Economic Phases of Grove Irrigation

E. F. DeBusk,
Extension Specialist in Citrus Culture, University of Florida

The surface or flooding method is found to be the most practicable and most economical for citrus grove irrigation in Florida. Briefly stated, an installation for this method of irrigation consists of a main or permanent pipe line leading from the water supply to the highest part of the grove, equipped with outlets at convenient intervals, from which irrigation water flows by gravity or under low pressure through movable surface pipe lines or hose to all parts of the grove. Water is pumped into the main line by a centrifugal pump driven by a gasoline engine, electric motor or farm tractor. In the coastal sections, where a strong flow from wells can be obtained, irrigation water is usually carried through either ditches or main pipe lines alongside the grove, from which it is conveyed to the trees by means of smaller ditches and dams. The principal factors determining the economy and efficiency of the surface method of grove irrigation are (1) the capacity of water, (2) the size of the main pipe line, (3) the size of the surface pipe in relation to the capacity of the pump, (4) the number of surface pipe lines operated at the same time, (5) the method of distributing water from the surface pipe lines, (6) soil conditions and uniformity of distribution and penetration. An effort will be made to cover briefly the above mentioned factors in this paper.

CAPACITY AND SIZE OF THE MAINS

The capacity of an irrigation plant designed for a large acreage should be large enough to cover the grove or unit with two acre inches of water in ten days. For example, a plant for a 160 acre unit should have a capacity of 1400 G. P. M.; plant for a 100 acre unit 900 G. P. M. Very few conditions exist where less than 700 G. P. M. is most economical. In designing an installation for a smaller acreage, the grower should be guided largely by the unit cost of pumping and applying water, as the cost of installations for operation under different working heads up to 75 feet will vary only slightly with different capacities. It is the operating cost that counts. For example, the cost of installing 1000 feet of 6-inch iron pipe main, equipped with pump and engine to delivering 900 G. P. M. against a static head of 50 feet, is about equal to the cost of an installation with 1000 feet of 10-inch main equipped for delivering the same quantity of water against the same static head; whereas the cost of pumping water through the 6-inch main is about...
$1.65 per acre inch, against approximately 65 cents per acre inch for the installation using the 10-inch main. In the 6-inch main about $1.10, or 65% is consumed in overcoming the friction of the small pipe; in the 8-inch main only 10 cents or about 16% can be charged to friction loss. The cost of pumping 900 G. P. M. through a 12-inch main under the same conditions should not exceed 60 cents per acre inch. Thus it can readily be seen that strict attention should be given to the use of larger mains. Very few conditions exist where mains smaller than 8 inches can be used to the greatest advantage; especially is this true since concrete pipe is coming into general use for mains and is proving satisfactory. The capacity and size of the main should be matched so that the loss of head due to friction does not exceed one-half foot per 100 feet of main.

SURFACE PIPE FOR GROVE IRRIGATION

The following table shows the size of surface pipe (diameter in inches) recommended for different capacities and for different grades—fall per 100 feet of pipe lines:

<table>
<thead>
<tr>
<th>Gallons per minute</th>
<th>FALL PER 100 FEET</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 in. to 1 ft.</td>
</tr>
<tr>
<td>300</td>
<td>7 to 6</td>
</tr>
<tr>
<td>450</td>
<td>8 to 7</td>
</tr>
<tr>
<td>700</td>
<td>9 to 8</td>
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<tr>
<td>900</td>
<td>10 to 9</td>
</tr>
</tbody>
</table>

The above table is based on the natural flow of water with different slopes of the pipe line. For example, should one desire to lay a surface pipe line 500 feet long, the outlet end of which is to be 5 feet below the intake and where the intake end is to be kept just covered with water, a 7-inch pipe will be needed to deliver 450 gallons per minute. Under the same conditions, an 8-inch pipe would be required to deliver 750 gallons per minute.

However, where water is discharged from the main pipe line into the surface pipe line under pressure, which is usually the case, for each pound of pressure at the intake end, 2 feet 4 inches should be added to the total fall of the entire length of the line in determining the size of surface pipe needed for a given capacity. The fall per 100 feet is found by dividing .01 of the length of the line by the total fall—natural fall plus the fall allowed for pressure at intake end. If tight joints are made in the surface pipe line it makes but little difference whether the total fall comes in a few feet of the line or is uniformly distributed throughout the entire length.

The maximum length of a surface pipe line depends upon the contour of the ground, the amount of water to be delivered and the economy of the investment.

It is more economical to handle the entire head of water at least up to 800 or 900 G. P. M., through a single surface pipe line.

The weight or gauge of material that should be demanded by growers in purchasing surface irrigation pipe for the average Florida grove conditions is as follows:
4 to 5 inch pipe — 24 or 26 gauge
6-inch pipe — 24 gauge
7-inch pipe — 22 or 24 gauge
8-inch pipe — 22 gauge
9 to 12 inch pipe — 20 gauge

Lengths of surface pipe are 10 feet, 4 inches. All elbows, tees, crosses and Y’s should be of heavier gauge steel than is used in the pipe, and reinforced. It does not pay to buy the light weight pipe. It will not stand the strain. Surface pipe gets hard usage in grove irrigation. However, heavy weight pipe that has been in use for 12 years of five irrigations each is still in good condition. A lockseam pipe soldered the full length of the seam is preferred. Both ends of all surface pipe should be reinforced. A very satisfactory way to strengthen the tapered end of the pipe is by means of a sleeve made of heavy material with a special taper, and riveted on. This sleeve makes it practicable to make a very tight-fitting joint without buckling the pipe. The other end of the pipe should be reinforced by means of a band or collar of steel riveted on in a true circle and left smooth inside. The band should be pliable enough to permit the end of the pipe to conform to the end of the other pipe inserted so as to make a tight-fitting joint.

METHODS OF DISTRIBUTION

For most economical distribution of water, only one surface pipe line is needed in installations with capacities up to 800 or 900 G. P. M. The method eliminates erosion, even on the steepest slopes, and makes practicable uniform distribution. In operation, water is delivered from the permanent pipe line into the surface line which is laid down the grade midway between the tree rows at intervals of two or three rows.

In laying the surface line, one of the distributing crosses is placed in the line at intervals of two or three tree rows. The distributing cross is equipped with butterfly valves by which the flow of water is regulated and cut off as desired. Suitable lengths and sizes of hose are connected to outlets of these crosses, by means of slip-joint nipples, to the opposite end of which are attached the distributing nozzles placed in position so as to distribute the water as desired. Water is then turned into the surface line from the permanent line and by adjusting the butterfly valves in the distributing cross, the flow of water to the nozzles is distributed as desired. After the water has been allowed to run a sufficient length of time with the nozzles in the first place, to give the required amount of water to the area thus covered, the nozzles are then moved, one at a time in rotation, to new positions and a new area is irrigated. The operation is repeated, the surface line is moved over and relayed as the area covered by the last one is irrigated, and so on until the entire grove has been irrigated.

Three types of distributing nozzles are used: The square type, 3 to 5 feet square, and made of 3 or 4 inch conductor pipe; the tubular type, made of a straight piece of conductor pipe 10 feet or longer, and
the drum-type, 10 to 15 inches in diameter. All types of nozzles are made with 9 to 25 perforations, for the discharge of water, $\frac{3}{4}$ to 1½ inch in diameter, the number and size depending upon the size of nozzles, head of water and grove conditions under which they are to be used. The square type of nozzle is adapted to irrigation where the land is level or where the tree rows are not ridged; the drum type and tubular type are especially adapted to irrigation where the trees are planted on mounds or ridges; the tubular type is preferred for steep hillside irrigation.

Where the grade of the land to be irrigated is two to five feet to the hundred and where a large head of water is to be delivered through one surface line laid down the grade, water may be distributed by means of lateral lines of conductor pipe leading off two or three rows from the distributing crosses in the surface line, in lieu of the nozzles and hose connections. Such conductor pipe should be provided with outlets of about one inch in diameter, each equipped with a gate to regulate the flow of water, and at intervals of about one foot in the conductor line.

**PROBLEM OF PENETRATION**

The method of distributing irrigation water as above described has been developed through an effort to obtain a more uniform penetration of irrigation water by our light, citrus soils and thereby increase their field capacity, to obviate erosion, and to reduce the labor cost of applying water; all of which have been attained.

In grove irrigation in Florida we are constantly confronted with the problem of the low water-holding capacity of our soils under field conditions. We find our soils containing from 24 to 28 per cent water when saturated and running below 4 per cent moisture in the top foot soon after an application of 3 inches of irrigation water, applied in the usual manner. A saturated soil that contains 27% moisture holds approximately 5 inches of water per foot depth. Theoretically, the same soil should contain approximately 16% moisture in the top foot as soon as it had absorbed an application of 3 inches of water, if it were uniformly distributed, and uniformly penetrated the soil. As a matter of fact, the field capacity of a soil for moisture is never equal to its saturation capacity, mainly because of lack of uniformity in distribution and penetration, but we must store more water in the soil by irrigation than is being stored under prevailing methods of applying water and under average soil conditions.

From a number of determinations, made, we find 64% to 96% of the entire root system of Florida citrus trees within the top foot depth of soil. This varies with soil conditions, age of trees and other factors. The best available information indicates that Florida bearing citrus groves need approximately three acre-inches of water per month or about one-tenth of an inch daily. About one-fourth of this is absorbed directly by the trees and the remaining three-fourths is lost mainly through direct evaporation from the soil. Since the water extracted from the soil by a plant is in direct pro-
portion to the root concentration in the soil, it can readily be seen that the demand for moisture made by the citrus tree upon the top foot of soil is very great, and that the efficiency and economy of grove irrigation depends in a large measure upon the uniformity of penetration and amount of water stored in the zone of highest root concentration.

In practice, we find that the amount of water stored in a grove soil—field capacity—is influenced by, (1) the rate of application, (2) running-dry areas, (3) dust mulch, (4) growing cover crop, (5) vegetable mulch, (6) tilth, and (7) contour of the land.

Instead of flooding an area with the full head of water from a single outlet of the surface line at the rate of 200 to 400 G. P. M., as is often the practice, more uniform penetration and a much higher absorption of water by the top foot is being obtained by dividing the head of water up into three or more outlets from the surface line, depending upon the volume, and applying it through a large number of small openings as provided for in the above described distributing nozzles. By this method water is allowed to run in less volume, and consequently over a longer period to give the required amount. This gives time for it to soak in, and the numerous small outlets make practicable a more uniform distribution, at the same time reducing the labor cost of applying water 50 to 75 per cent and eliminating the problem of erosion.

Water flowing at the rate of 300 G. P. M. from a 5-inch surface pipe has a velocity of 294 feet per minute as it leaves the pipe, and will result in much erosion in our sandy soils, as 70 feet per minute is the maximum safe velocity. Besides, when water is rapidly flowing over the surface of our sandy soils very little is soaking in. It flows to low areas and is absorbed most rapidly by areas containing the highest percentage of moisture because of low root concentration, where irrigation is not so much needed. It is only by applying water very slowly that the dryest areas, the areas of highest root concentration, can be wetted. Thus it can readily be seen why we get such a low field capacity by the usual flooding method. The soil is wetted only in spots while the roots in the dry areas suffer.

Since it is so extremely difficult to wet a soil that has been allowed to thoroughly dry out, a special effort should be made to distribute the irrigation water so as to prevent the exhaustion of moisture in areas of high root concentration, where the greatest demand for moisture is made.

Growing cover crops aid materially in the distribution of irrigation water and make practicable more efficient irrigation than can be obtained on the cultivated soils, especially on the dust mulch. A mulch of vegetation is very helpful in distributing irrigation water, besides it greatly reduces the loss of water resulting through direct evaporation from an unprotected soil.

**CONCLUSION**

It seems that the solution of the problem of producing fruit of better quality
and at a lower cost is based upon the problem of supplying more and cheaper organic matter to our groves, and of substituting, in a large measure at least, irrigation for cultivation. Undoubtedly such diseases as dieback, ammoniation, frenching, blight and splitting of fruit, are closely associated with a deficiency of organic matter in the soil and an inadequate and irregular water supply. Much of the dead wood in our bearing trees is the result of drought injury.

With irrigation water at less than 75 cents the acre inch applied; with such cover crops as Crotalaria producing up to eleven tons of dry material per acre in our young groves; with our idle lands, truck farms at off seasons, and even the Everglades, to draw upon for growing cheap organic material to supplement the cover crops in our bearing groves; we should be able to make even our light soils respond in successful competition with our keen brothers of the West.

Member: I would like to ask a question. Do I understand your total cost per acre inch to be 75c?

Mr. DeBusk: In some cases, less than that.

Member: Does that include the cost of moving your pipe?

Mr. DeBusk: Yes. With a large capacity of labor the cost is greatly reduced.

Member: Where is there a plant in existence?

Mr. DeBusk: There are several in the process of installation. Eustis is about as near as I can think of at this time. At Maitland there is one.

Member: What is the source of water supply?

Mr. DeBusk: You can afford to go several hundred feet to a lake. A well is pretty expensive. There is no reason why you can’t use a flowing well as advantageously as a lake.

Member: Is deep well water as beneficial to the grove as pond water?

Mr. DeBusk: As far as we know.

Member: In a deep well, where the height is around 60 feet, or more, it requires a turbine, doesn’t it?

Mr. DeBusk: You can’t depend on lifting the water more than 16 or 18 feet with a centrifugal pump.

Member: This system of distribution you speak of, is that uniform distribution from the middle and under the tree, so that your ground is evenly wet, or do you have dry spots?

Mr. DeBusk: It depends upon the operator, who is operating the system. It’s like any other system, and depends on the labor and sufficiency. In the plan of distributing the water through a number of outlets, water will flow through a half-inch hole only about 6 or 7 feet in cultivated soil before it soaks in; with a three-quarter inch hole it goes a little further; with an inch hole, on the level, with water going at a greater pressure, under average conditions, will flow 15 or 17 feet before it all soaks in. You can leave it flowing all day and that’s as far as it goes, and no washing.

Member: How much water do you think best to apply?

Mr. DeBusk: At least an acre inch, and in some cases two or three; it de-
pends upon the soil, and the condition of
the moisture, in lower depth of the soil.

Member: On a ridge, 52 feet above sea
level, what depth would you drill for a
30-acre grove?

Mr. DeBusk: I couldn't say, even
with a well I couldn't tell you. The only
guide I know of would be to go to a num-
ber of other wells near your property,
and see how they range. The larger the
well, the larger the capacity, and the
lower your operating cost. It makes a
difference in your labor, fuel and pump-
ing.

Member: What would you estimate
the cost of irrigating a 50 acre grove?

Mr. DeBusk: It is from $40 to $110
an acre, and in some cases more.