

Irrigate for

MORE PROFITS



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Georgia Agricultural Extension Service
University System of Georgia
Athens

Foreword

By WALTER S. BROWN, *Director*
Georgia Agricultural Extension Service

A good, practical irrigation system is, in my opinion, one of the best forms of crop insurance that a Georgia farmer can have. This is particularly true in the case of crops and pastures which are highly susceptible to drought injury.

It is true that we have a fairly abundant yearly rainfall in this state but almost every year we have hot, dry periods during the spring, summer and fall which seriously injure and curtail our growing crops. A dependable supply of water through some form of irrigation will often mean the difference between success and failure, profit and loss, in the production and marketing of our farm products.

GEORGIA AGRICULTURAL EXTENSION SERVICE
UNIVERSITY SYSTEM OF GEORGIA

WALTER S. BROWN, *Director*
Athens

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for More Profits

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Supplemental moisture applied by the most up-to-date methods of irrigation is paying dividends to Georgia farmers. High-quality vegetable crops, forage crops and specialty products are being grown during drought periods on a profitable basis. In addition, growers eliminate the risk of losing expensive seed, labor, time and fertilizer when lack of moisture causes crops to fail to germinate or produce.

Investment in irrigation equipment is proving justifiable on crops that respond to supplemental water and which bring a relatively high return per acre. Irrigation should, in numerous instances, help to improve the fertility, friability and water-holding capacity of many soils by assuring stands of cover crops, which are sources of humus, and providing ample moisture at the time they are turned under. Improving the water-holding capacity of soils will help, in no small degree, to reduce soil erosion due to surface run-off and wind.

WHY IRRIGATE IN GEORGIA?

"It is the best crop insurance I ever had even though I might not need irrigation every season," say Georgia farmers.

Despite the fact that rainfall averages about 5,000 tons per acre annually in Georgia, lack of moisture during the growing season often reduces yields of high-priced crops and sometimes causes crop failures. Weather records show that drought periods occur one year out of three during the month of April in south Georgia. Yet, in numerous instances, truck growers could have recovered the original investment in irrigation equipment in one season's operation by supplying needed moisture during such critical periods. For example, in April 1946, vegetable growers lost as much as \$300 per acre in their early season production in some areas of south Georgia because of set-backs due to lack of moisture. Some "close calls" with the weather have been experienced by early plant growers as exemplified in the following state-wide news release, "The first general rain since March 29 fell in Colquitt and adjoining counties on April 16 (period of 16 days), and came just in time to prevent serious damage to the \$4,000,000-a-year tomato plant crop." Growers are not always as fortunate.

Investigations of weather records, as recorded at various weather stations over the State, reveal that major and minor drought periods occur frequently in spring, late summer and fall months. A drought period is considered to exist if, in two weeks' time, not more than 1-4 inch rainfall occurs within a 24-hour period. The type of soil, its moisture condition and types of crops grown will largely determine whether the crops would suffer from lack of moisture at the end of a 14-day dry spell. However, the drought chart, Figure 1, shows that *prolonged* dry periods are frequent and consequently are injurious to plant growth. In middle Georgia long dry periods frequently occur in May, June, September and October. In south Georgia, as the chart shows, drought periods happen more frequently in May, September, October and first half of November. Weather records at Blairsville for the period 1931 through 1946 reveal that crops, although not ordinarily affected by lack of moisture in spring and summer months, are subject to dry periods in September and October. In 11 years out of the 16, these north Georgia fall droughts, in many instances, lasted for 20 to 30 days.

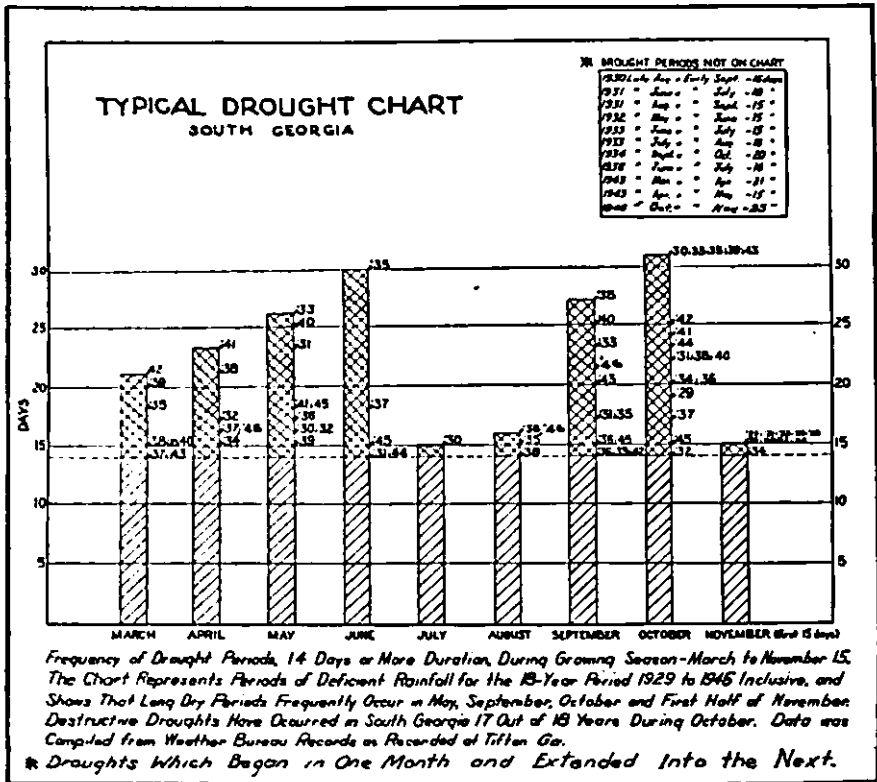


FIG. 1. Drought chart based on U. S. Weather Bureau records.

WATER SOURCES

Numerous natural streams, large and small, flow the year-round in all major agricultural areas. Water can be diverted from the streams by ditches located at higher elevations than the irrigated land in many sections of the Piedmont and Mountain regions of the State. These gravity-type irrigation systems are inexpensive to install and require little cash outlay for maintenance. With wood plentiful in these regions, diversion dams built of timber and plank can be easily and economically installed as a means of diverting portions of the stream flow into the irrigation supply ditch. Figure 2 shows the general layout of such a dam. A more permanent type of di-

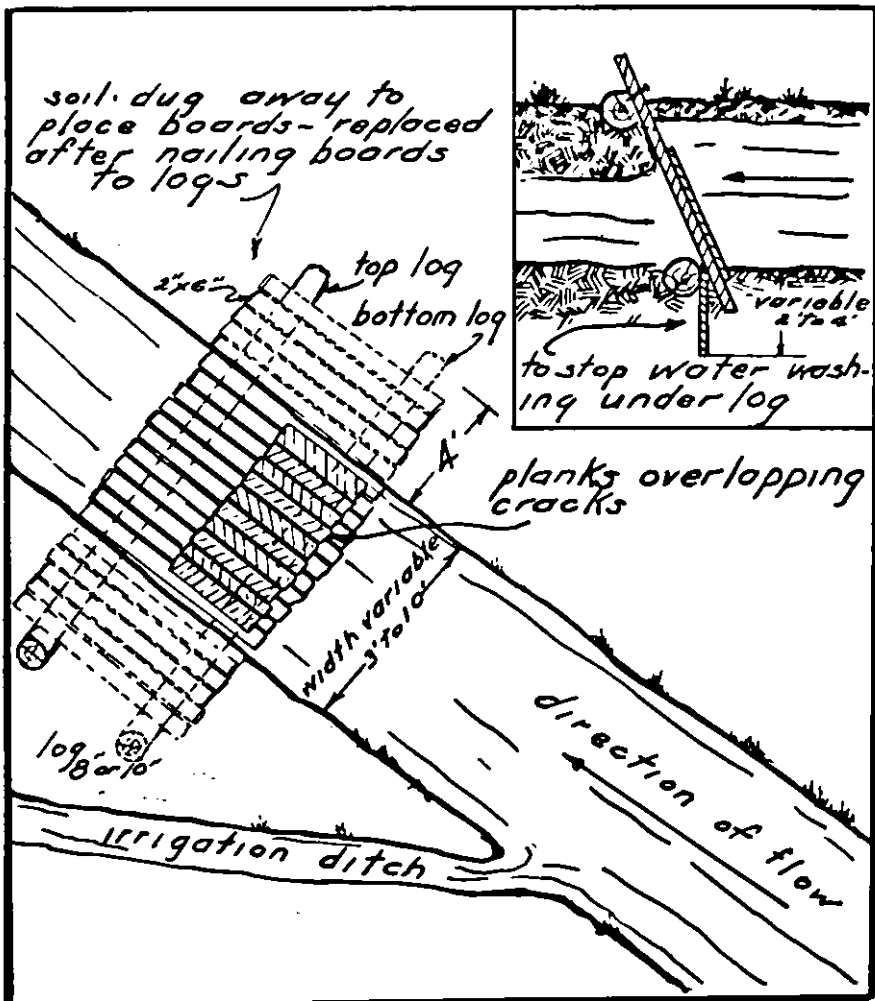


FIG. 2. Inexpensive log-plank diversion dam for small irrigation projects.

TABLE 1. CAPACITY OF FARM IRRIGATION DITCH AT VARYING GRADES

| Width of Ditch in Inches | Depth of Ditch in Inches | Depth of Water in Inches | Grade Inches/100 feet | Discharge | |
|--------------------------|--------------------------|--------------------------|-----------------------|------------------|------------------|
| | | | | Cu. Ft. Per Sec. | Gallons Per Min. |
| 14 | 10 | 6 | 2 | 0.8 | 360 |
| 14 | 10 | 6 | 3 | 1.1 | 495 |
| 14 | 10 | 6 | 6 | 1.6 | 720 |
| 14 | 10 | 6 | 12 | 2.2 | 990 |
| 14 | 10 | 6 | 18 | 2.7 | 1215 |

version dam can be made of concrete. During periods of heavy run-off the planks are removed for the entire width of the channel so as not to restrict the flow of water. The size of the supply ditch will depend largely upon the acreage to be irrigated. For example, an irrigation ditch approximately 14 inches wide with a water depth of 6 inches and laid out on a grade of 6 inches per 100 feet will carry 1.6 cubic feet of water per second or 720 gallons per minute. (One cubic foot per second equals 450 g.p.m.) With level or gently sloping land and a soil containing very little sand, this would be enough water to irrigate 50 to 60 acres by surface methods. If deep sandy soils are involved or extremely long ditches are required, the irrigated acreage would be substantially reduced. Table 1 shows the capacity of a small supply ditch laid out on various grades.



FIG. 3. Farm pond furnishing water for gravity sprinkler system in Muscogee County.

Many farm ponds are dependable sources of water for small irrigation projects and are now being constructed as such more than for the purpose of fish propagation. (See Figure 3.) However, in some cases, ponds are constructed with sufficient additional capacity over and above the requirements of irrigation to permit propagation of fish. Care should be exercised in selecting the dam site and the material used in making the fill. In cases where considerable amount of sand or porous material is mixed in the soil, the addition of colloidal clay, known commercially as Bentonite, to the soil in the center section of the dam and in a strip along the bottom of the fill usually aids in reducing seepage losses. Ponds not only furnish water for irrigation pumping projects, but can serve sprinkler systems by gravity when situated at elevations 12 feet or more above the land to be irrigated. (See Figure 4.) Irrigation pipe is easily connected to drain pipe in pond by use of adapter unit. (See Figure 4A.) Where ponds depend largely upon watershed runoff and the area is void of year-round streams or springs, a minimum of 1.5 acre feet of water should be impounded for each acre to be irrigated. For instance, if five acres of diversified truck crops are to be irrigated, at least 7.5 acre feet of water should be stored in the pond in order to carry the crops through drought periods to maturity and take care of normal evaporation and some seepage losses.



FIG. 4. *Low pressure sprinkler system operated by gravity. Pond in upper background.*



FIG. 4A. *Irrigation pipe connected to drain pipe in dam with simple adaptor unit. Valve controls flow of water.*

Heavy users of irrigation water, such as pastures, alfalfa and, perhaps, pecans and peaches, will require correspondingly larger amounts of storage water in the pond. A pond 1.5 acres in area and averaging five feet deep would have a storage capacity of 7.5 acre feet of water.

Where perennial streams or springs flow into the pond area the storage capacity of the pond can be reduced accordingly. During periods of non-irrigation, such streams tend to replenish the water used for irrigation. The amount of flow of such streams should be measured at periods of low flow so the proper storage capacity of the pond can be determined. Measurement of water in streams is discussed in another section of this bulletin. For the past several years certain governmental agencies have been assisting farmers financially, in a certain degree, with the construction of ponds, the amount of financial aid depending largely upon conditions existing on each farm.

Many natural lakes in middle and south Georgia, bounded by fertile cropland, serve as excellent sources of water for low-cost irrigation developments. One county in particular, Lowndes, boasts the existence of 100 such fresh water lakes.

Artesian wells in the coastal area and in river valleys of the Coastal Plain and southwest Georgia are potentially valuable to farmers in the production of truck crops, tobacco, forage crops and specialty

crops under irrigation. Many artesian wells flow, unchecked, under natural pressure with the wastage of millions of gallons of water daily.¹ (See figure 5.) Several flowing wells have been tested for



FIG. 5. *Flowing artesian well discharging 225 gallons per minute (13,500 gallons per hour.)*

flow and pressures developed and the majority were found to develop sufficient pressure to operate low-pressure sprinkler irrigation systems. Figure 6 shows low-pressure revolving sprinklers in operation on a tobacco planted bed. As the need for irrigation gains in recognition in middle and south Georgia, the importance of conserving the artesian water supplies will become more significant. Flowing wells which have been properly installed can be capped with a quick coupler device during periods of non-use at a very low cost (less than \$5). Capping of wells



FIG. 6. *Low-pressure revolving sprinklers operated by natural pressure from flowing artesian well. (Irrigating tobacco plants and early vegetables.)*

¹ State and Federal geologists report that the major portion of 45,000,000 gallons flowing daily from wells is wasted. Bul. No. 49, The Geological Survey.

when not in use will help conserve the underground supply and stabilize the pressure, which has been decreasing gradually, without reducing the normal flow or causing damage to the well.

Deep wells are being drilled for irrigation purposes in localities where perennial streams or natural lakes do not exist and where suitable ponds can not be constructed for storage of water. Drilled wells of the size suitable for irrigation purposes are costly to install and the subsequent deep well pumping equipment is likewise very expensive. These types of irrigation systems deserve careful consideration and a thorough study of crops to be grown and availability of suitable markets before construction work of any kind gets under way. Only reliable well-drilling contractors should be employed to drill irrigation wells. A few deep well irrigation systems are in operation in Georgia with successful results being obtained in the production of high-quality specialty crops where ready markets are available. Figure 7 shows a well-drilling rig in operation in Turner County. Geologists state that there is an abundance of water in the underground region of artesian flow for the development of irrigation projects in south Georgia. Depths to which wells must be drilled to tap the artesian supply vary in different sections of the State and the height to which water rises in wells is directly related to the elevation of the land above sea level. The State Department of Geology, in cooperation with the Geological Survey, has valuable information concerning deep wells, their installation, productivity and testing. The design and installation of deep well irrigation systems is discussed in another section of this bulletin.



FIG. 7. *Modern well-drilling rig drilling irrigation deep well. (Note rig is mounted on bed of truck.)*



FIG. 8. *Measuring flow of stream with portable 90° triangular-notch weir.*

MEASUREMENT OF WATER

Measurement of water in streams will become more important as irrigation gains in popularity. By measuring flow of streams, discharge of artesian wells or other types of flows during period of low flow, the amount of water available for irrigation developments can be determined. Portable weirs, Figure 8, and other similar measuring devices are used to measure flow of water. A stake is set in the water above the weir, the top of which is exactly on the level with the crest of the weir. The flow is determined by measuring the height of the water above the crest (measurement taken at the stake) and using this figure with relation to the weir table, Table 2. If, for example, the height of water measured $7\text{-}3/16$ inches, the table shows the discharge to be 0.7 second feet or 315 gallons per minute.

RESULTS OF IRRIGATION

Water has two main functions with relation to growing of crops. It gives turgidity to plants and serves as a carrier of plant food elements.

By early 1947 an estimated 85 to 90 farmers over the State were growing crops of various types under irrigation. Results obtained by some of them, together with experiment station findings, have

TABLE 2. DISCHARGE OF 90° TRIANGULAR-NOTCH WEIR.

| Head (H) | * Dis-charge (Q) | Head (H) | * Dis-charge (Q) | Head (H) | * Dis-charge (Q) | Head (H) | * Dis-charge (Q) |
|-----------------|------------------|-----------------|------------------|-----------------|------------------|------------------|------------------|
| In. | Sec.-ft. | In. | Sec.-ft. | In. | Sec.-ft. | In. | Sec.-ft. |
| 2 $\frac{1}{2}$ | .046 | 4 $\frac{1}{4}$ | 0.272 | 7 $\frac{1}{8}$ | 0.730 | 9 $\frac{1}{2}$ | 1.48 |
| 2 $\frac{1}{2}$ | .052 | 5 $\frac{1}{8}$ | .289 | 7 $\frac{1}{8}$ | .760 | 9 $\frac{1}{2}$ | 1.52 |
| 2 $\frac{3}{4}$ | .058 | 5 $\frac{1}{4}$ | .306 | 7 $\frac{1}{4}$ | .790 | 9 $\frac{1}{4}$ | 1.57 |
| 2 $\frac{3}{4}$ | .065 | 5 $\frac{1}{2}$ | .324 | 7 $\frac{1}{2}$ | .822 | 10 $\frac{1}{8}$ | 1.61 |
| 2 $\frac{3}{4}$ | .072 | 5 $\frac{3}{8}$ | .343 | 7 $\frac{1}{2}$ | .854 | 10 $\frac{1}{8}$ | 1.66 |
| 3 | .080 | 5 $\frac{1}{2}$ | .362 | 7 $\frac{1}{2}$ | .887 | 10 $\frac{1}{4}$ | 1.71 |
| 3 $\frac{1}{4}$ | .088 | 5 $\frac{3}{4}$ | .382 | 8 $\frac{1}{8}$ | .921 | 10 $\frac{1}{4}$ | 1.76 |
| 3 $\frac{1}{4}$ | .096 | 5 $\frac{3}{4}$ | .403 | 8 $\frac{1}{4}$ | .955 | 10 $\frac{1}{4}$ | 1.81 |
| 3 $\frac{3}{4}$ | .106 | 5 $\frac{3}{4}$ | .424 | 8 $\frac{1}{4}$ | .991 | 10 $\frac{1}{2}$ | 1.86 |
| 3 $\frac{3}{4}$ | .115 | 6 | .445 | 8 $\frac{1}{2}$ | 1.03 | 10 $\frac{1}{2}$ | 1.92 |
| 3 $\frac{3}{4}$ | .125 | 6 $\frac{1}{4}$ | .468 | 8 $\frac{1}{2}$ | 1.06 | 10 $\frac{1}{2}$ | 1.97 |
| 3 $\frac{3}{4}$ | .136 | 6 $\frac{1}{4}$ | .491 | 8 $\frac{3}{4}$ | 1.10 | 11 $\frac{1}{8}$ | 2.02 |
| 3 $\frac{3}{4}$ | .147 | 6 $\frac{3}{8}$ | .515 | 8 $\frac{3}{4}$ | 1.14 | 11 $\frac{1}{8}$ | 2.08 |
| 3 $\frac{3}{4}$ | .159 | 6 $\frac{3}{8}$ | .539 | 8 $\frac{3}{4}$ | 1.18 | 11 $\frac{1}{4}$ | 2.13 |
| 4 $\frac{1}{8}$ | .171 | 6 $\frac{3}{4}$ | .564 | 9 | 1.22 | 11 $\frac{1}{4}$ | 2.19 |
| 4 $\frac{1}{8}$ | .184 | 6 $\frac{3}{4}$ | .590 | 9 $\frac{1}{8}$ | 1.26 | 11 $\frac{1}{2}$ | 2.25 |
| 4 $\frac{1}{8}$ | .197 | 6 $\frac{3}{4}$ | .617 | 9 $\frac{1}{4}$ | 1.30 | 11 $\frac{1}{2}$ | 2.31 |
| 4 $\frac{1}{8}$ | .211 | 6 $\frac{3}{4}$ | .644 | 9 $\frac{1}{4}$ | 1.34 | 11 $\frac{3}{4}$ | 2.37 |
| 4 $\frac{1}{8}$ | .225 | 7 $\frac{1}{8}$ | .672 | 9 $\frac{1}{2}$ | 1.39 | 11 $\frac{3}{4}$ | 2.43 |
| 4 $\frac{1}{8}$ | .240 | 7 $\frac{1}{8}$ | .700 | 9 $\frac{1}{2}$ | 1.43 | 12 | 2.49 |
| 4 $\frac{1}{8}$ | .256 | | | | | | |

* Multiply these figures by 450 to obtain flow in gallons per minute.

been compiled and are given in Table 3. In many instances, where market conditions were favorable and the farm management efficient, farmers have stated that their irrigation system paid for itself the first dry season. It is considered necessary, however, to operate the average installation in Georgia a number of years to recover the installation cost.

TABLE 3. PRODUCTION OF VARIOUS CROPS — IRRIGATED VS. NON-IRRIGATED

| Crop | Yield Per Acre | | Soil |
|-------------------------------------|---|--|-----------------|
| | Irrigated | Non-Irrigated | |
| Alfalfa ¹ | 1 to 2 tons increase with irrigation | | Heavy type |
| Bush string beans | 260 bu. | 125 bu. | Sandy loam |
| Collards | 1200 lbs. | Failure in fall of 1943 | Clay loam |
| Collards | 500 doz. bunches | No crop in fall | Sandy loam |
| Corn | 25 bu. roasting ears; 35 bu. mature corn with irrigation | | Sandy loam |
| Cabbage plants | 1,000,000 | 500,000 | Sandy loam |
| Escarole | 600 bu. | 400 bu. | Sandy loam |
| Gladioli bulbs ² | Produced 75,000 bulbs with irrigation. Lost 50,000 bulbs before irrigation. | | Silt loam |
| Irish potatoes | Production doubled and more U. S. No. 1 | | Fine Sandy loam |
| Irish potatoes | Production increased some and doubled number of U. S. No. 1 | | Sandy loam |
| Ladino clover seed | 35 lbs. | None | Clay loam |
| lima beans | 80 bu. | 40 bu. | Silt loam |
| Onion Plants | Production increased 2 to 4 times | | Sandy loam |
| Peaches ³ | All medium to large size | Few large, mostly medium and small | Sandy loam |
| Perm. Pasture (dairy) | 35 lbs. more milk per acre per day | | Silt loam |
| Perm. Pasture (beef) | 2 to 3 head per acre with steady gains per animal per day | | Silt loam |
| Pecans ⁴ | Better quality, heavier production with irrigation | | Sandy loam |
| Plum seedlings | 500,000 | 125,000 | Sandy loam |
| Raspberries | Production increased 2 to 4 times | | Clay loam |
| Strawberries | 3,000-4,000 quarts | 1,000-1,500 quarts | Sandy loam |
| Snap beans | 300 bu. | 150 bu. | Sandy loam |
| Sweet potato slips ² | 100% survival | Uncertain production | Silt loam |
| Tobacco | 1400 lbs. | 1,000 lbs. | Pebbly loam |
| Tobacco plants | More and sturdier plants assured with irrigation | | Sandy loam |
| Turnip greens | 10 tons | 3.5 tons | Silt loam |
| Tomatoes | 200 bu. | 100 bu. (Sometimes no crop in fall) | Sandy loam |
| Vegetable plants (tomato & cabbage) | Production doubled with irrigation | | Sandy loam |

(1) Results reported by TVA.

(2) Production not on a per acre basis.

(3) Results reported in South Carolina.

(4) 1947 was first year pecans were irrigated.

Double cropping can be accomplished on many farms where irrigation systems are installed and superior crops grow as compared to non-irrigated crops. Because of this improved quality and the fact that crop production is more likely assured under irrigation, cannery representatives and freezer-locker operators are expressing their interest in inducing more growers to take advantage of their irrigation possibilities.

SOILS SUITABLE FOR IRRIGATION

The soils best suited to supplemental irrigation are those that are well drained, free working and not too heavy and sticky or too coarse. Table 3 shows favorable results obtained with irrigation on soils ranging from fine sandy loam to clay loam. Clay soils are unable to absorb water at the relatively rapid rates sandy loams are able to take in water; therefore, irrigation of the heavier soils is a more difficult job. More time and labor are required to irrigate the clay soils because of the slow rate of penetration since care must be exercised in preventing water from standing on the surface and causing scalding of plants. Also, excess runoff must be avoided to eliminate possibility of soil erosion. However, addition of organic matter to the heavier soils will improve their ability to absorb water and make the soil freer working as well. Many acres of fertile soil, ordinarily too wet to cultivate, can be made productive under irrigation by following simple drainage practices such as construction of sidehill intercepting ditches to control seepage and installation of open ditches or tile lines to drain wet areas in the fields.

IRRIGATION WATER REQUIREMENTS

Considerable amount of investigational work has been carried on to determine the storage capacity for useful water of several typical Georgia soils. The dry weight per cubic foot of each of the soil types was first determined by driving out all moisture with the use of ovens. The field capacity is then determined by adding moisture to the soil simulating the application of water by irrigation. The field capacity, expressed in percent of the dry weight, is the maximum amount of moisture a soil will retain after irrigation and after gravitational water movement (downward drainage) has ceased. With this information, the permanent wilting point is then calculated for each of the soils. The permanent wilting point, also expressed in percent of the dry weight, is the percentage of moisture at which plants begin to wilt. The difference in the field capacity percentage and the wilting point percentage is called the range of useful moisture.

Since the range of useful moisture of a soil is expressed in percent of dry weight, the pounds of useful water are obtained by multiplying this percentage by the dry weight of the soil. Referring to Table 4, the range of useful moisture for Norfolk Sandy Loam is 4.9 percent (9.7 - 4.8); thus multiplying 88 pounds (dry weight per cu. ft.) by 4.9 percent the pounds of useful moisture are found to be 4.3 pounds. Converting the 4.3 pounds of water to inches depth we

find that Norfolk Sandy Loam will retain .81 inches of water per foot of soil. This is the amount of water that would be applied by irrigation to raise the moisture content of the first foot of soil from the permanent wilting point to field capacity.

WHEN TO IRRIGATE

Knowing the dry weight of a soil, the field capacity percentage and the permanent wilting percentage, (Table 4), the moisture condition can be readily determined by weighing any measured portion of the soil.

Cylinders made of light-gauge galvanized iron and holding $1/5$ cubic foot of soil (6 inches in diameter and 12 inches long) are often used. Samples of soil are collected by driving the cylinder into the ground until top of cylinder is flush with the ground level. Referring to Table 4, Fannin Silty Clay Loam weighing 82 pounds per cubic foot, dry weight, will weigh approximately 94 pounds with the moisture content at the wilting point ($82 \times 14.9\%$) + 82 = 94.2.

A $1/5$ -cubic-foot cylinder of this soil near the wilting point would then weigh 18.8 pounds (94.2 divided by 5 = 18.8). Similarly, this soil at field capacity will weigh about 106 pounds per cubic foot and a cylinder of it would weigh 21 pounds. The difference in weight represents the range of useful moisture, sometimes called "available capacity," and Table 4 shows it to be equivalent of 2.3 inches of water per foot depth of soil.

Hence, the weighing of the soil, coupled with the "feel" of the soil to the hand and general appearance of the crop, go to make up an accurate method of determining the time to irrigate. Like greasing a tractor in advance to prevent damage to moving parts, the secret in irrigating is to start applying water *before* the wilting point is reached instead of *after* the plants begin suffering from lack of moisture.

Many an irrigation farmer has been seen irrigating during periods of light showers because experience has taught him that a light, brief shower quickly evaporates without penetrating to the root zone of plants. Moreover, such light applications actually cause roots of plants to be drawn closer to the surface where they are more than ever subjected to droughty weather.

Since this bulletin deals primarily with sprinkler methods of irrigation it is considered unnecessary to discuss in detail the movement of moisture in soils as related to surface methods, particularly furrow and corrugation, of applying water.

TABLE 4. RANGE OF USEFUL MOISTURE AND WATER CAPACITY OF SEVEN GEORGIA SOILS

| Soil | Dry Weight Per Cu. Ft | Field Capacity | Perm. Wilting Point | Range of Useful Moisture | Storage Capacity For Useful Water Per Ft. Depth |
|--|-----------------------|----------------|---------------------|--------------------------|---|
| Norfolk Sand Toombs County | 90 lbs. | 7.0% | 3.5% | 3.5% | 0.96 in. |
| Norfolk Sandy Loam Lanier County | 88 lbs. | 9.7% | 4.8% | 4.9% | 0.81 in. |
| Sandy Loam Colquitt County | 80 lbs. | 12.5% | 6.3% | 6.3% | 0.96 in. |
| Cecil Sandy Clay Loam Spalding County | 85 lbs. | 13.0% | 6.5% | 6.5% | 1.06 in. |
| Cecil Sandy Clay Loam Jackson County | 90 lbs. | 19.4% | 9.7% | 9.7% | 1.08 in. |
| Fauquier Silty Clay Loam Union County | 82 lbs. | 20.8% | 14.9% | 14.9% | 2.30 in. |
| Silty Clay Loam Jackson County | 80 lbs. | 33.7% | 16.8% | 16.7% | 2.57 in. |

In both of these irrigation methods, the movement of water is less rapid in soils when in an unsaturated condition and much slower in fine textured than coarser soils. Therefore, under surface methods of irrigation, special attention must be given to the soil type and the kind of crops grown, including their root systems, to assure the plants sufficient moisture during periods of greatest demand.

Since water moves slowly in clay soils, it is important to maintain the moisture content at a high point to assure as rapid movement of water as possible between furrows or corrugations for fast-growing crops during periods of heavy demand for water. "Some crops have many fine roots and root hairs, thus reaching to within a very short distance of every soil particle and its covering of moisture. Others have much smaller root systems, and many small masses of soil may not contain any root at all. Under the former condition moisture moves to the roots through extremely short distances, whereas under the latter the distances may be appreciable."²

Hence, under certain conditions during hot, drying weather it would be possible for crops to suffer from lack of moisture regardless of the fact that the moisture content of the soil could be well above the wilting point. Sprinkler irrigation methods, however, apply water quite uniformly over the entire surface of the cropland, thereby largely eliminating the difficulty sometimes experienced with surface methods.

2. U.S.D.A. Farmers' Bulletin No. 1922 by M. R. Lewis.

WATER REQUIRED BY DIFFERENT CROPS

The depth from which different crops will obtain water depends on the kind of crop and the depth, character, and moisture content of the soil and subsoil. Pastures and truck crops are shallow-rooted and require moisture close to the surface for maximum growth. For such crops the upper 12 to 18 inches are the most important and, in irrigation practice, may be considered as the root zone. A large number of crops, including Irish potatoes, alfalfa and orchards, obtain the major part of their moisture supply from the upper two to four feet. These figures represent what may be called normal conditions for the crops mentioned and apply where the soil is at least as deep as the root zones specified and favorable moisture conditions are maintained in those zones. Deep-rooted crops should be allowed to dry out the subsoil as far as possible without suffering for water. The whole root zone should then be filled to field capacity by irrigation.

Weather conditions have a marked effect on the rate at which crops use water but, in general, truck crops and similarly shallow-rooted crops require one inch of water per week, pastures two to three inches every ten days and hay crops, such as alfalfa, a heavy irrigation, four to six inches, between cuttings.

SPRINKLER IRRIGATION

A large majority of the irrigation systems in Georgia are of the sprinkler type. Water can be applied more efficiently on most soil types by some method of sprinkler irrigation. Less labor is required

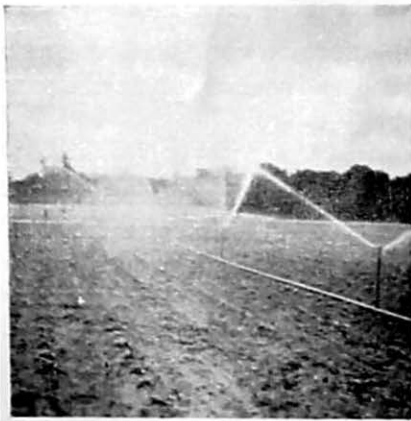


FIG. 9. The sprinkler line, commonly called lateral line, is moved from one setting to another at right angles to, and both sides of, the main line (in background).



FIG. 10. Sprinkler-irrigation pipe is lightweight, is equipped with quick-acting couplers and is made in 20-foot lengths.

by this method and water can be handled with a greater degree of ease and efficiency by inexperienced farm labor.

Chief advantages of sprinkler irrigation over furrow and flood methods are (1) requires less water to accomplish the desired results; (2) inexperienced labor can handle the water satisfactorily and with less amount of work; (3) no leveling of land is necessary which mean fertility not lost due to moving topsoil; (4) not necessary to construct and maintain supply ditches; (5) soils do not form a heavy crust; (6) soluble fertilizers can be applied through the sprinklers, thus providing an additional saving in labor, and (7) rate of application of water can be easily controlled to prevent over-irrigation and soil erosion.

The portable revolving sprinkler system is the type most commonly used and is well adapted to all types of crops. Revolving sprinklers, when attached to lengths of lightweight portable pipe, can be moved from one position to another from a main supply line until the field is completely irrigated. (See Figure 9.) The pipes, both supply and laterals, are equipped with self-sealing, quick-acting couplers, making it possible to move several lengths of pipe from one setting to another in a matter of minutes. (See Figure 10.) The sprinklers usually operate at pressures ranging from 25 to 60 pounds, depending largely upon local conditions and the farmer's personal choice.



FIG. 11. *Single-nozzle sprinkler, recently developed, will give uniform distribution of water at low pressures, 3 to 15 pounds.*

Revolving sprinklers in the low-pressure class, 3 to 15 pounds, have been developed recently and tests conducted by the Extension Service indicate that they will play an important part in low-cost irrigation of tobacco beds, orchards and truck crops. (See Figure 11.) These sprinklers will be particularly useful in irrigating fertile plots of land, located below farm ponds, by gravity flow. A pond with its water surface not less than 12 feet higher than land to be irrigated will furnish enough pressure to satisfactorily operate the low-pressure sprinklers. Where flow by gravity cannot be utilized, appropriate pumping equipment is installed to deliver water at higher elevations and with pressure sufficient to operate the sprinklers.

Another type of sprinkler system, called perforated-pipe system, consists of light gauge portable quick-coupler pipe having a set pattern of small holes drilled along the top side to give a spread of water in strips ranging from 25 to 55 feet wide, depending upon operating pressures (6 to 20 pounds). (See Figure 4.) This type of system is lower in first cost than revolving sprinklers but its use is limited to low-growing crops and on sandy loam type of soils. The system is particularly well suited to pasture and hay production. It has proved its practicability in this regard for the past 10 years in irrigated sections of the West.



FIG. 12. *Uniformly sloping land and soil type such as shown here in Houston County exists in a few sections of Georgia and is ideal for the development of community irrigation projects.*

COMMUNITY IRRIGATION PROJECTS

Although there has been no irrigation development on a community basis in the State, preliminary investigations indicate that a number of possibilities warrant further study. Considerable land in central and south Georgia is sufficiently level to be irrigated by surface methods from irrigation canals and the soil is of the type that should respond well to irrigation. (See Figure 12.) In north



FIG. 12A. Strip-border system of irrigation. Water is turned into the strips from a main supply ditch. Note one-wire electric fence for dividing off pasture.

Georgia the conversion of old mining ditches into irrigation canals to furnish water by gravity for low-pressure sprinkler systems on productive low land presents definite possibilities. Personnel of the State Geology Department and U. S. Geological Survey has been collecting basic information, in their water resources work for several years, and such information is essential to the proper design and successful operation of community projects. Many more stream gauging stations on smaller streams are needed in areas where community irrigation projects have possibilities.

Studies being made at the present time in connection with the larger river development projects in the State indicate that irrigation is being given major consideration as an important contribution to the economic justification of the projects. Preliminary irrigation data compiled for one of these large river basin projects reveals that the increased value of diversified crops due to irrigation would amount to \$25,000,000 annually on about 464,000 acres of land. Low-cost electrical energy, produced by power plants on the project, would be utilized to operate the irrigation pumps for the community projects.

NEW DEVELOPMENTS

Pasture irrigation is drawing the interest of the livestock people, particularly dairymen, and demonstration projects and experimental work is under way. (See Figures 13 and 13A.) Irrigation of permanent pastures is resulting in increases in nutritive value of forage as well as in yields. Protein, phosphorous, lime and vitamin content of the forage is increased due to irrigation when pastures are supplied



FIG. 13. *Portable sprinkler irrigation system on permanent pasture of Ladino clover and Dallis grass mixture in Oglethorpe County.*

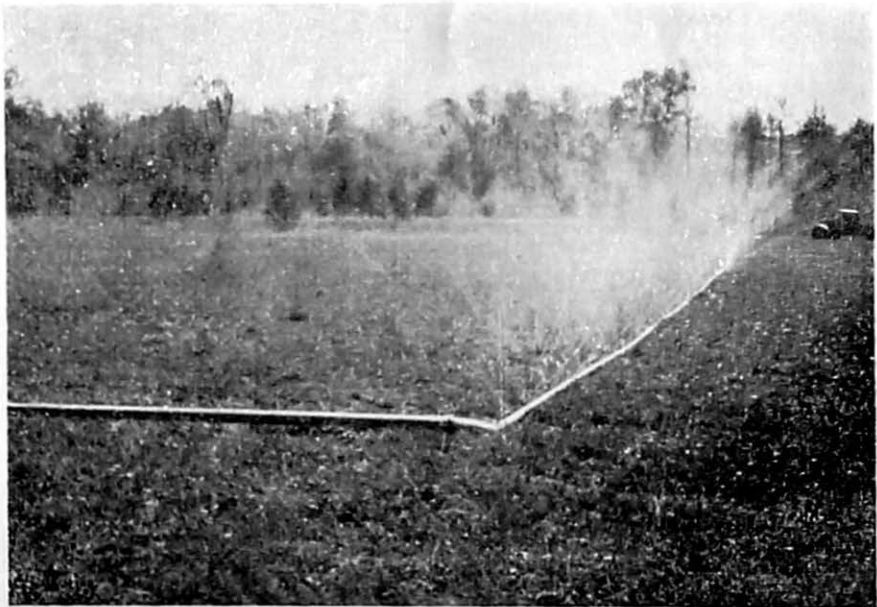


FIG. 13A. *Perforated pipe sprinkler system irrigating pasture in Greene County.*

with ample fertilizer elements. Dairymen often refer to the fall months when long dry periods retard growth of pastures and consequently cause milk production to fall off.

Irrigation systems are being designed so that, over a period of years, increased milk production will amortize the installation costs and pay for annual charges. The recent development of low-pressure sprinkler systems will favor the average dairyman in obtaining low-cost irrigation. Dairymen and agricultural leaders favor the idea of planning the irrigation system to take care of winter grazing crops since supplemental water will permit early seeding in the fall and provide an early, vigorous growth which should develop a better sod for grazing under rather wet soil conditions later in the winter.

Small fruits and peaches offer a wide open field as to their production under irrigated conditions. Freezer-locker plant operators are interested in processing more berries during periods when peaches are not being handled. Strawberries can be produced at the rate of 3,000 to 4,000 quarts per acre under irrigation. Horticulturists believe irrigation of peach orchards will aid materially in maintaining the humus content of soils, thereby keeping trees in a high state of production over a longer period of years. Demonstration projects are getting under way this year on peaches to determine the effects of irrigation in establishing and growing cover crops as well as the application of water during the fruiting period. Preliminary results



FIG. 13B. *Portable revolving sprinkler system irrigating pecan grove in Colquitt County.*

of irrigation of peaches indicate that practically all fruit packs out medium to large, thus bringing a premium on the market. In the opinion of progressive growers, supplemental irrigation is essential to the successful production of peaches.

The frozen food industry can add considerably to the income of Georgia farmers but, at present, the greater percent of frozen foods sold in the State is grown and processed outside the State. Consequently, the producer and processor profits are not realized by Georgians in this growing industry now representing about ten million dollars in the State. Frozen foods are more palatable and nutritious than those preserved by other methods and Georgia farmers can, with modern machinery and irrigation equipment, produce as good quality produce as anyone else. The use of labor-saving equipment in growing, harvesting and processing produce either on large scale individual enterprises or community basis will enable the Georgia farmers to meet the outside competition and realize greater income.

Tobacco was irrigated for the first time with revolving sprinkler systems in Georgia in 1946 and probably for the first time anywhere

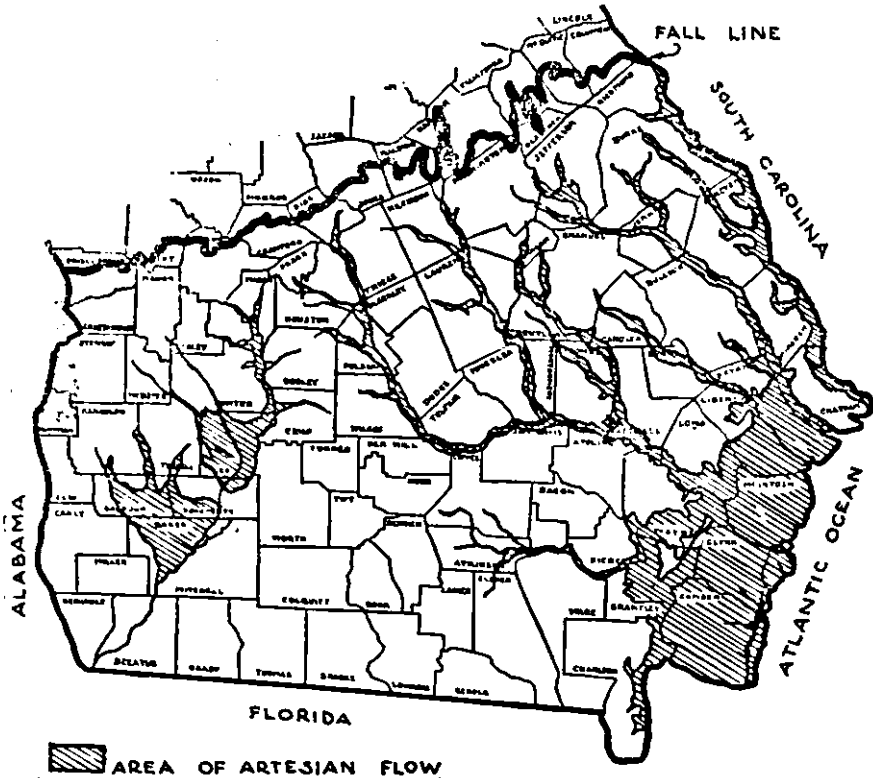


FIG. 14. Area of artesian flow in Georgia.

in the tobacco belt. The supplemental water applied during critical periods of growth when dry weather persisted paid off in increased yields. One grower produced 500 pounds more per acre under irrigation and the quality was on a par with non-irrigated tobacco grown on his farm and other farms.

The first pecan grove irrigation project is under way in Colquitt County. Thirty-five acres of mature pecan trees will be irrigated with a portable revolving sprinkler system; water to be furnished by a .13-acre farm pond. (See Figure 13B.) Irrigation will be employed during dry periods when the nuts are filling out and during fall and winter droughts to assure good stands and growths of cover crops. The owner of this irrigated pecan orchard in Colquitt County is convinced that irrigation two years ago would have increased the quality and quantity of nuts to the extent of \$10,000. Such an increase in income, due to irrigation, would more than twice pay for the necessary irrigation equipment required to cover his acreage.

The discovery that flowing artesian wells develop enough pressure, in most cases, to operate portable low-pressure sprinkler systems marks another step forward in the State's irrigation program. Figure 14 shows the area of artesian flow in the Coastal Plain of Georgia. The area covers a large portion of the fertile agricultural land in

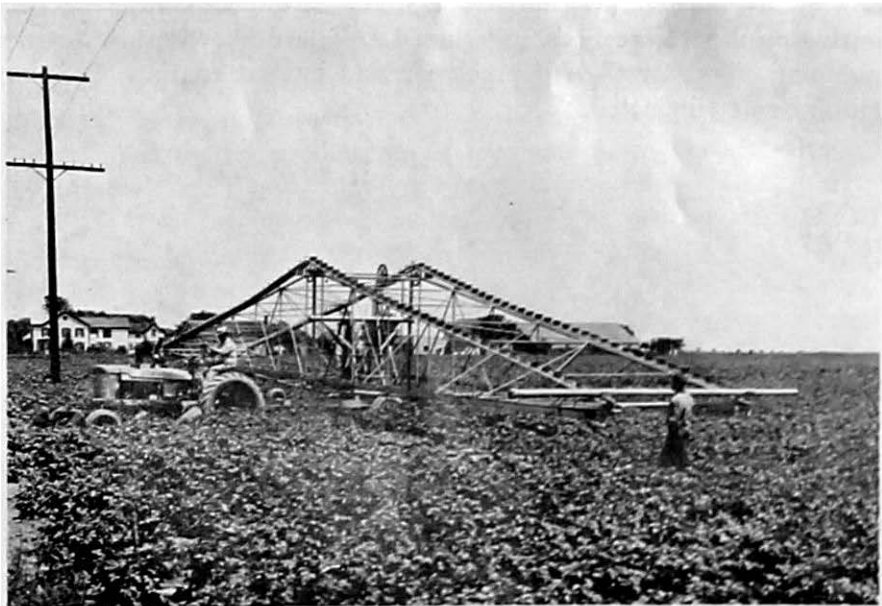


FIG. 15. *Irrigation pipe moving machine. End to end distance of conveyor is 60 feet (the usual setting of lateral lines.)*



FIG. 15A. A long-range sprinkler in operation on a dairy pasture in Fulton County.

the southern part of the State. Where existing flowing wells are utilized to operate sprinkler systems, the only investment necessary is in the portable supply pipe and sprinkler pipe as no pumping units are required. Therefore, initial equipment investments are very reasonable on a per acre basis and annual costs are likewise low because pumping costs as well as depreciation and interest charges on pumping units are eliminated.

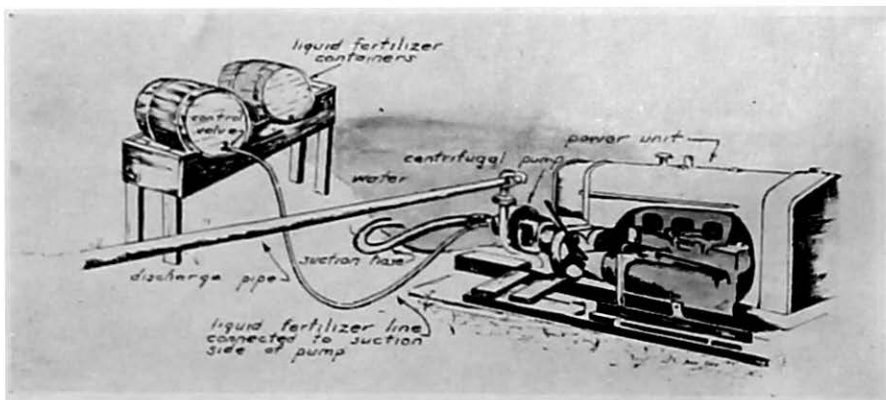


FIG. 15B. Fertilizing with the irrigation system requires only the simplest of equipment. The pump draws in fertilizer and water simultaneously.

Irrigation is fast revolutionizing tobacco plant propagation. Availability of small capacity sprinkler systems enables growers to locate their tobacco beds on higher, better-drained land where blue mold can be controlled more easily and effectively. These sprinkler systems can be operated by natural pressure from flowing artesian wells, Figure 6, with gravity flow from overhead water tanks, by automatic pressure domestic water systems or even by operating the portable sprinkler irrigation equipment normally used to irrigate crops in the field.

Pipe moving machines for the large commercial grower are now on the market to save man power and time in moving portable sprinkler pipe from one setting to another. As the pipe conveyor is drawn down the crop rows, one man uncouples the pipe section by section and loads it on the machine while another man on the opposite side of the endless chain conveyor unloads the pipe and couples it up in readiness for the operation of sprinklers at the new setting. (See Figure 15.)

The current development of over-size high-pressure large-capacity sprinklers is drawing the attention of irrigation engineers and growers particularly with respect to their contribution to saving in labor operations. One manufacturer announces the production of a giant-type sprinkler which will discharge water at sufficient pressure to irrigate from three to four acres from each setting. Other over-size revolving sprinklers are now available which, according to manufacturers' performance charts, will give an effective coverage of $1/2$ to $3/4$ acre per setting at medium high pressures of 70 to 80 pounds per square inch. It appears that these types of sprinklers will be best suited to the production of hay and forage crops (alfalfa, dairy pastures, etc.) until more information is available as to water distribution features of the sprinklers. It might develop that these large capacity sprinklers can be used in the future for above-tree irrigation of peaches, pecans and other types of orchards which might prove profitable to grow under irrigated conditions. Above-tree sprinkling might prove to be impractical from the standpoint of the water interfering with spray schedules in controlling diseases.

The newest in scientific methods of applying fertilizer involves the use of complete fertilizers that are soluble in water and can be applied to crops by introducing required amounts into the irrigation water. Each barrel of the soluble complete fertilizer can be readily introduced into the irrigation water at very little cost for additional equipment. If irrigation is by some surface method, the soluble fertilizer is mixed with the water in the main supply ditch.

If irrigation is by means of some type of sprinkler system, the required amounts of fertilizer solution are introduced into the system simply by connecting a hose to the suction side of the irrigation pump. Problems concerning the availability of materials and prices of this completely new and labor-saving method of applying fertilizers are under study at the present time.

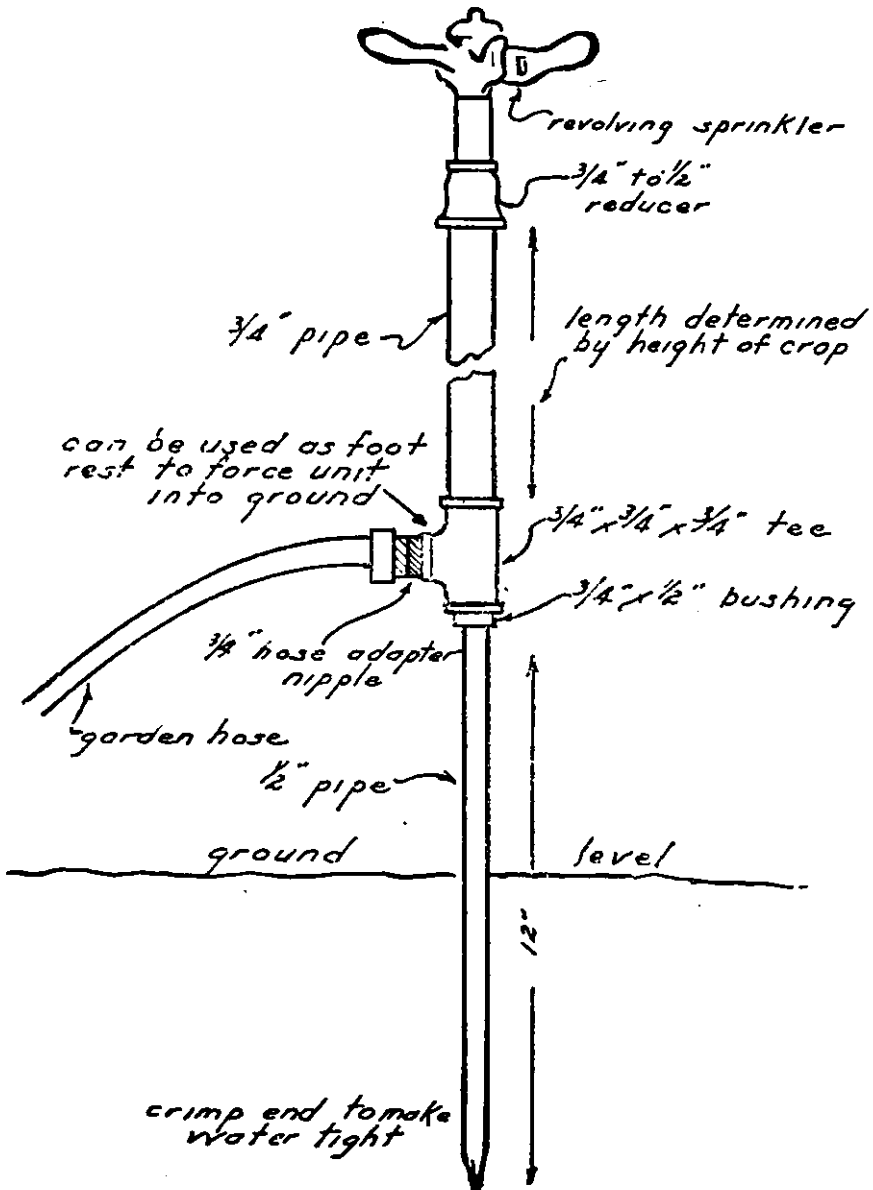


FIG. 16. Sprinkler irrigation unit for gardens.

Early in 1947 a leading Fulton County farmer began applying liquid nitrogen through his sprinkler system to fertilize a substantial acreage of roasting ear corn and turnip greens. After the fertilizer is applied through the sprinklers, a follow-up application of water is made to wash fertilizer off the plants and into the soil to prevent burning of foliage.

An analysis of irrigation laws of other states is being made. There are no Georgia laws at present that govern the use of public waters, surface or underground, for irrigation purposes. As the value of irrigation increases in the agricultural development of the State, legislation will be needed to govern the appropriation of water for this purpose. Such laws will give protection to those farmers who make investment in equipment and become dependent upon irrigation water in carrying out their farming operations. It can readily be seen that the smaller streams will not support irrigation projects on all the farms along their course. Therefore, the first ones to install systems will eventually need legal protection to insure them of adequate supplies during drought periods. The installation of additional stream gauging stations on the smaller watersheds will aid materially in determining quantities of water available in small streams for irrigation purposes and be of value in planning reservoirs for supplying water to small community irrigation projects.

GARDEN IRRIGATION

The use of a small single-nozzle revolving sprinkler attached to a portable pipe and hose assembly, Figure 16, is recommended, in general, for garden irrigation. Where sources of water are limited, the size of the nozzle on the sprinkler can be regulated to correspond to the capacity of well, spring or stream.

A new development in revolving sprinkler design permits the use of sprinkler heads on pressures as low as three pounds. In many instances, the farm water system, to which the garden irrigation unit is connected, does not provide sufficient pressure to operate the conventional high-pressure sprinklers.

The following table gives the discharge and diameter of coverage of a typical low-pressure irrigation sprinkler at pressures ranging from three to 15 pounds.

TABLE 5. PERFORMANCE OF LOW PRESSURE REVOLVING SPRINKLER

| Pounds Pressure | 1 1/64" Nozzle | | 3/16" Nozzle | | 7/32" Nozzle | | 1/4" Nozzle | | 9/32" Nozzle | |
|-----------------|----------------|-----|--------------|-----|--------------|-----|-------------|-----|--------------|-----|
| | Dia. Ft. | GPM | Dia. Ft. | GPM | Dia. Ft. | GPM | Dia. Ft. | GPM | Dia. Ft. | GPM |
| 3 | 18 | 1.5 | 19 | 1.7 | 20 | 2.3 | 21 | 2.9 | 21 | 3.5 |
| 5 | 27 | 1.9 | 23 | 2.2 | 20 | 2.9 | 30 | 3.8 | 31 | 4.5 |
| 8 | 33 | 2.4 | 34 | 2.8 | 35 | 3.7 | 36 | 4.7 | 37 | 5.6 |
| 10 | 35 | 2.6 | 36 | 3.1 | 38 | 4.1 | 39 | 5.2 | 40 | 6.2 |
| 12 | 38 | 2.9 | 39 | 3.5 | 41 | 4.5 | 42 | 5.6 | 43 | 6.7 |
| 15 | 41 | 3.3 | 42 | 3.9 | 44 | 5.1 | 45 | 6.4 | 46 | 7.6 |

Information on the production of various crops under irrigation, time to irrigate and amounts to apply can be found in other sections of this bulletin.

DRAINAGE PRIOR TO IRRIGATION

Countless acres of fertile land adjacent to perennial streams or other dependable sources of water could be cultivated and made to grow high-quality crops if proper drainage practices were employed to dispose of excess water. In many cases the land is kept continually wet on account of seepage from sidehills that constantly flows to the lower areas. Intercepting ditches located along the sidehill where the water breaks out will intercept the flow and carry it away from the lower area, thus permitting the soil to dry out sufficiently to cultivate row crops or grow hay or pasture crops. In swampy areas where excess water spreads over an appreciable area due primarily to the lack of a defined drainage channel, the use of ditching dynamite will give good results with a minimum of hand labor. (See Figure 17.)

After provisions are made to take care of the excess water, the year-round stream serves as an excellent source of water for portable sprinkler irrigation systems. Hence, otherwise worthless land can be reclaimed and made to produce quality and quantity produce, including dairy pastures, under a sound program of fertilization and irrigation.



FIG. 17. Ditching dynamite can be used effectively in all sections of the State if blasting is done when soil is in saturated condition.

DESIGNING SPRINKLER IRRIGATION SYSTEMS

The design of irrigation systems is left largely to the discretion of engineers familiar with irrigation practices and problems and representatives of reliable equipment companies who are generally familiar with agricultural practices.

This section of the bulletin is prepared primarily for those engineers representing educational institutions, equipment companies or other organizations who might have need for a concise set of tables and related data for figuring individual jobs. It will enable the engineer, particularly the one representing the educational field, to design an irrigation system within a tolerable degree of accuracy and will provide the prospective irrigator with sufficient information for him to call for bids or quotations from irrigation equipment companies. In the last analysis, it is the equipment dealer who selects the exact pump, power unit and drive to meet the conditions specified for a job and it is impractical for an engineer, other than the equipment representatives, to maintain rating charts for all makes and sizes of pumps, including data on types and sizes of impellers and power units.

The design of an irrigation system depends upon many factors as they exist on the particular farm to be irrigated. These are (1) the water supply; (2) distance from the water source to edge of field;

(3) the elevation of field above water source; (4) dimensions of area to be irrigated; (5) possible future expansion; (6) type of soils; (7) crops to be grown; (8) probable markets for produce; (9) type of power available; (10) financial status of grower, and (11) labor available. The size and type of pumping unit, length and size of main and lateral pipe lines and number and size of revolving sprinklers (when required) are all dependent upon local conditions as listed above. Pump characteristics, horsepower requirements, pipe sizes, friction losses, operating pressures on sprinklers, their size and spacing and operating costs can be determined only after careful field data has been compiled and personal attitude or choices of the grower are taken into consideration.

As an aid in compiling field data and for use as basic information in preparing quotations, a form similar to the one illustrated in Figure 18, used by engineers of the Georgia Agricultural Extension Service, is quite useful. This information coupled, perhaps, with a layout sketch on the reverse side of the data sheet is usually sufficiently complete to enable an engineer to design a practical and efficient irrigation system for the particular farm under consideration.

After the adequacy of the water supply is determined, allowing 10 g.p.m. for each acre to be irrigated,³ measurements are taken to determine the static head (elevation of land above the water supply)

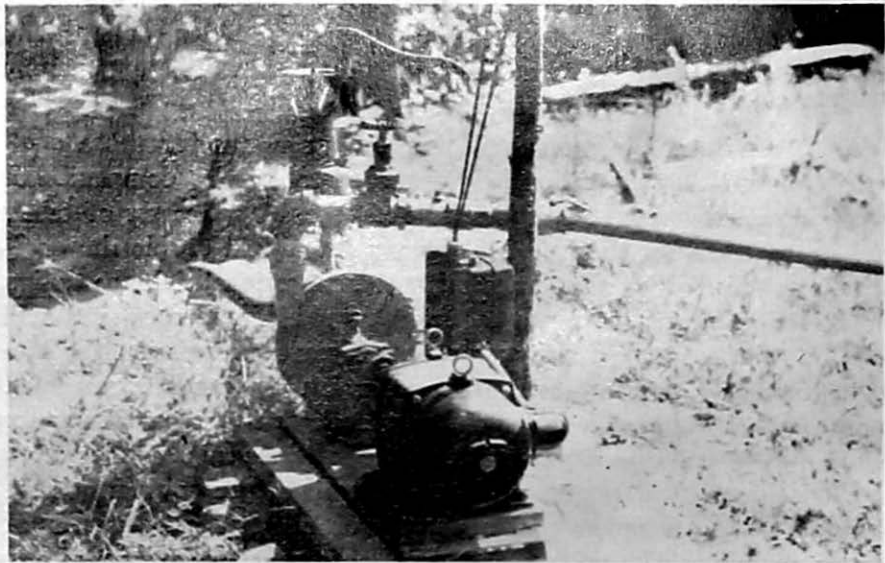


FIG. 17A. *Power lines in rural areas furnish enough electricity to each farmer to irrigate 25 acres without special line construction.*

3. A flow of 10 g.p.m. will apply one inch of water over one acre in a period of six days on an operating schedule of 12 hours per day. Evaporation losses, loss of time in moving pipe, changing locations and not altogether perfect distribution of water have been taken into account.

FIG. 18. IRRIGATION DATA FORM

Name _____ Date _____

Location _____ County _____

Mail Address _____ Soil _____

Water Supply _____

Lift to Field _____ Length of Main and Size _____

Friction (Total) _____

Operating Pressure _____

Total Head _____ Length of Lateral and Sizes _____

Acres: Present and Crops _____

Sprinklers: Type and Number _____

Acres: Future and Crops _____

Diversion Works _____ Fertilizer Practices _____

Length of Ditch _____

Power _____ HP _____

Pump: Kind _____ Capacity _____

Drainage Data _____

Remarks _____

and the distance from the water source to the edge of the field to be irrigated. The static head can be readily determined with the



FIG. 19. Deep well turbine pump with pulley for flat belt drive by tractor. Discharge outlet at lower left.

use of a hand level if the distance from the water supply to the high point in the field is reasonable (300 or 400 feet). If the distance is in excess of 400 feet, the static head might better be determined with an engineer's level or similar instrument to eliminate chance of error. The field dimensions and the location of the main supply line can next be determined. In case of row crops the main line is run perpendicular to the rows so that the lateral line (sprinkler line) runs in the same direction as the rows. In the majority of cases, the main line is located through the center of the field so that one line of lateral pipe

extending from the main line to the edge of the field will suffice. Being portable, the lateral line can be set up to operate on either side of the main line. (See Figure 9.) Knowing the pipe requirements, both main and lateral, we refer to the friction charts, Tables 6 and 8.

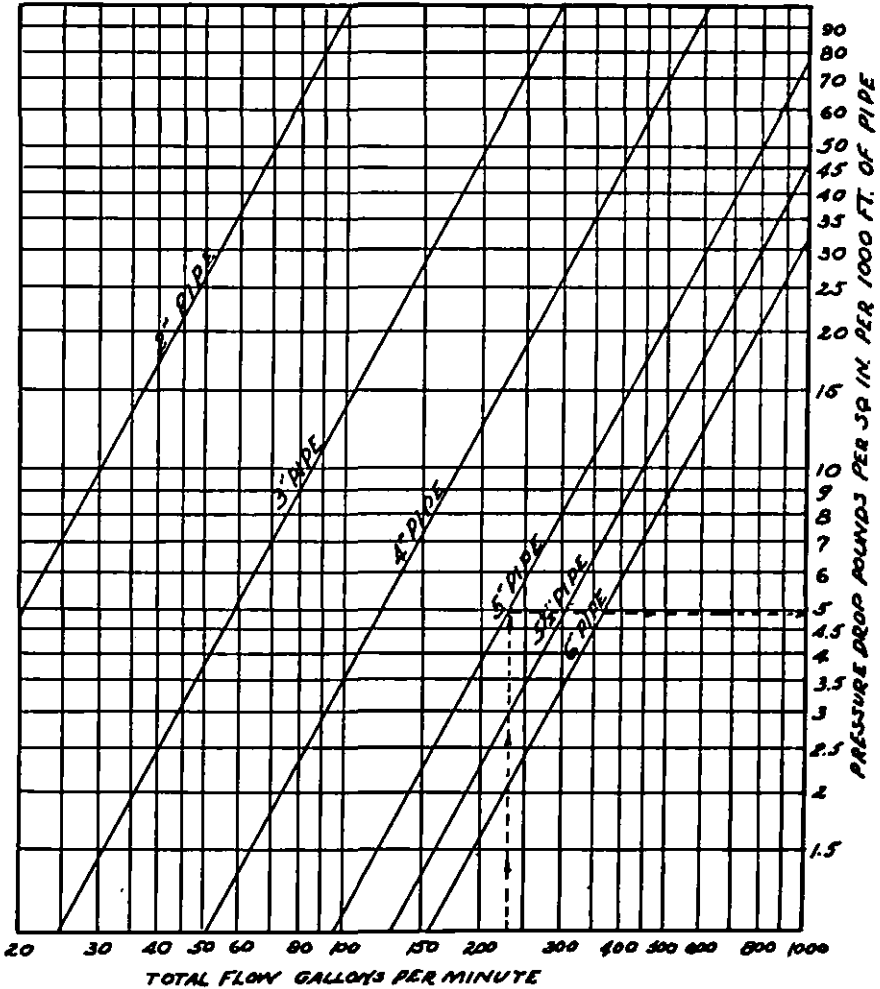
Assuming the acreage to be 20, the amount of water flowing through the main line will be 200 g.p.m. and the revolving sprinkler type of system is to be installed. The friction loss in four-inch pipe is 13 pounds per square inch per 1,000 feet of pipe. This is the correct size main line to install since friction losses should be figured on the basis of one to two pounds per 100 feet of pipe.⁴ If the lateral line is 400 feet long and the sprinklers are spaced 40 feet apart, ten sprinklers of 20 g.p.m. capacity each will be installed.

Tables 5 and 9 give capacity of sprinklers at different pressures. To determine the correct size lateral pipe to keep friction losses at a minimum, follow the line at 20 g.p.m. horizontally to three-inch pipe, then drop down vertically to the line marked "10" (10 sprinklers) and follow horizontally again to nine pounds which is the friction loss in the 400 feet of lateral pipe. Adding 13 pounds, 9 pounds and 40 pounds (pressure for sprinklers) a total of 62 pounds is obtained. Converting pounds pressure to feet head

4. If larger pipe is installed to further reduce friction losses below these amounts, the additional annual charges for the larger size pipe (depreciation and interest) will be greater than the saving realized in power costs when pumping at the lower total head.

(62 x 2.3), we find that the friction head and pressure head amount to 142.6 feet.⁵ Assuming that the static head (elevation of field above water supply) is 20 feet, then the total head under which the pumping unit must operate is 163 feet.

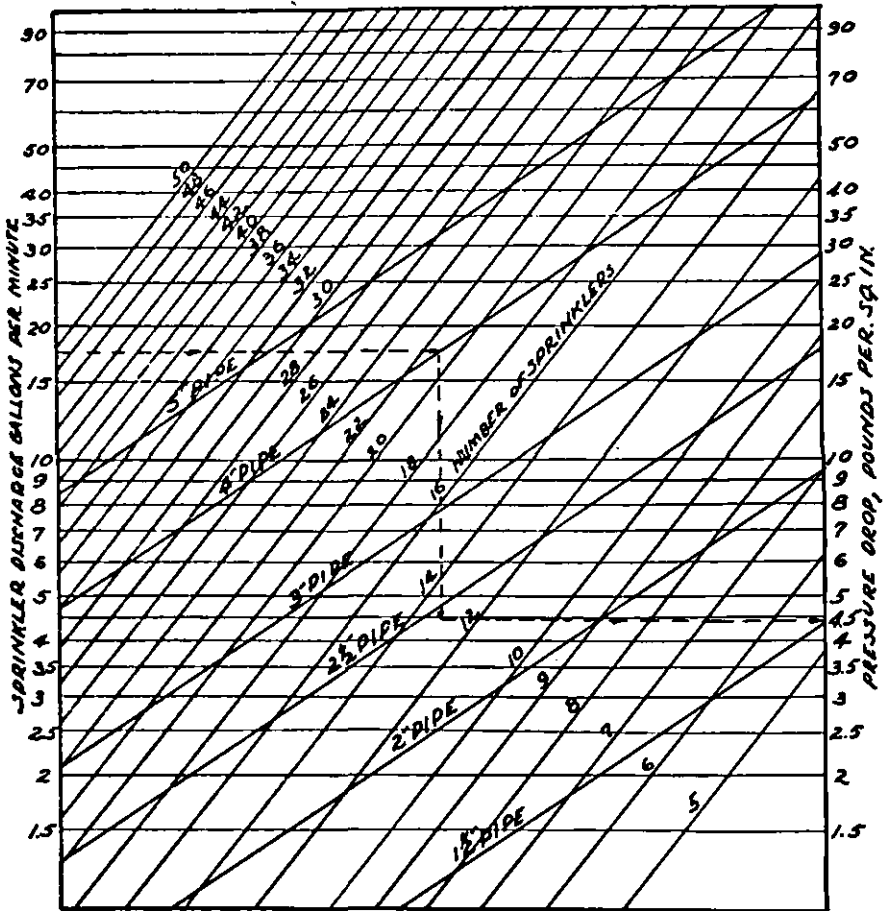
TABLE 6. PRESSURE DROP IN MAINS*



* Based on Saph and Schoder Formula. (Courtesy Commercial Metals Treating, Inc.)

5. One pound pressure is equivalent to 2.3 feet head (or column) of water.

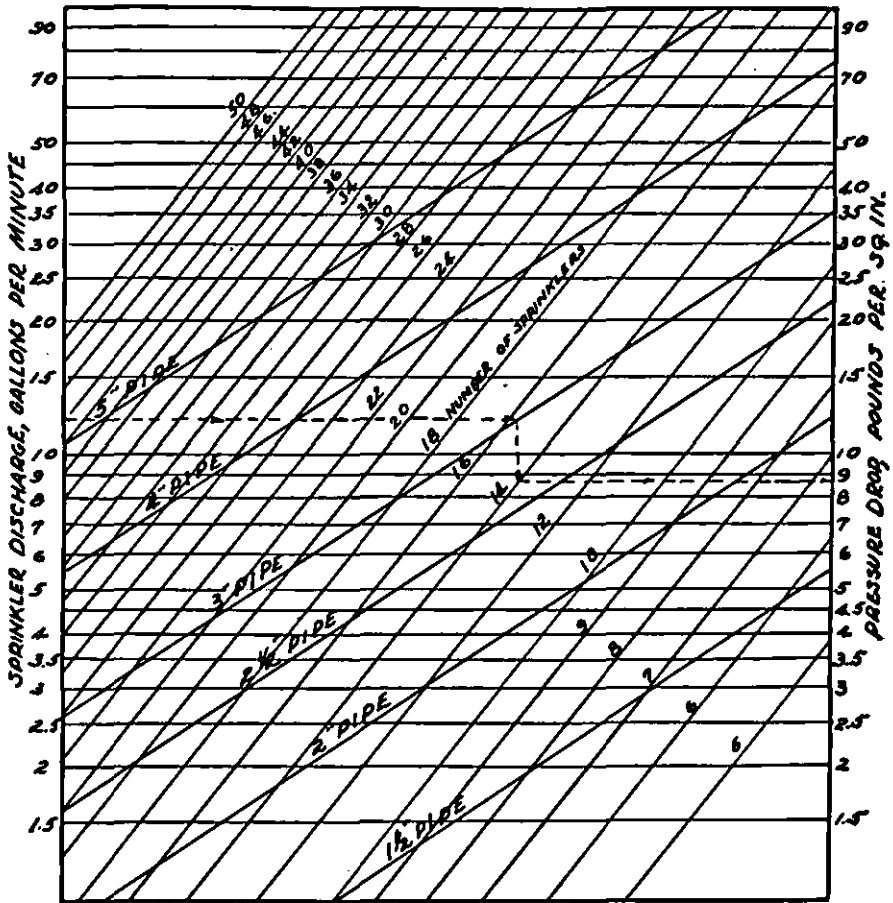
TABLE 7. PRESSURE DROP IN LATERALS*



* Sprinklers spaced approximately 60 feet apart.

(Courtesy Commercial Metals Treating, Inc.)

TABLE 8. PRESSURE DROP IN LATERALS*



* Sprinklers spaced approximately 40 feet apart.
 (Courtesy Commercial Metals Treating, Inc.)

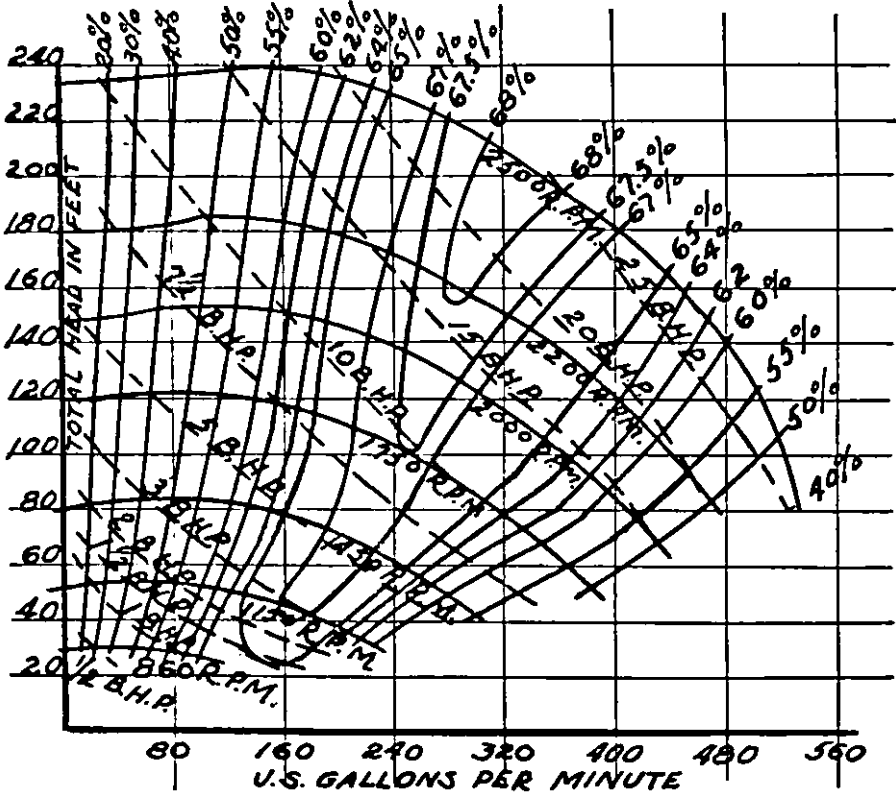
TABLE 9. DISCHARGE AND DIAMETER OF COVERAGE FOR NO. 40 RAIN BIRD SPRINKLER

| Pressure | Nozzles 5" x 32 | | Nozzles 11" x 32 | | Nozzles 3" x 32 | | Nozzles 3" x 1" | | Nozzles 13" x 32 | | Nozzles 7" x 32 | | Nozzles 1" x 32 | | Nozzles 9" x 32 | |
|----------|--------------------|-----------|---------------------|-----------|--------------------|-----------|--------------------|-----------|---------------------|-----------|--------------------|-----------|--------------------|-----------|--------------------|-----------|
| | Diameter | Discharge | Diameter | Discharge | Diameter | Discharge | Diameter | Discharge | Diameter | Discharge | Diameter | Discharge | Diameter | Discharge | Diameter | Discharge |
| 25 | 82 | 4.74 | 83 | 5.45 | 85 | 6.31 | 85 | 7.12 | 86 | 9.23 | 88 | 11.7 | 91 | 14.8 | 95 | 16.8 |
| 30 | 85 | 5.19 | 88 | 6.00 | 91 | 6.98 | 91 | 7.85 | 94 | 10.1 | 96 | 12.8 | 100 | 16.2 | 104 | 18.4 |
| 35 | 87 | 5.63 | 90 | 6.50 | 94 | 7.57 | 94 | 8.52 | 98 | 11.2 | 101 | 13.8 | 106 | 17.6 | 110 | 20.0 |
| 40 | 88 | 6.06 | 92 | 6.98 | 96 | 8.10 | 96 | 9.16 | 101 | 11.8 | 105 | 14.9 | 110 | 18.9 | 115 | 21.4 |
| 45 | 89 | 6.45 | 93 | 7.45 | 98 | 8.62 | 98 | 9.80 | 103 | 12.6 | 108 | 15.9 | 114 | 20.1 | 119 | 22.8 |
| 50 | 90 | 6.83 | 95 | 7.87 | 100 | 9.10 | 100 | 10.4 | 105 | 13.3 | 110 | 16.8 | 118 | 21.2 | 123 | 24.1 |
| 55 | 91 | 7.18 | 96 | 8.30 | 101 | 9.56 | 101 | 10.9 | 107 | 14.1 | 112 | 17.7 | 121 | 22.4 | 126 | 25.2 |
| 60 | 92 | 7.52 | 97 | 8.67 | 102 | 10.0 | 102 | 11.5 | 108 | 14.7 | 113 | 18.5 | 123 | 23.4 | 127 | 26.1 |

—Courtesy Rain Bird Sprinkler Mfg. Co.

Table 10 shows that a two-inch centrifugal pump,⁶ to deliver 200 g.p.m. at a total head of 163 feet, will require 13 horsepower on the

TABLE 10. RATING CHART FOR 2" TYPE BA CENTRIFUGAL PUMP



These curves are for a maximum permissible suction lift of 15 feet.
(Courtesy Gardner-Denver Co.)

6. Centrifugal pumps are rated according to size of the discharge opening. Usually the suction side is one size larger.

pump to operate it efficiently. Occasionally, a landowner prefers to install lateral lines of two or more sizes; that is, to reduce the diameter of pipe as the flow diminishes due to sprinklers taking out portions of the water along the line. Reducing to smaller pipe lowers the installation cost to some degree. However, when only one lateral line is installed and is operated alternately on both sides of the main line, it is necessary to transport the smaller pipe at the end of the lateral line to the extreme end of the field for the next setting, thus increasing the labor requirements appreciably.

Table 11 is convenient when figuring two or more sizes of pipe in a lateral line. Assuming a flow of 100 g.p.m. and ten 10-g.p.m. sprinklers are to operate on a 400-foot lateral line. Remembering that friction loss should usually not exceed 2 pounds per 100 feet of pipe, Table 11 shows that two-inch pipe will take care of about 50 g.p.m. with friction loss amounting to 1.2 pounds in the first 40 feet, 0.8 pound in the next 40 feet and 0.3 pound in the next 20 feet (making total of 100 feet of pipe). Thus the last 200 feet of the lateral line would be two-inch and the first 200 feet would be three-inch. The saving in investment by installing the three- and

TABLE 11. FRICTION LOSS IN PORTABLE IRRIGATION PIPE

| Flow in Line— GPM | Friction Loss in 40 Feet of Pipe Pounds per square inch | | |
|----------------------|---|--------|--------|
| | 2-inch | 3-inch | 4-inch |
| 20 | 0.4 | --- | --- |
| 30 | 0.6 | --- | --- |
| 40 | 0.8 | 0.1 | --- |
| 50 | 1.2 | 0.15 | --- |
| 60 | 1.6 | 0.2 | --- |
| 70 | 2.2 | 0.3 | --- |
| 80 | 2.8 | 0.4 | --- |
| 100 | 5.2 | 0.6 | 0.12 |
| 125 | --- | 0.9 | 0.20 |
| 150 | --- | 1.2 | 0.28 |
| 175 | --- | 1.6 | 0.36 |
| 200 | --- | 2.0 | 0.44 |
| 225 | --- | 2.6 | 0.6 |
| 250 | --- | 3.2 | 0.7 |
| 275 | --- | 3.9 | 0.9 |
| 300 | --- | 4.6 | 1.0 |
| 325 | --- | --- | 1.2 |
| 350 | --- | --- | 1.4 |
| 375 | --- | --- | 1.6 |
| 400 | --- | --- | 1.6 |
| 425 | --- | --- | 2.0 |
| 450 | --- | --- | 2.4 |
| 475 | --- | --- | 2.6 |
| 500 | --- | --- | 2.8 |

TABLE 12. PERFORMANCE CHART FOR 3-INCH PERF-O-RAIN PIPE — *TYPE C

| Inlet Pressure—Lbs. | LENGTH OF LINE IN FEET | | | | | | | | |
|------------------------|------------------------|----|-----|-----|-----|-----|-----|-----|-----|
| | | 50 | 100 | 150 | 200 | 250 | 300 | 350 | 400 |
| 6 | GPM | 16 | 32 | 48 | 63 | 78 | 93 | 107 | 120 |
| | SPREAD | 30 | 30 | 30 | 29 | 28 | 28 | 26 | 25 |
| 7 | GPM | 17 | 34 | 51 | 68 | 84 | 100 | 115 | 129 |
| | SPREAD | 33 | 32 | 32 | 32 | 31 | 30 | 29 | 27 |
| 8 | GPM | 18 | 36 | 54 | 72 | 89 | 106 | 122 | 137 |
| | SPREAD | 35 | 35 | 34 | 34 | 33 | 32 | 31 | 29 |
| 9 | GPM | 19 | 38 | 57 | 76 | 94 | 112 | 129 | 145 |
| | SPREAD | 37 | 37 | 37 | 36 | 36 | 34 | 33 | 31 |
| 10 | GPM | 20 | 40 | 60 | 80 | 99 | 118 | 136 | 153 |
| | SPREAD | 39 | 39 | 38 | 38 | 37 | 36 | 35 | 33 |
| 11 | GPM | 21 | 42 | 63 | 84 | 104 | 124 | 143 | 161 |
| | SPREAD | 40 | 40 | 40 | 39 | 39 | 38 | 37 | 35 |
| 12 | GPM | 22 | 44 | 66 | 88 | 109 | 130 | 150 | 169 |
| | SPREAD | 41 | 41 | 41 | 41 | 40 | 39 | 38 | 36 |
| 13 | GPM | 23 | 46 | 69 | 92 | 114 | 136 | 157 | 177 |
| | SPREAD | 43 | 43 | 42 | 42 | 41 | 40 | 39 | 38 |
| 14 | GPM | 24 | 48 | 72 | 95 | 118 | 140 | 161 | 181 |
| | SPREAD | 44 | 44 | 44 | 43 | 43 | 42 | 40 | 39 |
| 15 | GPM | 25 | 50 | 75 | 99 | 123 | 146 | 168 | 189 |
| | SPREAD | 45 | 45 | 45 | 44 | 44 | 43 | 41 | 40 |
| 16 | GPM | 26 | 51 | 76 | 101 | 126 | 150 | 173 | 195 |
| | SPREAD | 46 | 46 | 46 | 46 | 45 | 44 | 42 | 41 |
| 17 | GPM | 26 | 52 | 78 | 104 | 125 | 154 | 178 | 200 |
| | SPREAD | 48 | 47 | 47 | 47 | 46 | 45 | 43 | 42 |
| 18 | GPM | 27 | 54 | 81 | 107 | 133 | 158 | 182 | 205 |
| | SPREAD | 49 | 48 | 48 | 48 | 47 | 46 | 45 | 43 |
| 19 | GPM | 28 | 56 | 84 | 111 | 138 | 164 | 189 | 213 |
| | SPREAD | 49 | 49 | 49 | 49 | 48 | 47 | 46 | 44 |
| 20 | GPM | 29 | 58 | 86 | 114 | 141 | 168 | 194 | 218 |
| | SPREAD | 50 | 50 | 50 | 49 | 49 | 48 | 46 | 45 |

* Applies water at rate of 1 inch per hour.

—Courtesy W. R. Ames Co.

two-inch pipe compared with three-inch only would be approximately \$50. To some landowners this saving would not be sufficiently important to offset the extra labor in moving pipe as would occur in the case explained previously.

If the low-pressure perforated pipe sprinkler system is to be installed instead of revolving sprinklers the total head and, consequently, power requirements would be lower. The inlet pressure on 400 feet of three-inch perforated pipe to deliver 200 g.p.m. would be 17 pounds, Table 12, and the total spread of water would be 42 feet (21 feet on each side of the pipe). This type of system in operation is illustrated in Figure 4. The total head for this system would be 89 feet (20 feet static head; 29.9 feet friction in main line; 39.1 feet inlet pressure on sprinkler line). Referring to Table 10 the power required on the pump to do this job is six horsepower. This sprinkler pipe would need to be moved more frequently than the revolving sprinkler pipe because water is not sprayed as far at each setting. Obviously, the power requirements are lower, however, thus reducing fuel or electric power costs for the perforated pipe system.

IRRIGATION COSTS

The following is a typical quotation prepared and submitted to a prospective irrigator by an equipment company. The farmer will furnish his own tractor for power and the system is large enough to handle 20 acres of land. The per acre cost for the installation amounts to \$94.

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| | |
|--|-------------------|
| 200 lin. ft. 4" portable aluminum supply pipe (from pump to field) | \$ 206.40 |
| 880 lin. ft. 4" portable aluminum main pipe with take-off valve every 60' | 980.26 |
| 420 lin. ft. 3" portable aluminum lateral pipe with outlets for sprinklers every 40' | 347.75 |
| 120 lin. ft. 2" portable aluminum lateral pipe with outlets for sprinklers every 40' | 63.35 |
| 1—3" x 2" lateral reducer | 6.60 |
| 1—2" end plug for lateral | 1.05 |
| 1—4" x 3" take-off ell for lateral lines | 13.20 |
| 14—revolving sprinklers approx. capacity each, 14 g.p.m. | 84.00 |
| 14—1" x 3/8" riser pipes (for sprinklers) | 9.00 |
| 14—1" x 3/8" reducing couplings (to make connection to sprinklers) | 2.80 |
| 1—4" threaded adapter (from pump to aluminum pipe) | 8.00 |
| 1—3" x 2" centrifugal pump to deliver 200 g.p.m. at 185' when operating at 2,000 r.p.m., with pulley for flat belt drive and with 4" x 90° discharge ell | 105.00 |
| 1—3" x 15' suction hose | 37.50 |
| 1—3" foot valve | 5.00 |
| 14—Riser stakes and ferules for long riser pipes | 10.60 |
| TOTAL PRICE | \$1,880.50 |

1/3 cash with order balance on delivery unless credit is established.

If a power unit were to be purchased with the irrigation system the per acre cost would be about \$110.

Annual costs will vary with each individual system, depending upon type of equipment installed, electric power or fuel costs, fertilizer requirements and cost of labor, but on the average will amount to \$25 to \$35 per acre.

The following is an example of annual costs for a sprinkler system operating on ten acres of truck crops with a double-cropping program carried out each season. Basing the annual charges then, on 20 acres of land, the following cost breakdown is revealed: Cost of power electricity at 2c per kilowatt hour), \$7.40 per acre (for 18 inches of water—2 crops); Depreciation (10% on pump, 8% on pipe, sprinklers and electric motor), \$5.95 per acre; Labor (moving pipe) at 50c per hour, \$4.94 per acre; Interest on investment (\$1,450 @ 6%), \$4.35 per acre; Additional fertilizer (500 pounds est.), \$7.50 per acre; Total annual costs, \$30.15 per acre.

IRRIGATION FROM DEEP WELLS

In the case of deep wells, the distance to the water level while the pump is in operation and the friction loss in the pipe column must be added to the elevation of the high pump above ground level at the well, friction in main and portable lines and pressure head, to arrive at the total head under which the deep well pump must operate. Table 13 shows the number of impeller bowl assemblies or stages that are needed, together with horsepower requirements, to deliver different amounts of water at various total heads using a six-inch large size turbine.

For example, if 150 g.p.m. flow is required at a total head of 300 feet, the pump will require five stages and 16 horsepower to do the job. The deep well would need to be drilled large enough to accommodate the six-inch turbine. Ordinarily, this would require the installation of well casing with an inside diameter of 6 inches. The diameter of well casings for various sizes of turbines can be obtained from the manufacturers of deep well irrigation pumps. Upon the completion of a deep well by the driller, the landowner should arrange to have the well tested for capacity and draw-down by the drilling contractor if other arrangements for testing the wells are not made. This test is important as it enables the engineer or equipment firm to select the type and size of pump best suited for that job.

Also, after the deep well is completed, the driller should be required to furnish a complete log of the well showing depth of water, materials encountered while drilling and their location, points where the size of casing was changed and information concerning the perforations. This data is useful when it might become necessary to lower the pump in the well or to increase the capacity of the well. Usually, the reliable well-drilling contractor will, of his own accord, keep a complete log of each well he drills. Figure 19 shows a deep well turbine pump in Richmond County which furnishes water for a sprinkler irrigation system on a truck farm and uses tractor for power.

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TABLE 13. RATING CHART FOR 6-INCH DEEP WELL PUMP
(Courtesy Aurora Pump Company.)

