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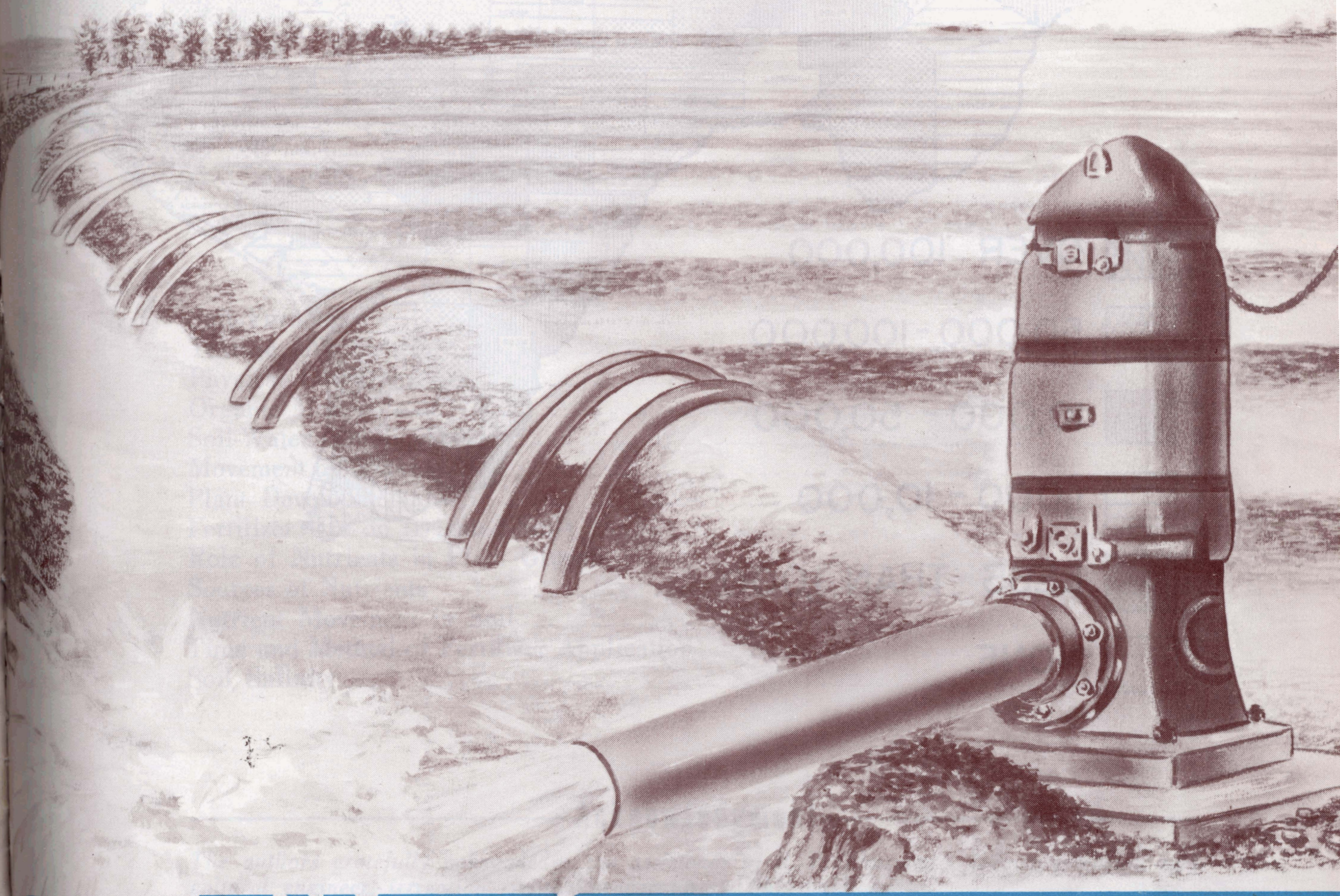
IRRIGATION AND MANAGEMENT OF TEXAS SOILS



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J. E. Hutchison, Director
College Station, Texas

DISTRIBUTION OF IRRIGATED ACRES IN TEXAS
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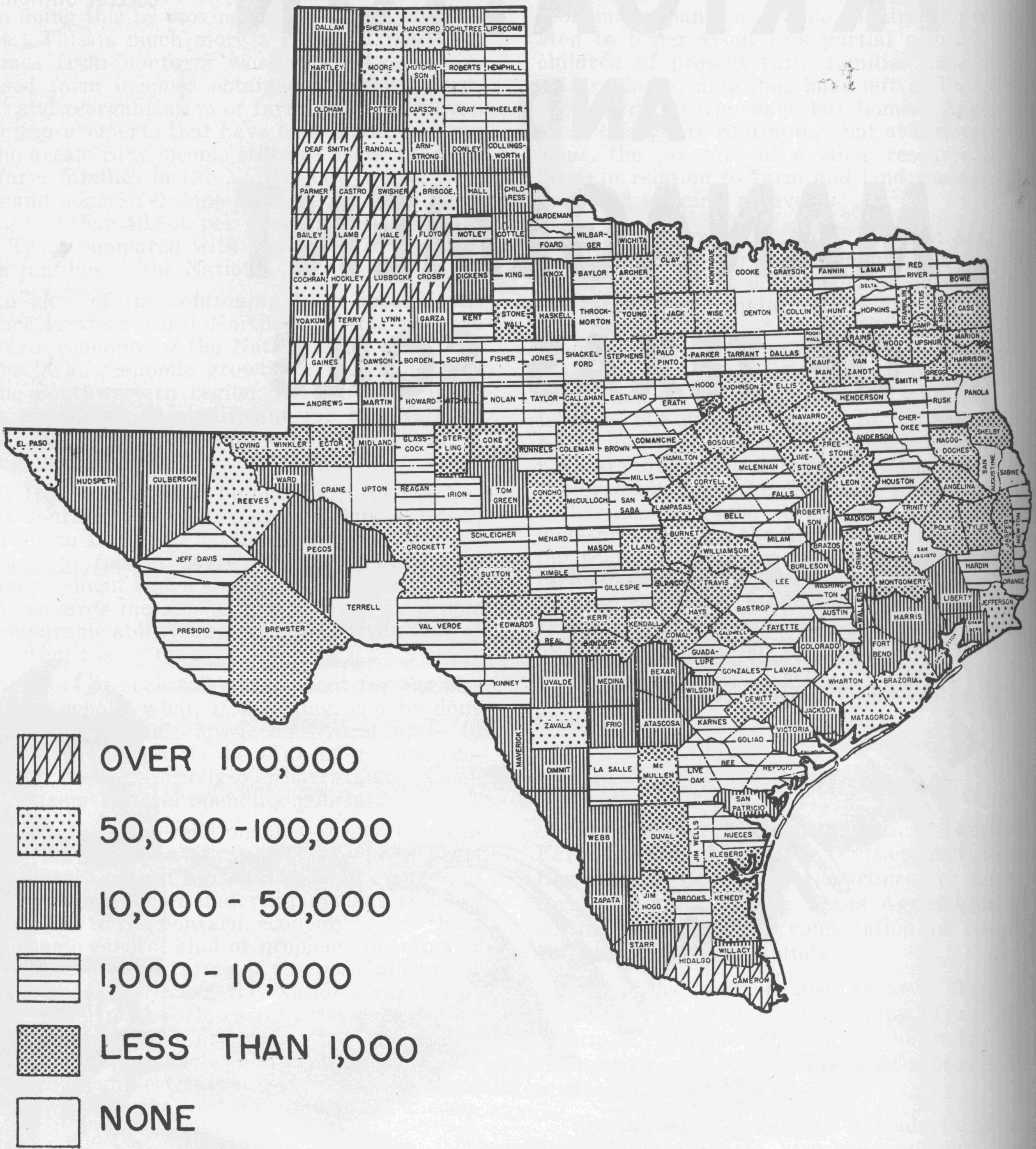

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Irrigation and Management OF TEXAS SOILS

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High-level production of farm crops depends on many factors, some of which are fertility, available moisture, air and physical condition of the soil. Good management is essential to attain the proper balance of them.

SOIL FORMATION

Soil formation is a slow but continual process. Steps in this process are not distinct; rocks weather and disintegrate into parent materials, which in turn are changed into a soil through many intermediate steps. Soil may form in one place or it may be moved by wind, water or ice. Five major influences on soil formation are climate, biological activity, parent material, topography and time. The climatic condition under which soils develop exerts a great influence upon the chemical and physical condition of the soil. Soils of humid regions are subjected to leaching, resulting in the loss of many soluble materials. Soil particles often are in advanced stages of decomposition with little inherent fertility remaining. Soils developed under more arid conditions are not subjected to this chemical leaching. Much of their native fertility remains available for use by the plants when the soil is placed under irrigation. Mineral nutrients usually are higher in arid than in humid soils, while organic matter usually is present in greater quantity in soils of the more humid areas.

TEXTURE AND STRUCTURE

Soil particles are grouped according to size in determining their textural class. The largest particles are classed as *sand*; intermediate particles, *silt*; and the finest particles, *clay*, The percentage of each fraction in a sample determines the textural class of the soil. Sands have fewer but larger pores than clays and permit rapid infiltration and internal movement of water through the soil profile. Silts and clays have smaller pores but greater water-holding capacities; however, water movement into and through the profile is not as rapid as it is in sandy soils. The relationship of water and air stored in the soil is important when considering a soil for irrigation purposes.

Other characteristics which influence the value of an irrigated soil are:

- **Topography and availability of water**
- **Soil depth for root development**
- **Ability of soil to store moisture for plant use**
- **Structure, texture and porosity**
- **Ability of the soil to produce crops**
- **Drainage**

Coarse-textured soils (sands) release moisture more easily than soils of finer texture (clays); however, the amount of available water for plant use is less in sands than in clays. The finer particles are also the most active from a fertility standpoint. Clay soils are more desirable for their fertility, but the sands are much easier to manage.

Soil structure refers to the manner in which the soil particles are held together. A granular or crumb structure generally is the most desirable, because it indicates a high degree of aggregation and usually has a well-balanced air, soil and moisture relationship.

The best soil for irrigation is one which combines sand, silt and clay in such a way that it has medium texture and open structure which allows deep penetration of roots, water and air. It should have good water storage capacity and good surface and internal drainage. A soil with all of these characteristics is hard to find. Therefore, the farmer must work with the soil as it exists and, through good management practices and adapted cropping systems, develop the highest possible level of economic production.

PHYSICAL CONDITION

The physical condition of the soil often is neglected to the extent that a serious loss in yield results, as well as damage to the soil structure. Good soil management practices can prevent this. Once damaged, it is difficult to restore the original physical structure of soil. Deterioration in tilth and structure usually occurs over a long period, and its restoration is also a slow process. Mechanical practices, such as deep tillage and subsoiling, while helpful in the rebuilding process, are seldom cures alone, due to the instability of soil components once they have deteriorated to a point where crop production is reduced. These practices should be joined by adapted management practices and cropping systems. The use of crops with extensive root systems will improve the physical condition of a soil in a short time. Small grain, grasses and deep rooted legumes can be used as soil conditioning crops. Best results are obtained where the nitrogen requirements of the particular practice used are fully provided.

Immediately after an irrigation, water displaces air in the pore spaces. As the soil dries, air returns to the pores as water is removed by evaporation from the surface and transpiration of plants. Management practices, such as plowing while wet and failure to add organic residues, will reduce pore spaces in the soil. Most virgin soils usually are in good physical condition and the solid (soil particles), liquid (water and soil solution) and gaseous phases (oxygen, carbon dioxide and others) are in balance. When a new soil is brought under cultivation, these properties are thrown out of balance, and after a period of time, this condition may lead to problems that result in declining yields. Under irrigation, these problems develop faster and assume serious proportions more rapidly than under dry farming conditions.

ORGANIC MATTER

The importance of organic matter in maintaining good physical condition in soils depends on the texture of the soil. Some irrigated soils in Texas have good textural characteristics and organic matter content is not of great importance. Organic matter is of great *importance* when texture and physical condition limit yields. Many of our most productive soils are low in organic matter content.

Organic matter serves many purposes in the soil, some of which produce desirable results immediately and directly, but many of which only make their effect felt indirectly and over a long period.

Direct effect of organic matter:

- **Supply nutrients, such as nitrogen and phosphorus**
- **Provide a source of energy for soil organisms**
- **Break down mineral portions of soil through decomposition, releasing nutrients for plant use**

Indirect effect of organic matter:

- **Improves soil structure**
- **Improves soil and water relations**
- **Influences the exchange complex of the soil**

Where soil physical condition is poor, organic matter should be added in liberal amounts. Cropping systems which return large amounts of plant residues during the rotation are helpful. Cotton burs or similar types of organic materials supplemented with plant nutrients such as nitrogen and phosphorus also aid in maintaining good physical condition. Green manure crops can be used to good advantage in certain areas to improve soil physical properties.

If soils become cloddy or difficult to work, or if water infiltration is slow, consider adding organic material to the soil.

SOIL-WATER RELATIONSHIPS

Soil serves as a storage reservoir for water. When water is in the root zone, plants can obtain their daily water requirements for proper growth and development. As the plants continue to use water, the available supply diminishes, and the plants finally stop growing unless more water is added.

The mineral particles making up soil are of many sizes touching each other only at certain points. The space not occupied by these particles is called pore space and may account for about half the total volume of soil. In well-drained soils, water is stored in some of this pore space. Water stored as soil moisture, which is available to the plants, is retained in the form of wedges at the point of contact and as thin films around each of the soil particles. Surface tension forces hold this water around the soil particles against the pull of gravity. As this soil moisture is used, the films become thinner, until eventually the forces holding moisture to the soil particles become so great that the plants no longer can obtain water. When this moisture condition is reached, the plant permanently wilts. Several soil moisture terms commonly used in irrigation are:

Field capacity — Amount of water a soil holds against drainage by gravity.

Permanent wilting percentage — Soil-moisture content at which plants permanently wilt.

Available moisture — Soil moisture available for normal plant use. It is the moisture in a soil between field capacity and the wilting point.

Saturation — A condition in which all pore spaces of the soil are filled with water. A soil remains saturated only if water is not allowed to drain from it.

The amount of water that can be stored in the soil and used by the plants depends upon the depth of soil occupied by the active root system of the plant, and the profile characteristics of the soil such as texture and structure. Fine-textured soils have more particles and more surface area than coarse-textured soils. Because coarse-textured soils have less water storage capacity, they must be irrigated more often with *less water per application* than clay soils. The approximate available water storage capacity for various texture soils per foot of depth is shown in Table 1.

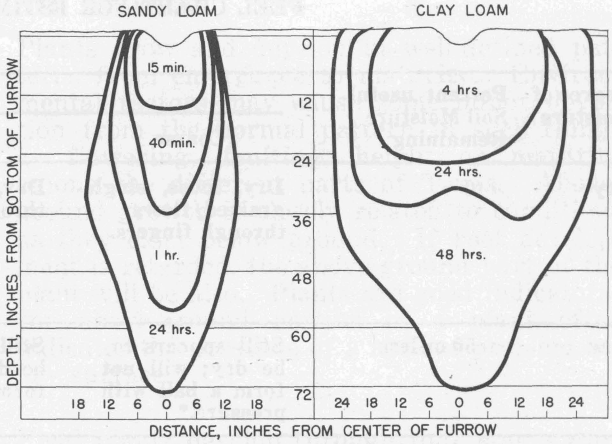
Table 1. Approximate available water storage capacity of soils

Soil Texture	Available water-inches per foot depth
Sands (coarse)	½ - 1
Sandy loams (medium)	1 - 1½
Silt and clay loams (medium)	1½ - 2
Clays (fine)	2 - 2½

The purpose of irrigation is to assure a continuous supply of available moisture in the plant root zone throughout the growing season. To supply needed soil moisture, the irrigator must know at all times the amount of available moisture in the plant root zone. By inspecting soil moisture conditions at regular intervals and at several depths, the irrigator learns the rate at which moisture is being used by crops at different soil depths. This information provides a basis for determining when and how much water to apply. A practical method of estimating the available soil moisture appears in the chart, page 8.

MOVEMENT OF WATER IN SOIL

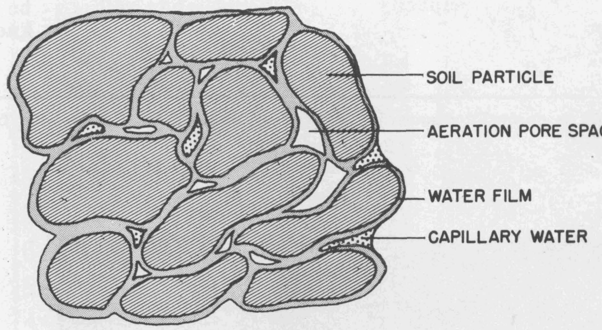
Water moves downward by gravity through the pores between the soil particles. Clay soils, which crack on drying, permit rapid entry of water as long as the cracks exist. When water



Downward movement is more rapid in sandy soils, and lateral movement is greater in clay soils.

is applied in furrows, the primary movement is downward; however, some lateral movement occurs. Lateral movement is greater but at a slower rate in clay soils than in sands.

Some water remains as a film around each of the soil particles while the excess continues



Moisture films and aeration pore space.

downward. All soil particles that come in contact with water are completely surrounded by moisture films, while those particles below remain at the same moisture content as before the water was applied.

A certain amount of water applied to the soil will wet the soil to field capacity only to a certain depth, depending upon the texture and dryness of the soil and the amount applied. In well-drained soils of uniform texture and structure, downward movement generally stops 2 to 3 days after irrigation.

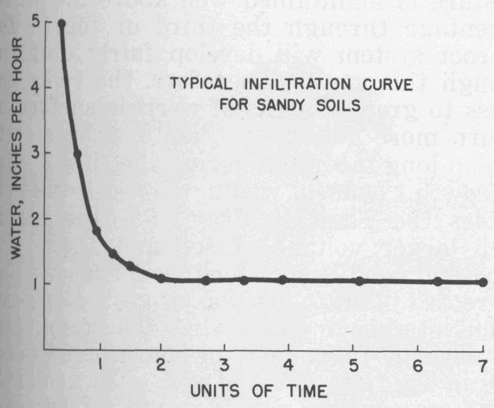
FEEL CHART FOR ESTIMATING SOIL MOISTURE

Degree of Moisture	Percent useful Soil Moisture Remaining	Feel Or Appearance Of Soils			
		Coarse	Light	Medium	Heavy-Very Heavy
Dry	0	Dry, loose, single-grained, flows through fingers.	Dry, loose, flows through fingers.	Powdery, dry, sometimes slightly crusted but easily breaks down into powdery condition.	Hard, baked, cracked; sometimes has loose crumbs on surface.
Low	50 or less	Still appears to be dry; will not form a ball with pressure.*	Still appears to be dry will not form a ball.*	Somewhat crumbly, but will hold together from pressure.*	Somewhat pliable; will ball under pressure.*
Fair	50 to 75	Same as coarse texture under 50 or less.	Tends to ball under pressure but seldom will hold together.	Forms a ball, somewhat plastic; will sometimes slick slightly with pressure.	Forms a ball; will ribbon out between thumb and forefinger.
Excellent	75 to field capacity	Tends to stick together slightly; sometimes forms a very weak ball under pressure.	Forms weak ball, breaks easily, will not slick.	Forms a ball and is very pliable; slicks readily if relatively high in clay.	Easily ribbons out between fingers, has a slick feeling.
Ideal	At field capacity	Upon squeezing, no free water appears on soil but wet outline of ball is left on hand.	Same as coarse.	Same as coarse.	Same as coarse.
Too wet	Above field capacity	Free water appears when soil is bounced in hand.	Free water will be released with kneading.	Can squeeze out free water.	Puddles and free water forms on surface.

*Ball is formed by squeezing a handful of soil very firmly with fingers.

Too dry

Ideal



Water moves into a sandy soil very fast at first, but slows down after a short time.

The rate at which water enters the soil is known as the *infiltration rate,* usually expressed in inches per hour. When water is applied to the soil, the rate of its movement into the soil is not uniform. Infiltration is greater at first and slows down as the wetted front moves to greater depths. After a period of time, the infiltration rate becomes practically constant. Rate of water movement through the soil profile is known as *permeability.*

The rate of water movement through the soil is influenced mainly by texture, structure and character of the soil profile. Movement of water in clay soils is slow, because the pores are small. The pores in sandy soil are relatively large; therefore, the rate of movement is much faster. Movement of moisture in soils between the ranges of field capacity and permanent wilting percentage is very slow, because such movement depends largely upon surface tension forces.

The character of the soil profile also affects the rate of water movement. Clay lenses, or compacted layers in the profile, retard downward movement of water. For instance, in the case of sandy topsoil with clay subsoil, the water moves rapidly through the sand but slackens its pace through the clay. If water is applied at a faster rate than it can move through the clay, the upper sand will become saturated temporarily.

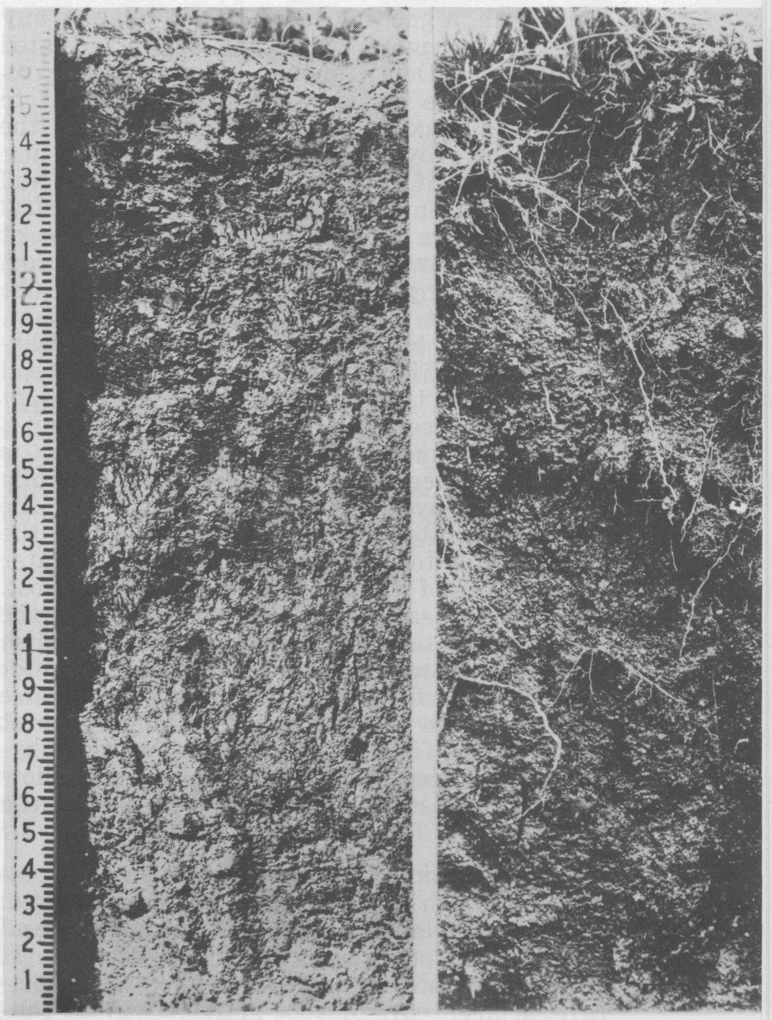
Good physical condition greatly improves the rate of water movement through the soil. Plowing soils when they are too wet or plowing to the same depth each year causes compact layers to develop which reduce the rate of water movement.

PLANT DEVELOPMENT

Plants grow and develop in well-defined patterns from emergence to maturity. Environmental factors may cause some minor deviation from the normal pattern in such things as flowering, fruiting, height or maturity among the different parts of Texas. Aboveground growth is closely related to conditions as they exist below ground. If root development is retarded, the above-ground part of the plant will be also. Plants are good indicators; the above-ground portion of a plant often indicates the presence of a serious problem below surface.

Field plants develop through four stages during their life cycle; germination, vegetative growth, reproductive processes and maturation. The soil is important in all phases but

Soils in good physical condition will increase water intake and water-holding capacity of the soil.



probably exerts its greatest influence on the plant root system. For most row crops a critical period is that of getting a uniform stand. Once attained, the remainder of the crop year is relatively easy except for natural hazards, such as hail, drouth or flood. Soil that is in good physical condition makes a uniform stand easier to obtain.

Plants begin to develop roots even before seedlings emerge from the soil. Roots are responsible for finding nutrients and water to sustain the plant. Each plant develops a fantastic number of roots; even so, the roots of a crop probably do not come in contact with more than 2 percent of the total surface of the soil particles in the root zone under the most favorable conditions. The plant root obtains water by osmotic forces and by transpirational pull, and is greatly affected by temperature, humidity, wind velocity, moisture, aeration and toxic materials. Mineral and water supplies available to the plant depend upon the extent and vigor with which the roots explore the root zone. Dry areas in the plant root zone greatly reduce the feeding area of the plant.

Soil depth, a good measure of the value of any soil, is even more important under irrigated conditions. Depth should be examined carefully to make certain that it is sufficient to provide a maximum of feeding area for the crop to be grown. Many Texas crops can use several feet of soil and draw both water and nutrients from this depth if the soil physical properties are favorable. Rooting habits of the crop grown should be fully understood. Water should never be placed so deep in the profile that it cannot be utilized by the plant. On the other hand, plant roots penetrate only moist soil. Therefore, if only 2 feet of soil is wet where the soil is 6 feet deep, the plant must concentrate all its roots in the upper 2 feet. This amounts to having a soil which is only 2 feet deep and is underlaid by a totally impervious layer. On the other hand, if the soil is saturated to depths beyond which the plant is able to withdraw moisture, this water is wasted, and valuable soil nutrients are lost. If excessive salts must be leached from the root zone, water must be applied to accomplish this purpose without regard to depth of root penetration. Capillary movement of moisture upward is slow and usually insufficient to meet the needs of field crops. Therefore, soil physical properties should be favorable to allow the plant to extend its roots throughout the soil reservoir for moisture and nutrients.

Under irrigation, moisture conditions and rooting habits can be controlled to a large degree. Plants, like animals, absorb nutrients and water where they are easiest to obtain. If only the surface soil is kept supplied with moisture, a large part of root activity will be concentrated in this area. If, however, the soil moisture is maintained well above the wilting percentage through the third or fourth foot, the root system will develop fairly uniformly through this zone. Therefore, the roots have access to greater areas of particle surface and in turn more nutrients. Plants such as cotton develop long tap roots during the first 3 weeks of growth. A deep, well-developed root system enables the plant to draw moisture from a much larger volume of soil and allows it to withstand conditions which would cause a shallow-rooted plant to develop severe water stress. Recent studies indicate that the cotton plant will develop 75 percent or more of its feeder roots in the first 2 feet of soil. The remainder of the root system develops and utilizes moisture and nutrients from the third, fourth and fifth feet of the profile. As a general rule, most crops develop about 70 percent of their root system in the upper 50 percent of the root zone.

The producer should know the relationship between the stage of development of his crop and its water requirements. Water used by the plant varies with the crop, stage of growth, climate and soil fertility. Physical properties of the soil which control storage and movement of water and air also influence the use of water by the plant. When the soil reservoir is filled prior to planting, additional irrigations often are not needed until the plant reaches rapid vegetative growth or comes into the fruiting period.

FERTILIZER USE ON IRRIGATED SOILS

Another requirement of equal importance to that of sufficient moisture is adequate levels of plant nutrients. A proper balance of moisture and fertility is necessary to make irrigation profitable.

Nitrogen and phosphorus are the major plant nutrients most likely to be deficient in irrigated Texas soils. Some areas are deficient in potassium as well as some secondary and minor elements.

ROLE OF NUTRIENTS IN PLANT GROWTH

Nitrogen promotes vegetative growth and develops a plant capable of producing good yields if other elements are adequate. If nitrogen is in short supply, plants will be small and colored light green to yellow. An over-balance of nitrogen will result in excessive vegetative growth and a poor fruit set. Organic matter can supply a good portion of the nitrogen needed.

Phosphorus is deficient in many Texas soils and must be supplied from other sources. Phosphorus encourages the development of good root systems and is important in the set-

Organic matter, such as barnyard manure, cotton burs or crops residues, helps to improve the physical condition of soil as well as provide plant nutrients.

ting of fruit and seed production. Phosphorus deficiency often shows up in young plants as a slight reddening of the younger leaves. Phosphorus deficiency symptoms in older plants are difficult to detect.

Potassium generally is adequate in most soils in Texas where irrigation is practiced. In areas with coarse-textured soils, or soils with poor drainage and poor aeration, the addition of potassium often gives a profitable response. The exact nature of the role of potassium in a plant is not known, but is thought to be a regulator of plant metabolic processes.

Other plant nutrients such as calcium, magnesium, sulfur and the minor elements are equally important in crop production. Most irrigated Texas soils have enough of these nutrients for good plant growth, but some localized areas show profitable yield increases when these elements are added.

SOURCES OF NUTRIENTS

Soil. The primary source of nutrients is the soil itself. Most Texas soils have a good reservoir of plant nutrients. Their release and availability determine whether plant nutrients need to be added. If removal by the crop is faster than release by the soil, additional nutrients must be added or yields will diminish. A soil analysis provides a good basis for determining the amounts and kinds of nutrients needed to produce optimum results.

Organic matter. Soil organic matter is the important source of nitrogen. It also contains phosphorus, potassium, calcium and other necessary minerals. As organic matter decomposes, these nutrients are released and become available for plant growth. For each 1 percent of organic matter in a silt loam soil, approximately 40 pounds of nitrogen will be released during the season. This value is lower for clay soils and higher for sandy soils. The actual amount of nitrogen released depends on the cropping system, moisture, temperature, drainage and other factors.

Organic matter is decomposed by micro-organisms, which are small plants and animals and require nutrients the same as higher plants. If organic material is low in nitrogen, this element should be applied to supply the micro-organisms so that soil nitrogen will not be tied up. The addition of about 20 pounds of nitrogen per ton of organic residues low in nitrogen usually is adequate.

Any type of organic material is of value. All crop residues should be returned to the soil. Green manure crops are valuable sources of organic material. Cotton burs and barnyard manure have proved to be of value in increasing crop production. Organic matter also is important in maintaining soil structure and tilth. It improves aeration and water penetration—important in irrigated areas.

Whether the application of organic materials, such as cotton burs or growing green manure is profitable depends on the soil physical condition and the costs involved. If the soil structure is a problem, it usually will pay.

Commercial fertilizers. If sufficient nutrients are not maintained in the soil, commercial fertilizer can be used to insure fertility levels that are adequate for good crop growth under irrigated conditions.

Commercial fertilizers are available as straight materials, such as superphosphate, or as mixed fertilizer, such as 10-20-0 or 10-20-10. They are also available in dry, liquid or gaseous forms. The form to select depends primarily on cost.

At low rates, mixed fertilizers usually are cheaper than separate materials, since only one application is needed; however, straight fertilizer materials may be cheaper where high rates are used.

Ammonium nitrate (33½-0-0) and superphosphate (0-20-0) are examples of straight fertilizer materials often used to supply needed plant nutrients.

If mixed fertilizers are used, those of higher analysis usually are cheaper than low-analysis fertilizers, and a smaller amount of fertilizer has to be handled.

Determine the nutrient needs of your soil by a soil test, and then determine the source and the grade that will supply this need at the *lowest cost.*

A number of straight nitrogen fertilizer materials are available. Nitrogen materials most commonly used are ammonium sulfate (21-0-0), ammonium nitrate (33½-0-0), anhydrous ammonia (82-0-0), and urea (45-0-0). Experimental results generally show only small differences due to the source of nitrogen used. Therefore, a pound of nitrogen from one source should be about as effective as a pound of nitrogen from another.

Residual effects from nitrogen fertilizer might be a consideration in choosing the source of nitrogen to use. Ammonium sulfate leaves an acid residual three times greater than the other three main nitrogen sources and may be of some value on alkaline soils. Some nitrogen sources, such as sodium nitrate, leave an alkaline residual and may be of some value on acid soils.

Sidedressing the crop with nitrogen is a good practice on soils of medium to coarse texture.

NUTRIENT MOVEMENT IN SOIL

Nitrogen is applied either in ammonium or nitrate form, or as urea. Urea breaks down in a short time into the ammonium form. When ammonium sources are applied, the ammonium ions (NH_4^+) become attached to clay particles. Nitrogen in this form will not leach, nor will it be taken up too readily by most plants. If soil temperature is about 55 degrees F. or above and if moisture is available, soil microorganisms will change ammonium nitrogen into nitrate nitrogen and then be taken up by plants. Nitrate nitrogen (NO_3-) is not attached to clay particles; it is water-soluble and it moves with soil moisture. On coarse-textured soils, nitrates could be leached out of the root zone, but on medium to fine-textured soils, loss of nitrate nitrogen would be less.

Phosphorus, when applied as superphosphate, is mostly in the form of mono-calcium phosphate, a form most available for plant growth.

When phosphorus is applied to soils high in calcium, the phosphorus will revert to di-calcium and tri-calcium phosphate forms. Even though these forms are less available than mono-calcium phosphate, they will become available later for plant use. Because of this phosphate reversion, phosphorus fertilizers usually should be banded rather than broadcast.

Potassium usually is applied as a salt — potassium chloride. When the fertilizer goes into solution, potassium becomes attached to the clay particle and is known as "exchangeable" potassium. Potassium in this form is available for plant growth. Potassium is readily leached from coarse-textured soils.

The loss of nutrients by leaching generally should be low in most irrigated soils. Whether leaching will be a problem depends on the depth to which the water penetrates. If enough water is applied at one irrigation so as to move below the root zone, losses could occur by leaching. However, as the water moves back toward the surface, the nutrients also will move.

TIME AND METHOD OF FERTILIZER APPLICATION

The application of fertilizer to coarse-textured soils should be limited, because of possible loss by leaching to immediately before or at planting or as a sidedressing after the crop is up. This is particularly important for nitrogen and potassium. On medium-to-fine-textured soils, time would not be too important from the standpoint of leaching. Method of application could be a consideration in when to apply fertilizer. If fertilizer is to be banded, time would be less critical than if it is to be broadcast or rebedded.

Fertilizer prices often are cheaper in the fall and winter months than in the spring. If the price difference is significant, it might be more profitable to apply fertilizer well ahead of planting, even though there might be some loss in efficiency of the fertilizer.

Fertilizer should be applied so that it will be in moist soil. Without moisture, plants do not absorb nutrients. Nitrogen in nitrate form moves readily with soil moisture; phosphorus and potassium do not move so readily.

The most widely accepted method of applying fertilizer is banding the fertilizer 2 to 4 inches to the side of the seed and 2 to 4 inches below. In certain areas, such as the High Plains, 5 to 10 inches to the side of the seed and 5 inches below is recommended so that the seedbed will not be disturbed. Placing fertilizer in the furrow and then rebedding should prove satisfactory also. Fertilizer, except in small quantities, should not be placed too near the seed, since injury can result.

Broadcasting fertilizer is satisfactory for forage crops, but generally not for row crops, except in acid soils. Drilling fertilizer is advisable for small grain.

Sidedressing is a satisfactory method of applying nitrogen. Potassium can be sidedressed on sandy soils, but should be applied prior to or at planting on medium to fine-textured soils. Phosphorus seldom should be sidedressed. If fertilizer is sidedressed, care should be taken to avoid cutting plant roots.

Fertilizer can be applied in irrigation water. This method is easy and economical. Disadvantages include unequal distribution if water is unevenly distributed. If nitrogen is applied in irrigation water as the ammonium form to alkaline soils, there is a possibility of 25 to 30 percent loss of the nitrogen as a gas.

Phosphorus applied in irrigation water will not move into the soil too readily, and in most soils it stays in the surface inch. Even with these disadvantages, savings in cost of application may more than offset losses in efficiency.

SOIL SALINITY

The accumulation of salts in irrigated soils can be a serious problem for the farmer. Salt accumulation in soils occurs mainly from two sources — salts in the irrigation water and a high water table.

All irrigation waters contain some dissolved salts. If sufficient leaching below the root zone of the plant is not practiced, the salts contained in the irrigation water accumulate in this region.

Poor stand of alfalfa, due to the accumulation of salt from irrigation water.

A high water table can result in salt accumulation. Water rises in the soil by capillarity 2 to 5 feet above the water table. As the water rises, it carries the dissolved salts with it. If the water table is high enough to permit water movement by capillarity to the soil surface, the water reaching the surface will evaporate and leave a salt deposit. Some leaching is necessary under most irrigated conditions. Adequate drainage must be established so that the water table at no time is maintained at less than 5 to 6 feet below the ground surface.

Salt-affected soils may be divided into three classes — saline, nonsaline-sodic and saline-sodic soils.

A *saline soil* contains soluble salts sufficient to interfere with the growth of most plants. Sodium salts are present but in relatively low concentration in comparison with calcium and magnesium salts. Saline soils often are identified by a white crust on their surface, spotty stands and stunted irregular plant growth. The permeability of saline soils is comparable to that of similar nonsaline soils. The principal effect of high soluble salts is to reduce the availability of water to the plant. Toxicity from specific ions may also occur, such as a chloride toxicity. With extremely high salt accumulations, leaves may curl and yellow, the margins of the leaves may appear burned or actual death of the plant may occur. Long before effects are observed, the general nutrition and growth of the plant will have been altered.

A *nonsaline-sodic soil* is relatively low in soluble salts but contains exchangeable sodium sufficient to affect its physical condition. As the proportion of exchangeable sodium increases, the soil tends to become dispersed, less permeable to water and of poorer physical condition. High sodium soils usually are plastic and sticky when wet and also form clods and crust when dry. These conditions result in reduced plant growth because of inadequate water penetration, poor soil aeration and soil crusting. Nonsaline-sodic soils are frequently in small and irregular areas and are often referred to as "slick spots" or "black alkali" areas. Sodic soils usually develop because of excessive high sodium in proportion to calcium and magnesium.

Saline-sodic soils contain quantities of soluble salt and adsorbed sodium sufficient to reduce yields of most crops. As long as soluble salts are in excess, the physical properties of these soils are similar to those of saline soils. If excessive soluble salts are removed, these soils may assume properties of nonsaline-sodic soils. This condition is encountered frequently following heavy rains and may result in the death of young plants. Both nonsaline- sodic and saline-sodic soils may be improved by replacing excessive adsorbed sodium with calcium and magnesium.

Management is important in producing crops on salt-affected soils. Some crops can tolerate more salts than others; consequently, the choice of the crop is important.

The amount of salt added to the soil each year is determined by the amounts of salt in the water and the volume of water applied. The amount of salt removed by leaching is determined by the salt content and the quantity of water passing below the root zone. As the quantity of salt in the soil or in the irrigation water increases, larger amounts of water must pass through the root zone to keep the soil salinity low enough for crop production. Soil salinity, however, cannot be reduced below the salinity of the water used for leaching.

As the availabliity of water to plants under high salinity conditions lessens, irrigation applications need to be more frequent. Plants grown on saline soils may not show typical wilting or moisture deficiency symptoms as readily as plants grown on nonsaline soils. Plants growing on high-saline soils often need water although the soil appears moist.

Soils that are irrigated with water high in sodium or containing a high percentage of exchangeable sodium may need a soil amendment to maintain soil structure. Soil amendments commonly used are of two types — those providing soluble calcium such as gypsum, and acid or acid-forming amendments such as sulfur, sulfuric acid, iron sulfate and aluminium sulfate. Application of limestone may be valuable as a source of calcium on acid soils but is questionable on alkaline soils. Where possible, amendments should be mixed thoroughly with the soil for best results. Amendments which are water soluble can be applied easily and economically in the irrigation water. The quantity needed depends on the water quality, quantity of exchangeable sodium to be replaced and completeness of the chemical reaction in the soil.

A complete soil analysis can determine the type of salinity problem and indicate the possible cause of trouble. Soil samples should be representative of conditions which exist. Instructions on how to take soil samples for salinity tests and where to send them to be tested can be obtained from local county agricultural agents.

The quality of irrigation water has an important influence on the results. The quality of irrigation water is influenced by: (1) the total amount of salts present, (2) the type of salts present, (3) the amount of irrigation water to be applied each year, (4) type of soil and drainage characteristics, (5) kind of crop to be grown and (6) the amount of rainfall received.

A water analysis reveals the kind and amounts of salt in the water. Farmers obtaining water from wells should have their water analyzed each year. Instructions on how to take water samples and where to send them for analysis can be obtained from local county agricultural agents.

Your County

EXTENSION AGENTS

can furnish you the latest information on farming, ranching and homemaking. They represent both The Texas A. & M. College System and the United States Department of Agriculture in your county.

Most county extension agents have their offices in the county courthouse or agriculture building. They welcome your visits, calls or letters for assistance.

This publication is one of many prepared by the Texas Agricultural Extension Service to present up-to-date, authoritative information, based on results of research. Extension publications are available from your local agents or from the Agricultural Information Office, College Station, Texas.

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