
26	1	3.5	23.0	9.4	40.9	2450
26	1	4.4	18.0	6.6	36.7	3080
26	1	5.6	38.2	11.1	29.1	3920
26	2	2.6	23.2	8.3	35.8	1820
26	2	3.0	13.0	4.8	36.9	2100
26	2	6.6	--	--	--	4620
26	3	3.2	16.4	6.5	39.6	2240
26	3	2.7	10.0	3.1	31.0	1890
26	3	6.5	19.8	7.4	37.4	4550
36	1	6.5	29.2	7.2	24.7	4550
36	1	4.2	26.0	6.7	25.8	2940
36	1	3.4	19.6	4.4	22.4	2380
36	2	5.5	23.8	10.3	43.3	3850
36	2	4.8	17.5	5.4	30.9	3360
36	2	2.2	7.2	2.0	27.8	1540
36	3	4.5	8.6	3.3	38.4	3150
36	3	2.4	7.8	2.5	32.1	1680
36	3	1.5	3.1	0.7	22.6	1050
2	1	3.4	14.6	5.0	35.2	2380
2	1	2.7	9.0	4.8	53.3	1890
2	1	1.6	16.7	3.6	21.6	1120
2	2	4.5	29.1	10.2	35.1	3150
2	2	2.4	20.6	5.7	27.7	1680
2	2	2.8	14.1	2.4	17.0	1960
2	3	4.5	29.5	8.7	29.5	3150
2	3	2.8	18.3	5.2	28.4	1960
2	3	2.8	9.0	3.1	34.4	1960
7	1	3.8	30.3	13.1	43.2	2660
7	1	3.6	30.1	10.4	34.6	2520
7	1	3.3	16.8	7.4	44.0	2310

Table 23. (Continued)

Plot Number	Depth feet	EC x 10^3 (mmhos. / cm.)	C. E. C. meq. / 100 gm.	Exch. Na meq. / 100 gm.	Exch. Na %	Total Soluble Salt ppm
7	2	3.0	21.6	6.3	29.2	2100
7	2	3.4	19.2	8.0	41.7	2380
7	2	2.4	12.6	4.3	34.1	1680
7	3	4.0	--	--	--	2800
7	3	4.6	--	--	--	3220
7	3	3.0	12.7	3.6	28.3	2100
15	1	5.5	26.7	8.2	30.7	3850
15	1	2.7	15.3	4.4	28.8	1890
15	1	1.6	26.1	7.7	29.5	1120
15	2	4.4	29.5	6.5	22.0	3080
15	2	2.1	10.9	3.4	31.2	1470
15	2	1.5	18.6	7.5	40.3	1050
15	3	5.3	--	--	--	3710
15	3	1.3	--	--	--	910
15	3	2.0	8.7	4.7	54.0	1400
22	1	4.8	22.8	7.5	32.9	3360
22	1	3.8	22.3	7.0	31.4	2660
22	1	4.3	16.0	5.7	35.6	3010
22	2	3.4	22.1	7.6	34.4	2380
22	2	5.0	23.0	6.0	26.1	3500
22	2	5.7	13.6	5.0	36.8	3990
22	3	2.9	13.0	4.9	37.7	2030
22	3	3.2	12.3	4.4	35.8	2240
22	3	4.0	9.6	4.0	41.7	2800
30	1	4.5	21.9	6.1	27.9	3150
30	1	2.9	23.1	7.1	30.7	2030
30	1	3.2	14.6	4.4	30.1	2240
30	2	3.6	11.2	3.5	31.3	2520
30	2	3.0	23.2	7.8	33.6	2100
30	2	2.8	12.4	2.7	21.8	1960
30	3	3.0	9.6	3.5	37.5	2100
30	3	5.0	7.6	6.2	81.6	3500
30	3	2.5	5.1	2.1	41.2	1750

Table 23. (Continued)

Plot Number	Depth feet	EC x 10^3 (mmhos. / cm.)	C. E. C. meq. / 100 gm.	Exch. Na meq. / 100 gm.	Exch. Na %	Total Soluble Salt ppm
35	1	3.0	29.8	10.3	34.6	2100
35	1	2.9	22.4	7.8	34.8	2030
35	1	1.8	17.2	5.0	29.1	1260
35	2	3.4	19.4	7.1	36.6	2380
35	2	3.5	14.2	5.5	38.7	2450
35	2	2.2	14.5	4.2	29.0	1540
35	3	1.6	9.0	3.5	38.9	1120
35	3	2.9	7.6	2.9	38.2	2030
35	3	2.6	7.6	2.3	30.3	1820
3	1	5.0	--	--	--	3500
3	1	4.5	--	--	--	3150
3	1	4.5	13.1	2.1	16.0	3150
3	2	5.0	28.3	7.6	26.9	3500
3	2	4.0	14.7	4.4	29.9	2800
3	2	7.0	15.6	4.4	28.2	4900
3	3	6.2	25.0	5.8	23.2	4340
3	3	4.0	12.7	3.3	26.0	2800
3	3	4.0	15.7	3.7	23.6	2800
8	1	4.8	29.5	8.7	29.5	3360
8	1	4.7	32.3	11.2	34.7	3290
8	1	4.4	11.5	2.8	24.3	3080
8	2	4.4	30.3	10.5	34.7	3080
8	2	4.6	19.2	6.1	31.8	3220
8	2	4.4	11.5	2.8	24.3	3080
8	3	5.1	--	--	--	3570
8	3	5.6	--	--	--	3920
8	3	4.4	13.3	4.0	30.1	3080
13	1	5.5	30.0	9.2	30.7	3850
13	1	4.1	28.2	9.1	32.3	2870
13	1	4.0	22.3	7.0	31.4	2800
13	2	4.0	17.8	5.8	32.6	2800
13	2	4.4	13.5	5.7	42.2	3080
13	2	3.8	10.8	4.1	38.0	2660
13	3	4.2	--	--	--	2940
13	3	5.1	--	--	--	3570
13	3	4.8	11.8	4.6	39.0	3360

Table 23. (Continued)

Plot Number	Depth feet	EC x 10^3 (mmhos. / cm.)	C. E. C. meq. / 100 gm.	Exch. Na meq. / 100 gm.	Exch. Na %	Total Soluble Salt ppm
24	1	3.6	17.6	7.0	39.8	2520
24	1	3.8	11.8	4.0	33.9	2660
24	1	6.0	29.2	12.0	41.0	4200
24	2	3.6	12.8	5.2	40.6	2520
24	2	3.5	10.6	3.9	36.8	2450
24	2	8.0	29.7	11.5	38.7	5600
24	3	3.0	7.6	3.7	48.7	2100
24	3	2.8	--	--	--	1960
24	3	5.5	13.9	6.3	45.3	3850
29	1	4.2	22.4	12.3	54.9	2940
29	1	4.1	25.9	8.7	32.6	2870
29	1	6.4	22.1	6.4	29.0	4480
29	2	4.2	16.0	5.3	33.1	2940
29	2	3.7	27.1	8.7	32.1	2590
29	2	6.6	28.5	8.5	29.8	4620
29	3	3.0	7.5	2.5	33.8	2100
29	3	3.6	17.6	7.0	39.8	2520
29	3	6.4	11.6	4.1	35.3	4480
34	1	5.0	28.7	10.5	36.6	3500
34	1	2.1	19.7	7.8	39.6	1470
34	1	1.8	18.2	5.0	28.0	1260
34	2	4.6	22.5	6.6	29.3	3220
34	2	6.5	18.0	6.6	36.7	4550
34	2	2.0	8.0	2.5	31.3	1400
34	3	5.2	12.2	4.6	37.7	3640
34	3	5.1	12.1	4.8	39.7	3570
34	3	2.1	11.5	2.5	21.7	1470
4	1	4.0	--	--	--	2800
4	1	4.5	24.1	6.3	26.1	3150
4	1	10.5	17.5	5.5	31.4	7350
4	2	4.3	29.5	9.1	30.8	3010
4	2	6.0	23.3	7.2	30.9	4200
4	2	6.0	15.1	3.6	23.8	4200

Table 23. (Continued)

Plot Number	Depth feet	EC x 10^3 (mmhos. / cm.)	C. E. C. meq. / 100 gm.	Exch. Na meq. / 100 gm.	Exch. Na %	Total Soluble Salt ppm
4	3	5.5	--	--	--	3850
4	3	6.5	--	--	--	4550
4	3	5.0	--	--	--	3500
11	1	4.3	29.8	9.6	32.2	3010
11	1	4.5	26.9	9.2	34.2	3150
11	1	3.9	20.1	5.5	27.4	2730
11	2	4.5	20.9	8.0	38.3	3150
11	2	4.6	13.3	4.8	36.1	3220
11	2	4.2	16.0	5.4	33.8	2940
11	3	4.8	--	--	--	3360
11	3	5.8	--	--	--	4060
11	3	4.4	11.9	4.4	37.0	3080
18	1	4.2	24.0	8.7	36.3	2940
18	1	3.6	20.7	8.1	39.1	2520
18	1	3.6	17.0	6.4	37.6	2520
18	2	3.8	21.1	7.5	35.5	2660
18	2	3.4	14.1	5.1	36.2	2380
18	2	3.9	17.5	6.6	37.7	2730
18	3	4.5	--	--	--	3150
18	3	2.5	--	--	--	1750
18	3	3.5	9.5	3.8	40.0	2450
19	1	3.7	24.9	7.6	30.5	2590
19	1	3.2	11.6	5.1	44.0	2240
19	1	3.9	12.0	3.8	31.7	2730
19	2	3.4	23.0	7.6	33.0	2380
19	2	3.5	10.1	3.6	35.6	2450
19	2	3.2	7.4	2.4	32.4	2240
19	3	2.9	--	--	--	2030
19	3	2.8	--	--	--	1960
19	3	3.3	10.6	3.7	34.9	2310
27	1	4.8	23.5	9.0	38.3	3360
27	1	2.9	29.1	4.4	15.1	2030
27	1	4.5	33.0	12.0	36.4	3150

Table 23. (Continued)

Plot Number	Depth feet	EC x 10^3 (mmhos./cm.)	C.E.C. meq./100 gm.	Exch. Na meq./100 gm.	Exch. Na %	Total Soluble Salt ppm
27	2	4.5	19.7	5.5	27.9	3150
27	2	3.6	25.7	9.2	35.8	2520
27	2	3.0	34.7	13.1	37.8	2100
27	3	3.3	12.4	5.7	46.0	2310
27	3	3.8	13.8	5.7	41.3	2660
27	3	4.9	15.3	4.8	31.4	3430
32	1	2.8	19.6	7.4	37.8	1960
32	1	6.5	24.5	9.4	38.4	4550
32	1	4.5	25.2	8.7	34.5	3150
32	2	3.6	18.8	9.4	50.0	2520
32	2	5.2	21.7	8.7	40.1	3640
32	2	3.5	25.4	6.4	25.2	2450
32	3	3.9	10.4	4.8	46.2	2730
32	3	6.1	8.4	3.7	44.0	4270
32	3	2.3	7.8	3.0	38.5	1610
5	1	4.5	29.9	8.0	26.8	3150
5	1	4.8	28.1	9.1	32.4	3360
5	1	2.6	15.2	3.4	22.4	1820
5	2	4.0	26.9	7.1	26.4	2800
5	2	5.5	19.6	5.7	29.1	3850
5	2	2.5	11.3	2.1	18.6	1750
5	3	5.2	--	--	--	3640
5	3	3.9	--	--	--	2730
5	3	2.7	13.3	4.6	34.6	1890
12	1	4.1	11.9	10.7	90.0	2870
12	1	3.6	25.6	8.4	32.8	2520
12	1	4.2	20.8	9.8	47.1	2940
12	2	4.6	15.3	5.9	38.6	3220
12	2	4.1	16.9	6.7	39.6	2870
12	2	3.8	10.7	3.7	34.6	2660
12	3	5.5	--	--	--	3850
12	3	4.2	--	--	--	2940
12	3	3.1	11.8	4.6	39.0	2170

Table 23. (Continued)

Plot Number	Depth feet	EC x 10^3 (mmhos. / cm.)	C. E. C. meq. / 100 gm.	Exch. Na meq. / 100 gm.	Exch. Na %	Total Soluble Salt ppm
16	1	3.8	25.5	9.3	36.5	2660
16	1	2.8	24.1	7.9	32.8	1960
16	1	2.3	18.7	5.1	27.3	1610
16	2	3.8	22.6	8.8	38.9	2660
16	2	3.1	15.3	6.5	42.5	2170
16	2	3.5	17.0	5.1	30.0	2450
16	3	4.8	--	--	--	3360
16	3	2.5	--	--	--	1750
16	3	2.0	11.5	4.3	37.4	1400
20	1	1.6	24.0	7.9	32.9	1120
20	1	2.7	17.4	4.2	24.1	1890
20	1	2.6	13.6	4.6	33.8	1820
20	2	3.5	13.1	4.7	35.9	2450
20	2	3.7	15.7	4.0	25.5	2590
20	2	2.5	11.6	4.6	39.7	1750
20	3	1.9	--	--	--	1330
20	3	3.1	--	--	--	2170
20	3	1.9	9.8	4.9	50.0	1330
25	1	5.0	25.2	7.2	28.6	3500
25	1	3.1	22.6	5.5	24.3	2170
25	1	4.9	35.3	10.9	30.9	3430
25	2	3.4	19.4	6.5	33.5	2380
25	2	2.6	13.5	3.7	27.4	1820
25	2	3.6	39.1	11.3	28.9	2520
25	3	3.2	16.4	6.5	39.6	2240
25	3	2.7	10.0	3.1	31.0	1890
25	3	6.5	19.8	7.4	37.4	4550
33	1	3.6	25.7	10.9	42.4	2520
33	1	3.2	24.7	9.0	36.4	2240
33	1	4.6	28.9	10.1	34.9	3220
33	2	4.2	26.9	11.0	40.9	2940
33	2	2.6	15.1	5.7	37.7	1820
33	2	1.5	22.8	6.7	29.4	1050

Table 23. (Continued)

Plot Number	Depth feet	EC x 10^3 (mmhos. / cm.)	C. E. C. meq. / 100 gm.	Exch. Na meq. / 100 gm.	Exch. Na %	Total Soluble Salt ppm
33	3	3.8	12.6	4.4	34.9	2660
33	3	2.3	8.5	4.0	47.1	1610
33	3	1.5	6.1	1.8	29.5	1050
6	1	5.0	27.0	9.8	36.3	3500
6	1	3.7	27.5	13.1	47.6	2590
6	1	3.2	23.5	6.7	28.5	2240
6	2	5.0	17.8	5.8	32.6	3500
6	2	4.0	19.1	6.0	31.6	2800
6	2	4.0	15.6	4.8	30.8	2800
6	3	4.7	--	--	--	3290
6	3	5.9	--	--	--	4130
6	3	3.0	12.7	4.6	36.2	2100
9	1	5.6	30.7	11.2	36.5	3920
9	1	4.0	23.8	9.8	41.2	2800
9	1	4.0	10.5	4.7	44.8	2800
9	2	4.6	23.5	8.0	34.0	3220
9	2	3.6	10.9	4.8	44.0	2520
9	2	3.0	10.6	3.8	35.8	2100
9	3	6.5	--	--	--	4550
9	3	5.0	--	--	--	3500
9	3	2.7	11.6	5.1	44.0	1890
14	1	3.3	27.3	8.8	32.2	2310
14	1	5.1	23.1	7.5	32.5	3570
14	1	3.5	23.9	7.7	32.2	2450
14	2	3.3	13.6	4.7	34.6	2310
14	2	3.3	15.3	4.8	31.4	2310
14	2	2.9	13.9	4.7	33.8	2030
14	3	2.6	--	--	--	1820
14	3	3.3	--	--	--	2310
14	3	3.5	12.5	4.7	37.6	2450
23	1	3.2	20.8	7.0	33.7	2240
23	1	3.7	18.7	5.8	31.0	2590
23	1	7.5	24.4	13.1	53.7	5250

Table 23. (Continued)

Plot Number	Depth feet	EC x 10^3 (mmhos. / cm.)	C. E. C. meq. / 100 gm.	Exch. Na meq. / 100 gm.	Exch. Na %	Total Soluble Salt ppm
23	2	3.7	18.1	7.0	38.7	2590
23	2	4.5	14.2	4.9	34.5	3150
23	2	4.2	23.8	10.3	43.3	2940
23	3	3.0	7.0	3.7	52.9	2100
23	3	4.2	12.8	4.2	32.8	2940
23	3	7.0	8.5	4.9	57.6	4900
31	1	2.7	21.2	5.7	26.9	1890
31	1	3.2	24.0	7.2	30.0	2240
31	1	1.5	20.0	10.1	50.5	1050
31	2	2.7	13.6	5.3	39.0	1890
31	2	2.7	15.2	6.7	44.1	1890
31	2	1.3	11.2	3.8	33.9	910
31	3	2.2	9.7	2.9	29.9	1540
31	3	1.7	8.3	2.8	33.7	1190
31	3	1.3	8.6	3.5	40.7	910

Table 24. Some Chemical Characteristics of Cajon Clay Loam Taken in 1956.

Plot No.	Depth inches	EC x 10^3 (mmhos. / cm.)	H_2O Paste pH	H_2O 1:5 pH	1:5 NH_4AC pH	Calculated Exch. Na meq. / 100 gm.	Total Soluble Salt ppm
1	2	3.97	8.08	9.48	8.53	39.2	2779
10	2	4.77	8.12	9.30	8.48	36.6	3339
17	2	3.45	8.12	9.47	8.53	39.2	2415
21	2	--	8.03	9.37	8.33	29.0	--
26	2	3.63	8.17	9.40	8.58	41.8	2541
36	2	2.60	8.23	9.43	8.35	30.0	1820
1	12	2.20	8.30	9.37	--	32.6*	1540
10	12	3.45	7.35	8.65	--	15.9*	2415
17	12	6.50	8.05	9.25	8.47	36.1	4550
21	12	6.40	8.03	9.32	8.47	36.1	4480
26	12	8.93	7.87	9.15	8.45	35.1	6251
36	12	6.00	7.92	9.40	8.45	35.1	4200
1	24	4.80	7.97	9.43	--	34.0*	3360
10	24	3.93	8.13	9.20	--	28.6*	2751
17	24	10.57	7.78	9.20	8.47	36.1	7399
21	24	5.40	8.00	9.30	8.35	30.0	3780
26	24	8.20	7.90	9.20	8.40	32.5	5740
36	24	10.70	7.76	9.22	8.40	32.5	7490
1	36	4.37	8.20	9.67	--	39.5*	3059
10	36	4.83	8.17	9.27	--	30.3*	3381
17	36	7.53	7.97	9.38	8.47	36.1	5271
21	36	6.30	7.97	9.45	8.52	38.7	4410
26	36	7.70	7.87	9.38	8.45	35.1	5390
36	36	4.20	8.43	9.58	8.20	22.3	2940
2	2	4.15	8.07	9.37	8.47	36.1	2905
7	2	3.13	8.13	9.18	8.50	37.7	2191
15	2	3.97	8.13	9.52	8.50	37.7	2779
22	2	3.17	8.11	9.40	8.50	37.7	2219
30	2	3.40	8.10	9.10	--	26.3*	2380
35	2	4.75	8.13	9.43	8.63	44.3	3325

Table 24. Some Chemical Characteristics of Cajon Clay Loam Taken in 1956. (Continued)

Plot No.	Depth inches	EC x 10^3 (mmhos. / cm.)	H_2O Paste pH	H_2O 1:5 pH	1:5 NH_4AC pH	Calculated Exch. Na meq. / 100 gm.	Total Soluble Salt ppm
2	12	3.63	8.17	9.60	--	37.9*	2541
7	12	6.33	7.88	8.88	8.35	30.0	4431
15	12	4.13	7.70	8.90	--	21.7*	2891
22	12	5.60	7.98	9.35	8.52	38.7	3920
30	12	5.97	7.95	9.33	8.57	41.2	4179
35	12	7.40	7.93	9.25	8.45	35.1	5180
2	24	3.80	8.23	9.60	--	37.9*	2660
7	24	8.50	7.83	8.87	8.43	24.1	5950
15	24	6.90	7.63	8.95	8.35	30.0	4830
22	24	10.75	7.83	9.00	8.32	28.4	7525
30	24	9.47	7.78	8.98	8.37	31.0	6629
35	24	9.07	7.72	9.22	8.38	31.5	6349
2	36	4.87	8.10	9.45	--	34.4*	3409
7	36	5.33	7.92	9.20	--	28.6*	3731
15	36	4.73	8.10	8.93	--	22.4*	3311
22	36	6.93	7.98	9.42	8.47	36.1	4851
30	36	5.15	8.00	9.52	8.53	39.2	3605
35	36	4.75	8.12	9.58	8.45	35.1	3325
3	2	6.30	8.20	9.35	--	32.1*	4410
8	2	7.30	8.13	9.32	8.60	42.8	5110
13	2	8.50	8.17	9.45	8.63	44.3	5950
24	2	6.83	7.97	9.28	8.47	36.1	4781
29	2	7.30	8.17	9.42	8.70	47.9	5110
34	2	2.60	8.10	9.20	--	28.6*	1820
3	12	2.83	8.13	9.20	--	28.6*	1981
8	12	5.90	8.17	8.87	8.40	32.5	4130
13	12	4.43	8.13	8.73	--	17.7*	3101
24	12	6.80	8.03	9.30	8.50	37.7	4760
29	12	7.93	7.98	9.15	8.52	38.7	5551
34	12	10.26	7.92	9.15	8.45	35.1	7182

Table 24. (Continued)

Plot No.	Depth inches	EC x 10^3 (mmhos. / cm.)	H_2O Paste pH	H_2O 1:5 pH	1:5 NH_4AC pH	Calculated Exch. Na meq. / 100 gm.	Total Soluble Salt ppm
3	24	5.43	7.90	8.63	--	15.4*	3801
8	24	8.50	7.83	8.87	8.35	30.0	5950
13	24	10.75	7.80	8.95	8.30	27.4	7525
24	24	8.10	7.90	9.18	7.65	28.2*	5670
29	24	9.50	7.80	9.13	8.38	31.5	6650
34	24	10.90	7.80	9.12	8.43	34.1	7630
3	36	4.13	8.00	8.63	--	15.4*	2891
8	36	4.37	8.10	9.13	--	27.0*	3059
13	36	5.95	7.95	8.60	--	14.7*	4165
24	36	7.63	7.93	9.30	8.43	34.1	5341
29	36	8.37	7.90	9.25	8.40	32.5	5859
34	36	6.43	8.07	9.52	8.45	35.1	4501
4	2	8.30	8.17	9.40	8.68	46.9	5810
11	2	9.23	8.08	9.67	8.63	44.3	6460
18	2	8.07	8.13	9.48	8.62	43.8	5649
19	2	6.75	8.20	9.43	8.65	45.4	4725
27	2	9.23	8.10	9.18	8.62	43.8	6461
32	2	10.37	8.13	9.30	8.78	52.0	7259
4	12	5.97	7.88	8.90	--	21.7*	4179
11	12	4.75	8.00	8.95	--	22.8*	3325
18	12	--	--	--	--	--	--
19	12	8.10	8.10	9.33	8.48	36.6	5670
27	12	9.10	7.92	9.20	8.45	35.1	6370
32	12	9.50	7.97	9.18	8.55	40.2	6650
4	24	5.30	7.83	8.60	--	14.7*	3710
11	24	6.40	7.73	8.83	--	20.0*	4480
18	24	14.40	7.80	9.00	8.45	35.1	10080
19	24	11.75	7.95	9.15	8.33	29.0	8225
27	24	12.90	7.70	8.65	8.25	24.9	9030
32	24	11.10	7.83	9.13	8.42	33.6	7770

Table 24. (Continued)

Plot No.	Depth inches	EC x 10^3 (mmhos. / cm.)	H_2O Paste pH	H_2O 1:5 pH	1:5 NH_4AC pH	Calculated Exch. Na meq. / 100 gm.	Total Soluble Salt ppm
4	36	3.60	8.23	8.83	--	20.0*	2520
11	36	5.33	8.13	9.16	--	27.7*	3731
18	36	6.00	8.05	9.50	8.50	37.7	4200
19	36	7.53	7.95	9.40	8.47	36.1	5271
27	36	11.57	7.75	8.80	8.25	24.9	8099
32	36	7.07	8.13	9.58	8.35	30.0	4949
5	2	3.40	8.00	9.18	8.50	37.7	2380
12	2	3.60	8.15	9.42	8.50	37.7	2520
16	2	3.60	8.15	9.50	8.58	41.8	2520
20	2	2.70	8.05	9.38	8.42	33.6	1890
25	2	2.97	8.17	9.47	8.50	37.7	2079
33	2	3.62	8.12	9.43	8.65	45.4	2534
5	12	3.13	8.07	8.63	--	15.4*	2191
12	12	3.90	7.98	9.08	8.40	32.5	2730
16	12	3.37	7.77	9.07	--	25.8*	2359
20	12	6.80	8.05	9.30	8.42	33.6	4760
25	12	6.10	7.93	9.18	8.43	34.1	4270
33	12	7.00	7.93	9.17	8.47	36.1	4900
5	24	2.67	8.33	8.83	--	20.0*	1869
12	24	7.33	7.83	8.90	--	21.7*	5131
16	24	4.00	8.00	9.10	8.50	37.7	2800
20	24	6.80	7.93	9.20	8.32	28.4	4700
25	24	7.87	7.87	9.23	8.48	36.6	5509
33	24	7.87	7.85	9.22	8.40	32.5	5509
5	36	3.73	8.40	9.03	--	24.7*	2611
12	36	5.47	7.97	9.07	--	25.8*	3829
16	36	2.00	8.32	9.23	--	29.3*	1400
20	36	7.17	7.90	9.25	8.40	32.5	5019
25	36	6.87	7.95	9.28	8.42	33.6	4809
33	36	7.33	8.00	9.50	8.48	36.6	5131

Table 24. (Continued)

Plot No.	Depth inches	EC x 10^3 (mmhos. / cm.)	H_2O Paste pH	H_2O 1:5 pH	1:5 NH_4AC pH	Calculated Exch. Na meq. / 100 gm.	Total Soluble Salt ppm
6	2	3.43	8.08	9.32	8.60	42.8	2401
9	2	4.73	8.07	9.23	8.50	37.7	3311
14	2	3.77	8.10	9.50	8.50	37.7	2639
23	2	3.65	8.03	9.47	8.45	35.1	2555
28	2	3.03	8.10	9.32	8.55	40.2	2121
31	2	3.40	8.02	9.47	8.50	37.7	2380
6	12	3.00	8.30	8.67	--	16.3*	2100
9	12	4.07	8.13	9.08	--	25.8*	2849
14	12	3.33	8.00	8.67	--	16.3*	2331
23	12	6.55	7.93	9.18	8.50	37.7	4585
28	12	7.05	7.95	9.23	8.43	34.1	4935
31	12	6.20	7.97	9.18	8.48	36.6	4340
6	24	6.20	8.05	8.75	8.35	30.0	4340
9	24	5.50	7.85	9.15	8.45	35.1	3850
14	24	5.50	7.90	8.70	--	17.0*	3850
23	24	10.30	7.95	9.05	8.40	32.5	7210
28	24	7.87	7.82	9.13	8.35	30.0	5509
31	24	8.20	7.87	9.28	8.48	36.6	5740
6	36	2.73	8.37	9.13	--	27.0*	1911
9	36	3.65	8.23	9.48	8.55	40.2	2555
14	36	5.90	8.11	8.87	--	21.0*	4130
23	36	5.90	8.17	9.60	8.57	41.2	4130
28	36	7.90	7.73	9.25	8.27	25.9	5530
31	36	5.17	8.12	9.58	8.20	22.3	3619

*Calculated from the following Regression equation:

$$Y = 23.22x - 184.99, \text{ with } r = 0.666.$$

The rest of the calculated values were estimated from the regression equation, $Y = 51.24x - 397.87$, with $r = 0.843$.

Table 25. Some Chemical Characteristics of Cajon Clay Loam Taken in 1961.

Plot No.	Depth feet	EC x 10^3 (mmhos. / cm.)	Paste pH	C. E. C. meq. / 100 gm.	Exch. Na meq. / 100 gm.	Exch. Na %	Exch. K meq. / 100 gm.	Total Soluble Salt ppm
1	1	4.20	7.90	24.2	6.8	28.1	1.1	2940
1	1	4.40	7.90	24.4	6.5	26.6	1.1	3080
1	2	8.40	7.80	25.4	7.6	29.9	1.2	5880
1	2	8.60	7.80	24.6	7.3	29.7	1.3	6020
1	3	13.00	7.61	12.4	4.5	36.3	0.7	9100
1	3	14.00	7.59	12.4	4.1	33.1	0.7	9800
10	1	6.80	8.05	31.5	10.1	32.1	1.4	4760
10	1	7.00	8.01	31.9	10.3	32.3	1.5	4900
10	2	12.40	7.70	27.3	9.5	34.8	1.0	8680
10	2	13.20	7.90	27.2	9.4	34.6	1.0	10640
10	3	18.00	7.86	21.1	4.8	22.7	0.4	12600
10	3	16.00	7.84	21.9	5.1	23.3	0.4	11200
17	1	5.10	8.10	26.7	8.5	31.8	1.1	3570
17	1	5.90	8.00	27.1	8.2	30.3	1.1	4130
17	2	5.90	7.89	16.6	5.9	35.5	0.5	4130
17	2	6.10	7.81	16.6	6.1	36.7	0.5	4270
17	3	9.50	7.88	9.6	3.0	31.2	0.2	6650
17	3	9.50	8.92	9.6	3.0	31.2	0.2	6650
21	1	2.70	8.10	26.1	8.3	31.8	1.2	1890
21	1	2.70	8.30	25.9	8.3	32.0	1.2	1890
21	2	6.50	8.00	20.1	7.1	35.3	0.7	4550
21	2	6.30	8.00	20.1	7.1	35.3	0.7	4410
21	3	9.70	7.90	14.1	4.8	34.0	0.4	6790
21	3	9.30	7.90	13.9	5.4	38.8	0.4	6510
26	1	6.30	8.00	33.6	10.5	31.3	1.2	4410
26	1	6.30	8.00	33.8	10.7	31.7	1.3	4410
26	2	11.50	7.90	27.0	8.6	31.9	1.7	8050
26	2	10.50	7.70	27.0	9.2	34.1	1.6	7350
26	3	12.10	7.80	20.0	7.3	36.5	0.9	8470
26	3	11.70	7.80	20.0	7.5	37.5	0.9	8190

Table 25. (Continued)

Plot No.	Depth feet	EC x 10^3 (mmhos. / cm.)	Paste pH	C. E. C. meq. / 100 gm.	Exch. Na meq. / 100 gm.	Exch. Na %	Exch. K meq. / 100 gm.	Total Soluble Salt ppm
36	1	3.80	8.20	28.4	7.7	27.1	1.3	2660
36	1	3.80	8.00	28.4	7.6	26.8	1.3	2660
36	2	8.70	7.90	15.5	5.4	34.8	0.9	6090
36	2	9.30	7.90	15.5	5.4	34.8	0.9	6510
36	3	7.40	7.80	7.1	2.1	29.6	0.4	5180
36	3	7.60	7.80	6.9	2.1	30.4	0.3	5320
2	1	10.20	7.60	19.4	5.6	28.9	0.9	7140
2	1	9.80	7.60	19.2	5.3	27.6	0.9	6860
2	2	7.50	7.50	19.2	7.0	36.5	0.9	5250
2	2	8.50	7.70	18.8	7.0	37.2	0.9	5950
2	3	11.00	7.40	14.8	5.3	35.8	0.6	7700
2	3	11.00	7.40	14.4	5.3	36.8	0.6	7700
7	1	7.00	7.93	35.0	10.8	30.7	1.5	4900
7	1	7.40	7.91	35.0	10.4	29.6	1.4	5180
7	2	12.60	7.64	17.3	8.2	47.5	0.9	8820
7	2	12.40	7.70	17.3	8.3	47.6	0.8	8680
7	3	12.00	7.60	17.0	5.6	32.9	0.6	8400
7	3	12.00	7.60	17.0	5.8	34.1	0.6	8400
15	1	4.90	8.10	28.8	8.7	30.2	1.1	3430
15	1	4.70	7.86	28.4	8.8	31.0	1.1	3290
15	2	10.80	7.80	22.0	6.9	31.4	0.9	7560
15	2	10.70	7.80	22.0	7.0	31.8	0.9	7490
15	3	12.00	7.90	13.3	4.2	31.6	0.3	8400
15	3	11.60	7.80	13.1	4.2	32.1	0.4	8120
22	1	7.60	8.10	25.3	7.9	31.2	1.1	5320
22	1	7.40	8.20	25.3	8.1	32.0	1.1	5180
22	2	8.00	8.00	22.3	6.6	29.6	0.9	5600
22	2	8.80	8.00	22.3	6.7	30.0	0.9	6160
22	3	9.20	7.90	12.6	3.9	31.0	0.5	6440
22	3	8.80	7.90	13.2	3.9	29.5	0.4	6160

Table 25. (Continued)

Plot No.	Depth feet	EC x 10^3 (mmhos./cm.)	Paste pH	C.E.C. meq./100 gm.	Exch. Na meq./100 gm.	Exch. Na %	Exch. K meq./100 gm.	Total Soluble Salt ppm
30	1	4.70	8.10	27.5	8.9	32.4	1.1	3290
30	1	4.80	8.00	27.9	8.9	31.9	1.3	3360
30	2	15.10	7.88	22.9	8.8	38.4	1.1	10570
30	2	14.90	7.82	22.7	8.8	38.7	1.1	10430
30	3	8.00	8.10	11.6	3.7	31.9	0.5	5600
30	3	9.00	7.90	11.6	3.3	28.8	0.5	6300
35	1	5.50	8.00	30.0	8.5	28.3	1.4	3850
35	1	4.50	8.00	29.8	8.3	35.9	1.4	3150
35	2	10.00	7.90	17.0	6.5	38.2	1.1	7000
35	2	10.00	7.90	17.0	6.6	38.8	1.1	7000
35	3	8.10	8.15	8.7	3.4	39.1	0.4	5670
35	3	8.50	8.05	8.7	3.1	35.6	0.4	5950
3	1	9.20	7.80	25.1	8.1	32.3	1.0	6440
3	1	8.80	7.91	25.1	8.2	33.1	1.0	6160
3	2	11.80	7.69	23.6	9.7	41.1	1.1	8260
3	2	12.20	7.71	23.8	9.5	39.9	1.1	8540
3	3	13.10	7.60	14.4	5.3	36.8	0.6	9170
3	3	12.90	7.60	14.4	5.5	38.2	0.6	9030
8	1	10.00	7.88	39.9	14.0	35.1	1.8	7000
8	1	9.80	7.92	40.5	13.1	32.2	1.7	6860
8	2	15.50	7.93	33.7	11.9	35.3	1.1	10850
8	2	14.50	7.97	33.8	11.8	34.9	1.0	10150
8	3	17.10	7.50	16.5	6.2	37.6	0.6	11977
8	3	16.90	8.50	16.5	6.1	37.0	0.6	11830
13	1	7.70	8.00	33.8	10.3	30.5	1.3	5390
13	1	7.70	8.04	33.8	10.6	31.4	1.2	5390
13	2	18.20	7.75	25.3	8.8	34.8	0.9	12740
13	2	17.80	7.79	25.3	9.1	36.0	0.9	12460
13	3	10.50	8.00	16.7	5.2	31.1	0.3	7350
13	3	10.70	7.96	16.9	5.1	30.2	0.3	7490

Table 25. (Continued)

Plot No.	Depth feet	EC x 10^3 (mmhos. / cm.)	Paste pH	C. E. C. meq. / 100 gm.	Exch. Na meq. / 100 gm.	Exch. Na %	Exch. K meq. / 100 gm.	Total Soluble Salt ppm
24	1	9.30	8.04	27.7	11.1	40.1	1.3	6510
24	1	9.50	8.08	27.7	11.0	39.7	1.3	6650
24	2	16.80	7.90	21.4	8.6	40.2	1.0	11760
24	2	15.20	7.90	21.4	8.6	40.2	1.0	10640
24	3	14.00	7.85	14.2	5.5	38.7	0.6	9800
24	3	14.00	7.95	14.2	5.5	38.7	0.6	9800
29	1	7.60	8.07	32.1	13.6	42.4	1.2	5320
29	1	6.80	8.03	32.3	14.2	44.0	1.2	4760
29	2	19.80	7.77	25.7	10.7	41.6	1.1	13860
29	2	20.20	7.83	26.1	10.5	40.2	1.2	14140
29	3	14.00	7.82	12.3	4.4	35.8	0.6	9800
29	3	14.00	7.78	12.7	4.1	32.3	0.5	9800
34	1	6.80	8.10	29.2	10.8	37.0	1.4	4760
34	1	6.80	8.10	29.2	10.4	35.6	1.5	4760
34	2	17.50	7.81	18.8	9.4	50.0	0.8	12250
34	2	16.50	7.79	18.8	9.2	48.9	0.8	11550
34	3	16.20	7.85	10.3	4.4	42.7	0.6	11340
34	3	15.80	7.95	10.3	4.5	43.7	0.5	11060
4	1	7.40	8.00	29.2	9.9	33.9	1.3	5180
4	1	6.60	8.00	29.0	10.9	37.6	1.3	4620
4	2	15.10	7.82	25.1	11.8	47.0	1.1	10570
4	2	19.90	7.78	25.3	12.6	49.8	1.2	10430
4	3	15.30	7.60	18.6	5.8	31.2	1.0	10710
4	3	14.70	7.70	18.8	5.4	28.7	1.0	10290
11	1	7.80	8.00	29.0	10.9	37.6	1.3	5460
11	1	7.80	8.00	29.0	10.5	36.2	1.2	5460
11	2	12.80	7.81	23.2	9.2	39.7	0.9	8960
11	2	13.20	7.79	23.4	9.3	39.7	0.8	9240
11	3	13.40	7.82	12.5	4.8	38.4	0.3	9380
11	3	13.60	7.78	12.7	4.9	38.6	0.4	9520

Table 25. (Continued)

Plot No.	Depth feet	EC x 10^3 (mmhos./cm.)	Paste pH	C.E.C. meq./100 gm.	Exch. Na meq./100 gm.	Exch. Na %	Exch. K meq./100 gm.	Total Soluble Salt ppm
18	1	8.40	7.97	22.5	8.4	37.3	1.0	5880
18	1	8.00	7.93	22.5	8.2	36.4	1.0	5600
18	2	11.10	7.90	20.0	8.5	42.5	0.6	7770
18	2	11.30	7.90	20.0	8.5	42.5	0.7	7910
18	3	8.90	8.15	9.9	3.8	38.4	0.3	6230
18	3	8.30	8.05	9.9	4.1	41.4	0.3	5810
19	1	5.20	8.10	23.6	8.5	36.0	1.0	3640
19	1	4.80	8.10	23.6	8.6	36.4	0.9	3360
19	2	10.50	7.93	20.9	9.1	43.5	0.8	7350
19	2	11.50	7.97	20.9	9.2	44.0	0.8	8050
19	3	11.00	7.95	13.3	5.1	38.3	0.4	7700
19	3	12.00	7.91	13.5	5.1	37.8	0.4	8400
27	1	10.10	8.02	38.7	14.1	36.4	1.3	7070
27	1	10.30	7.78	38.7	14.8	38.2	1.3	7210
27	2	16.00	7.79	39.3	13.9	35.4	1.9	11200
27	2	15.20	7.77	39.3	14.6	37.1	2.1	10640
27	3	13.00	7.82	20.9	7.0	33.5	1.0	9100
27	3	13.00	7.78	20.9	6.9	33.0	0.9	9100
32	1	9.80	8.05	35.7	14.2	39.8	1.5	6860
32	1	9.80	7.95	35.9	14.6	40.7	1.4	6860
32	2	16.00	7.80	23.7	9.9	41.8	0.9	11200
32	2	15.00	7.80	23.9	9.6	40.2	0.9	10500
32	3	12.20	7.85	11.0	3.9	35.5	0.4	8540
32	3	11.80	7.95	11.0	3.8	34.5	0.3	8260
5	1	8.00	7.81	30.4	10.9	35.9	1.2	5600
5	1	9.00	7.79	30.4	11.4	37.5	1.3	6300
5	2	15.10	7.53	23.1	10.6	45.9	1.1	10570
5	2	14.90	7.57	23.1	10.2	44.2	1.1	10430
5	3	14.30	7.52	17.9	5.5	30.7	0.6	10010
5	3	14.70	7.58	17.9	5.8	32.4	0.6	10290

Table 25. (Continued)

Plot No.	Depth feet	EC x 10^3 (mmhos. / cm.)	Paste pH	C. E. C. meq. / 100 gm.	Exch. Na meq. / 100 gm.	Exch. Na %	Exch. K meq. / 100 gm.	Total Soluble Salt ppm
12	1	8.80	7.94	35.9	8.6	24.0	1.0	6160
12	1	9.00	7.96	35.5	8.7	24.5	1.1	6300
12	2	15.80	7.75	23.6	9.1	38.6	0.9	11060
12	2	15.80	7.79	23.8	9.1	38.2	1.0	11060
12	3	18.90	7.82	13.5	6.1	45.2	0.4	13230
12	3	19.10	7.78	13.5	5.5	40.1	0.4	13370
16	1	7.20	8.00	29.7	9.9	33.3	1.1	5040
16	1	7.00	8.00	30.1	9.7	32.2	1.2	4900
16	2	13.40	7.95	22.4	8.0	35.7	0.8	9380
16	2	13.00	7.85	22.4	8.0	35.7	0.8	9100
16	3	13.50	7.92	12.5	4.4	35.2	0.4	9450
16	3	14.10	7.88	12.5	4.4	35.2	0.4	9870
20	1	5.00	8.50	24.6	8.9	36.2	1.1	3500
20	1	4.80	7.90	24.8	9.3	37.5	1.1	3360
20	2	9.00	7.91	25.7	10.5	40.9	1.0	6300
20	2	9.80	7.89	25.7	9.8	38.1	1.0	6860
20	3	11.00	7.87	15.3	6.0	39.2	0.6	7700
20	3	11.00	7.83	15.3	5.9	38.6	0.6	7700
225	1	7.10	8.05	27.5	9.8	35.6	1.1	5635
25	1	7.30	8.01	27.5	9.4	34.2	1.2	5607
25	2	11.00	7.95	26.6	10.2	38.3	1.7	5565
25	2	11.00	7.85	26.6	10.6	38.3	1.7	5495
25	3	12.00	7.92	15.4	9.0	58.4	0.8	5544
25	3	11.80	7.88	15.4	9.2	59.7	0.8	5516
33	1	7.20	7.90	33.5	12.7	37.9	1.6	5040
33	1	6.80	7.90	33.5	13.1	39.1	1.6	4760
33	2	14.10	7.69	23.8	9.4	39.5	1.0	9870
33	2	13.90	7.71	23.8	9.0	37.8	1.0	9730
33	3	14.00	7.80	12.5	4.5	36.0	0.4	9800
33	3	14.00	7.80	12.7	4.5	35.4	0.4	9800
6	1	8.20	7.89	31.3	11.4	36.4	1.3	5740
6	1	8.60	7.81	31.3	11.9	38.0	1.4	6020
6	2	12.00	7.70	27.0	12.8	47.4	0.7	8400

Table 25. (Continued)

Plot No.	Depth feet	EC x 10^3 (mmhos. / cm.)	Paste pH	C. E. C. meq. / 100 gm.	Exch. Na meq. / 100 gm.	Exch. Na %	Exch. K meq. / 100 gm.	Total Soluble Salt ppm
6	2	12.00	7.70	27.0	12.8	47.4	0.7	8400
6	3	11.90	7.71	18.4	6.6	35.9	0.6	8330
6	3	12.10	7.69	18.4	6.8	37.0	0.6	8470
9	1	10.50	8.02	33.1	11.7	35.3	1.5	7350
9	1	10.50	8.78	33.1	11.8	35.6	1.6	7350
9	2	15.20	7.72	19.3	10.3	53.4	1.2	10640
9	2	15.80	7.68	19.1	9.9	51.8	1.1	11060
9	3	15.60	7.89	14.3	4.5	31.5	0.3	10920
9	3	15.40	7.87	14.3	5.0	35.0	0.3	10780
14	1	6.80	8.10	30.7	9.7	31.6	1.2	4760
14	1	6.60	7.90	30.7	9.5	30.9	1.1	4620
14	2	12.60	7.71	26.3	9.1	34.6	1.0	8820
14	2	12.60	7.79	26.3	9.2	35.0	1.0	8820
14	3	14.20	7.88	14.9	5.4	36.2	0.4	9940
14	3	13.60	7.82	14.9	5.4	36.2	0.4	9520
23	1	6.60	8.10	24.7	9.8	39.7	1.2	4620
23	1	6.60	8.10	24.7	9.3	37.7	1.1	4620
23	2	13.20	7.94	23.1	8.5	36.8	1.0	9240
23	2	14.00	7.92	23.1	8.8	38.1	1.0	9800
23	3	13.00	7.90	13.2	4.8	36.4	0.5	9100
23	3	13.00	7.90	13.0	4.9	37.7	0.5	9100
28	1	8.00	7.95	38.0	14.3	37.5	1.4	5600
28	1	8.40	7.85	38.1	14.5	38.1	1.4	5880
28	2	10.60	7.80	36.0	12.6	36.0	1.5	7420
28	2	10.40	7.90	35.8	12.1	33.8	1.5	7280
28	3	10.90	7.81	18.3	7.5	41.0	1.0	7630
23	3	10.70	7.79	18.3	7.6	41.5	1.1	7490
31	1	10.30	8.00	30.1	10.2	33.9	1.4	7210
31	1	9.70	8.00	30.1	10.2	33.9	1.4	6790
31	2	7.80	8.00	23.5	9.5	40.4	0.9	5460
31	2	7.40	7.90	23.5	9.5	40.4	0.9	5180
31	3	11.00	8.10	9.8	3.9	39.8	0.5	7700
31	3	10.00	7.90	9.8	3.7	37.8	0.5	7000