Irrigating Small Acreages
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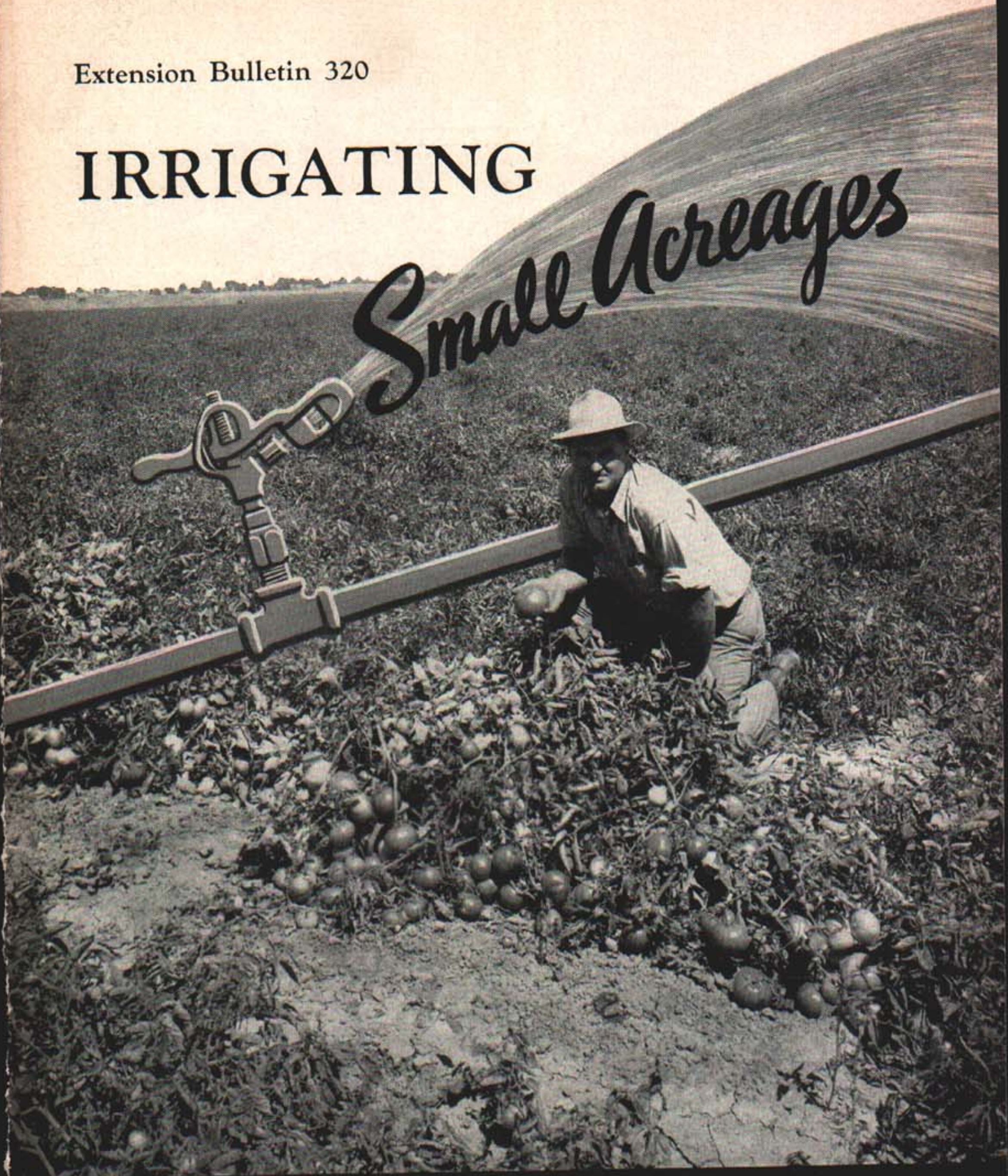
# IRRIGATING Small Acreages



*By John R. Davis*

MICHIGAN STATE COLLEGE
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EAST LANSING

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# Irrigating Small Acreages

*By JOHN R. DAVIS*[1]

Gardeners have long been aware of the detrimental effects of prolonged dry periods on vegetables, small fruits, and flowers. Stunted growth, premature ripening, and even a complete crop failure have been experienced. An irrigation system designed for small acreages makes it possible to prevent such losses by maintaining an adequate supply of soil moisture throughout the entire growing season. Large-scale systems have already proved their worth in Michigan[2]; a smaller system can do the same. An investment in irrigation equipment is an investment in crop insurance.

A good job of irrigating will require careful planning by the gardener. A little thought and a little extra effort will produce more fresh fruit and vegetables for your table, road-side stand, for canning or the freezer. This bulletin offers suggestions to (1) the home gardeners, and (2) those who wish to supplement their income through part-time truck crop production.

Water supply—how much is needed and where it can be obtained—is discussed. Information on crops and soils is presented to aid you to do a proper job of irrigating. Other subjects considered are—how to select and install garden irrigation equipment for best results, costs and profits, fertilizers, frost control by irrigation, proper soil management, and some of the many benefits irrigation can offer. You and your family can take advantage of available water to produce food for the table—good-quality food.

## BENEFITS FROM IRRIGATION

The following benefits can reasonably be expected from the supplemental irrigation of small acreages, from the time seed is planted in the soil until the crop is harvested:

1. Irrigation can eliminate a delayed germination of seed due to a lack of soil moisture, when all other conditions for crop growth are just right.

[1]Instructor in Agricultural Engineering. (The author wishes to express his appreciation to these staff members—R. L. Carolus, Horticulture; A. E. Erickson and R. L. Cook, Soil Science; W. H. Sheldon and E. H. Kidder, Agricultural Engineering—and to O. E. Maguire, Michigan Department of Health, for their comments and assistance in the preparation of this bulletin.)

[2]See Extension Bulletin 309, "Supplemental Irrigation in Michigan."

2. Light irrigations of seedings of beans, peas, carrots, and other sensitive crops can soften a soil crust so that the plants can emerge.

3. Application of water can be beneficial during transplanting, and just after the tender shoots appear above the ground.

4. A light irrigation of sandy and muck soils to prevent wind erosion may mean the difference—with small, seeded crops such as lettuce, onions, beets and carrots—between a good stand and a poor stand. Moist soil is not susceptible to wind erosion.

5. Fertilizers placed in dry soil can be wetted and made readily available to the plant roots. Water-soluble fertilizers may be applied by pumping them through the irrigation pipe and out through sprinklers, in solution with the irrigation water. Eliminating the moisture-hazard makes more efficient use of fertilizers (and may make profitable a heavier use), thus increasing the crop yields.

6. Under conditions of proper soil management, supplemental irrigation assures greater crop yields and improved quality by providing needed water at the proper time and in proper amounts.

7. Supplemental irrigation enables the grower to take advantage of higher prices that may prevail during years of deficient rainfall.

8. Sprinkler systems can be used as a protection against untimely killing frosts.

## I. WATER SUPPLY

### Source

The majority of garden irrigators utilize home wells or municipal systems as a source of water. Some gardeners will have available a reliable supply from streams, ponds, or lakes. (Figs. 1 and 2.) The cost of pumping may be lower if the water is obtained from a surface supply. Deep wells are usually more reliable than shallow wells, but are also more expensive. If several sources are available, the most dependable should be chosen; if all are equally dependable, the most convenient source should be selected.

### Quantity

The quantity of water available from the present domestic well will depend on the underground conditions, the condition of the well screen and casing, and the size and condition of the pump and power unit. From surface supplies, the available quantity will depend


**Fig. 1. In certain localities a properly constructed farm pond, such as the one shown here, can provide a good water supply for small-acreage irrigation.**

on the size and depth of the lake or pond—or with a stream, on the flow during the driest time of the driest years.

To determine the quantity of water available from a well or storage tank, open the outlet valve or sillcock nearest the area to be irrigated and pump water continuously for at least 1 hour. At the end of that time, direct the flow into a container of known capacity—a 10-gallon milk can will do nicely—and note the time required to fill the container. For example, if a 10-gallon can were filled in 2 minutes, the flow would be 5 gallons per minute, or 300 gallons per hour.

The flow of water in small streams should be determined with the help of the County Agricultural Agent or M.S.C. Extension Specialist.

In certain localities there may also be legal restrictions as to such use, which should always be checked into first.

## Quality

Generally speaking, any drinkable water is suitable for irrigation. Water from ponds and streams containing soil and organic matter will usually require screening to prevent clogging the sprinkler nozzles. Brine wells are questionable sources, as well as streams containing industrial wastes. Waters containing salts which total less than 700 parts per million concentration are suitable for most plants under most conditions.

The Michigan Department of Health will analyze water free of charge to determine its suitability for drinking, irrigation or other purposes. Contact the local health department, or write direct to the Michigan Department of Health for information. Special containers must be used for the water analysis; do not send in a sample of water in any other container.

**Fig. 2. For an efficient operation, irrigators depending on streams for their water supply must base plans on the flow "during the driest time of the driest years." The mobile unit pictured can pump 30,000 gallons an hour.**

## CROPS IRRIGATED

Some of the crops which have been successfully irrigated in Michigan are listed in Table 1. The depth of rooting of the crop as the growing season progresses will be a major factor in determining how much water should be applied, and how frequently. Enough water should be applied to penetrate down to the bottom of the plant feeder-root zone. If the soil is not moistened to full root-depth, shallow rooting is encouraged. The application of too much water will waste water and leach plant nutrients below the root zone.

## II. HOW MUCH WATER AND WHEN

Texture, organic-matter content, and structure of the soil will determine how much available water a soil can hold. In general, sandy soils will hold approximately 1 inch of available water per foot of depth; a loam, 1½ inches per foot of depth; a clay 2½ inches per foot of depth.

Most sandy soils will absorb water more rapidly than a loam or a clay soil. Some clay soils will absorb only ⅛ to ½ inch of water each hour. *Water should not be applied to the soil more rapidly than the soil will absorb it.* Too rapid application could result in puddling and soil erosion, as well as a loss of water and higher pumping costs.

*TABLE 1—Depth of rooting* of crops in Michigan*

| Very shallow (less than 18 inches) | Shallow (18 to 36 inches) | Moderately deep (more than 36 inches) |
|---|---|---|
| Lettuce | Beans | Blueberries |
| Radish | Carrots | Raspberries |
| Beets | Cucumbers | Grapes |
| Celery | Cabbage | Melons |
| Strawberries | Cauliflower | Sweet Potatoes |
| Potatoes | Flowers | Tomatoes |
| Spinach | Egg Plant | Tree Fruits |
| Onions | Peas | |
| Flowers | Sweet Corn | |
| | Peppers | |

*These depths will be affected by dense soil layers.

### AMOUNT OF WATER PER APPLICATION

Both research and experience have indicated this working rule for the highest yields of most crops: Water should be added whenever the plant has used about one-half of the water available to the plant roots in that particular soil.

However, crops such as lettuce and celery should be irrigated when *one-third* of the available water has been used.

The amount of water applied at each irrigation should be based on the crop, the root-depth, and the soil texture. Table 2 may serve as a general guide in determining how much water to apply.

*TABLE 2—Approximate amounts of water (in inches) to apply at each irrigation**

| Depth of feeder-root-zone (in inches) | INCHES OF WATER | | |
|---|---|---|---|
| | Sandy soil | Loam soil | Clay soil |
| 18 | ½—1 | 1—1½ | 1½—2 |
| 36 | 1—2 | 2—2½ | 3—4 |
| 48 | 1½—2½ | 2½—3½ | 4—5 |

*Based on irrigation at 50% available water in the feeder-root depth.

## WHEN TO IRRIGATE

Shallow-rooted crops, and crops on sandy soils, will require more frequent applications of water—and will show more benefit from irrigation—than deeper rooted crops and crops grown on clay soils.

To determine when to irrigate, the grower should carefully observe the moisture content of the soil during the growing season. It is inadvisable to wait until the crop begins to wilt, for some damage will have already occurred. A sound method used by irrigators is to test the water content of the soil by the "soil feel". Using a soil auger or a spade, the irrigator digs down into the root zone and obtains a handful of soil. (Fig. 3.) This soil is then squeezed in the hand and the need for water determined on the basis of wetness characteristics listed in Table 3. This

**Fig. 3. Taking a soil sample with a soil auger.**

test should be made as often as every 2 or 3 days on sandy soils, even during periods of occasional light rains.

By digging down into the soil at several places in the garden, 1 or 2 days after irrigating, the grower can determine whether he is getting enough water into the soil to reach the bottom of the feeder-root-zone, and to tell whether or not he is over-irrigating. A water

*TABLE 3—Wetness characteristics chart for determining soil moisture*

| Percentage of remaining available water | Feel or appearance of soils | | | |
|---|---|---|---|---|
| | Very coarse textured | Coarse textured | Medium textured | Fine and very fine textured |
| 0% (Dry) | Dry, loose, single-grained, flows through fingers | Dry, loose, flows through fingers | Powder-dry; sometimes slightly crusted, but easily breaks down into powdery condition | Hard, baked, cracked; sometimes has loose crumbs on surface |
| 50% or less (low) | 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* |
| 50% to 100% (Good to Excellent) | 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 |
| Above-field-capacity (Over-irrigated) | 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 in the palm of the hand.

application should be stopped prior to a complete wetting to the bottom of the root zone, because water will seep down in the soil even 1 or 2 days after the irrigation. Irrigation may be required less frequently during periods when the air is cool and the sky is cloudy—and during the early growing season of the particular crop. New seedlings or transplantings may require frequent, light applications of water in dry weather to stimulate maximum growth.

Irrigating with cold well-water during a hot, bright, sunny day might have a damaging effect on some plants. However, cold water may be applied after sundown or on cooler, less-sunny days without injury to any crop.

The full capacity of the pump may be made available for garden irrigation by watering the garden in the evening. During the day the pump may be needed to supply water for domestic uses, whereas it is not so needed at night, and the irrigation equipment can operate more satisfactorily. Another advantage is that less of the water being applied will be lost by evaporation.

## UTILIZING THE PRESENT WATER SYSTEM

The area that can be successfully irrigated in a reasonable period of time with the existing supply may be quite small. However, if the water source has a capacity large enough, a larger pump might be used to increase the area that can be irrigated. Table 4 shows the size of areas that may be irrigated by the water pump.

**Illustrative Example—**

Suppose your present pump fills a 10-gallon milk can with water in 1 minute, 40 seconds. The pump capacity is then 10 gallons divided by 1 4/6 minutes—6 gallons per minute, or 360 gallons per hour. Using Table 4, the size of the area that can be irrigated may now be determined—when hours-of-operation per day and days-of-operation per week have been determined according to the gardener's individual needs. Assuming in this example that you can irrigate 9 hours each day and wish to operate the system only 4 days each irrigation, your present system could irrigate an area of approximately 0.48 acres, equivalent to about the area of a garden 100 by 210 feet. (One acre equals 43,560 square feet.)

Table 4 can also be used to work out a second type of problem. A garden area of 150 by 200 feet having already been established, you wish to know if it is possible to irrigate this area with your present pump (the same pump as above). The area of 150 by 200 feet is .69 acre (150′ times 200′ divided by 43,560). For a pump capacity of 360 gallons per hour, irrigating the .69-acre plot would require 12 hours per day for about 4½ days; or, making use of all the regular working days in a week, 9 hours per day for 6 days. It would be possible, then, to irrigate this area with your present pump. An area larger than 1 acre, however, could not be irrigated in 6 days—unless the number of hours of operation per day exceeded 12 hours.

*TABLE 4—Areas that can be irrigated by applying one inch of water per week*

| Size of pump (In gallons per hour) | Hours of operation per day | AREA IRRIGATED | | | | | |
|---|---|---|---|---|---|---|---|
| | | Days of operation per week | | | | | |
| | | 1 | 2 | 3 | 4 | 5 | 6 |
| | | (area in acres) | | | | | |
| 200 GPH | 3 | 0.02 | 0.04 | 0.07 | 0.09 | 0.11 | 0.13 |
| | 6 | .04 | .09 | .13 | .18 | .22 | .26 |
| | 9 | .07 | .13 | .20 | .26 | .33 | .40 |
| | 12 | .09 | .18 | .26 | .35 | .44 | .53 |
| 400 GPH | 3 | .04 | .09 | .13 | .18 | .22 | .26 |
| | 6 | .09 | .18 | .26 | .35 | .44 | .53 |
| | 9 | .13 | .26 | .40 | .53 | .66 | .79 |
| | 12 | .18 | .35 | .53 | .70 | .88 | 1.06 |
| 600 GPH | 3 | .07 | .13 | .20 | .26 | .33 | .40 |
| | 6 | .13 | .26 | .40 | .53 | .66 | .79 |
| | 9 | .20 | .40 | .59 | .79 | .99 | 1.19 |
| | 12 | .27 | .53 | .80 | 1.06 | 1.33 | 1.59 |
| 800 GPH | 3 | .09 | .18 | .26 | .35 | .44 | .53 |
| | 6 | .18 | .35 | .53 | .70 | .88 | 1.06 |
| | 9 | .27 | .53 | .80 | 1.06 | 1.33 | 1.59 |
| | 12 | .35 | .71 | 1.06 | 1.41 | 1.77 | 2.12 |
| 1000 GPH | 3 | .11 | .22 | .33 | .44 | .55 | .66 |
| | 6 | .22 | .44 | .66 | .88 | 1.10 | 1.33 |
| | 9 | .33 | .66 | .99 | 1.32 | 1.66 | 1.99 |
| | 12 | .44 | .88 | 1.32 | 1.76 | 2.21 | 2.65 |
| 1200 GPH | 3 | .13 | .26 | .40 | .53 | .66 | .79 |
| | 6 | .27 | .53 | .80 | 1.06 | 1.33 | 1.59 |
| | 9 | .40 | .79 | 1.19 | 1.59 | 1.99 | 2.38 |
| | 12 | .53 | 1.06 | 1.59 | 2.12 | 2.65 | 3.18 |

If the pumping capacity is greater than those shown in the table, the number of acres that may be irrigated—or the number of hours-of-operation—can be calculated by expanding the table. For example, if the size of your pump is 1600 gallons per hour, the number of acres that can be irrigated would be twice the number given for a pump with a capacity of 800 gallons per hour. A 1600-gallon-per-hour system operating 4 days per week, 6 hours per day, could apply water to 2 times .70 acres—or to an area of 1.4 acres.

Table 4 does not apply for very shallow-rooted crops—such as strawberries—on sandy soils. These two conditions may warrant irrigation applications of only ½-inch (see Table 2, page 8). Table 4 assumes a one-inch application each week, so figures in that table for hours-a-day or days-of-operation per week are twice that for a ½-inch application. For example, with a pump capacity of 200 gallons per hour only 6 hours a day, 3 days per week are necessary to irrigate 0.26 acre—instead of 12 hours each day for the three days.

Remember, however, that the soil moisture supply under shallow-rooted crops in sandy soils will be depleted quite rapidly. Thus it will probably be necessary to apply the ½-inch of water twice each week. Two ½-inch applications each week will actually take the same total amount of time each week as one 1-inch application on the same area.

Always follow the recommendations listed in Table 2. Light applications of water on normally shallow-rooting crops in sandy soils will be required more often—probably every 3 to 4 days. And the soil moisture-content should be observed more critically than that under deeper rooted crops, or for other soil types.

## III. PLANNING THE SMALL ACREAGE SYSTEM

### PUMPING EQUIPMENT

Several types of pumps are presently in use for domestic water supply systems. Each type of pump has its individual performance characteristics, and one type may do a better job of pumping than another for a particular installation. The pump delivery in "gallons per hour" and the operating pressure are the two main characteristics to be concerned with. For your present pump, the capacity can be determined as previously described, (see page 10) and the pressure can be determined by installing a pressure gauge at the pump. Any reputable dealer can suggest the proper size and type of pump and power unit, the method and location of the installation, and the necessary supplementary equipment for a new or additional pumping system.

Always follow the manufacturer's or dealer's recommendations for the care and operation of the pump and power unit. Irrigation demands continuous operation of the system for several hours and, unless temperature cut-out switches are used, the motor or engine may overheat and possibly burn out. It may be necessary to have your dealer get a motor of the next larger size for your pump before it is used for irrigation. Motors running continuously for hours at a time may burn out because of improper wiring. *Before the pumping system is used for irrigation, consult your dealer or power company representative on both of these factors—the motor and the wiring.*

For greatest efficiency, plan your system so that the pump will run continuously while the garden-area is being watered. Such continuous pump operation eliminates wear on electric motor starting-mechanisms, insures uniform rates of water application on the garden, and will reduce the amount of electricity consumed.

Most of the pumps utilized for small-acreage irrigation, however, are designed for "normal" use on pressure-tank systems, where continuous operation is usually considered less economical. Operating only when needed to restore a certain level of pressure, they cut-off automatically when that pressure is reached. But it is possible to have either type of operation—"on-off" operation normally, continuous pumping when more desirable—without special re-adjustment. This is accomplished by regulating the pressure relationships during irrigation.

Three factors have to be known: (a) the pressure at which the pump cuts-off; (b) actual pressure at the sprinkler head; (c) loss of pressure between the two "in the line" (the pipeline or hose). So long as the "sprinkler pressure" plus the amount of "line pressure-loss" equals less than the "cut-off pressure," continuous pumping is assured.

Most pumps in farm water systems are adjusted to stop when the pressure in the tank reaches 40 pounds per square inch. If this 40 pounds per square inch is more than the pressure at the sprinkler plus the pressure lost in the pipe or hose, then the pump will run continuously. Tables listing sprinkler pressures at several different water flows can be obtained from the manufacturers of most high-quality sprinklers. If such tables are not available, you may have to try out several different sprinklers to find one that will not only keep the pump running continuously but also give the results you want.

The pressure in municipal water systems will fluctuate somewhat during the day. It is worthwhile to plan irrigating during the off-peak periods of the day, in early evening or at night. Some municipalities may restrict watering during a portion of the day.

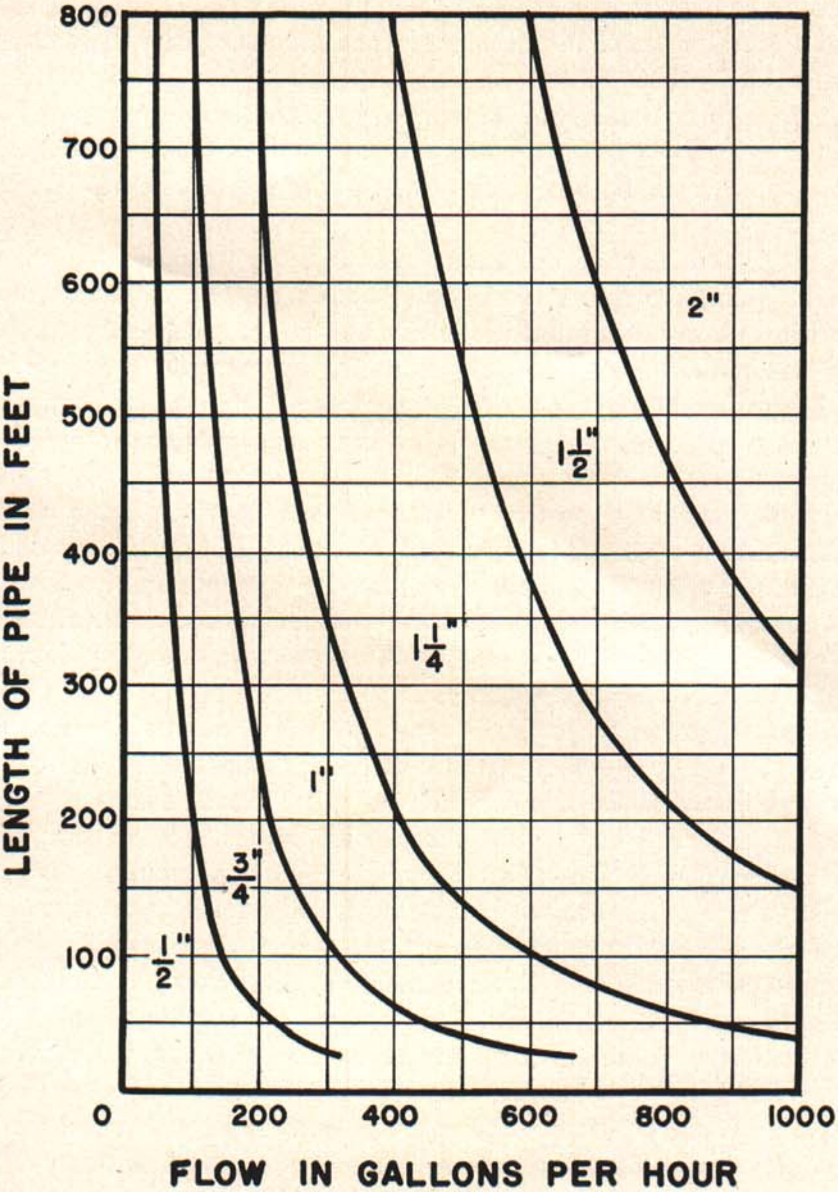


Fig. 4. "Pipe selection chart." Extend the values for a particular water flow and length of pipe from the pump to the sprinklers until they intersect, and read off the pipe-size. The sizes indicated between the heavy lines (½", ¾", 1", etc.) apply to any point on that part of the chart.

## GETTING WATER TO THE GARDEN

Hose and pipe are commonly used in small-acreage systems to convey water from the pump to the irrigated area. Generally, galvanized steel pipe—in the sizes commonly used in gardens—is less expensive than either hose or aluminum pipe.

### PIPE LINES

Galvanized steel is the only pipe small enough (under 2-inch) to prove economical for small irrigation systems so far. Steel pipe is not easily damaged and may be put underground. If 2-inch or larger pipe is necessary, aluminum pipe may be less expensive. Aluminum pipe should be coated if it is to be buried underground. Black pipe or other used pipe purchased from salvage yards has been used, but should be expected to give only limited service.

Steel pipe may be installed as part of a fixed, permanent system; or it may be installed as a semi-permanent, portable pipeline. Permanent pipes can be placed underground to avoid obstructing normal farming operations. However, some provision should then be made to drain the pipe every fall.

Or a semi-permanent or portable line may be installed on the ground surface. By uncoupling and moving the pipe, more than one area can then be irrigated with the same pipe.

Use Fig. 4 to select the proper size of pipe for carrying water from the pump to the garden. When water flows through pipes, some pressure is always lost. If a large amount of water is forced through a small pipe, the pressure-loss and pumping costs will be high. Figure 4 is based on this assumption—that for an average garden-irrigation system, a pressure loss of 5 pounds per square inch should be the maximum allowable loss in conveying water to the field.

#### How to Use the Chart (Fig. 4)

Suppose the pump has a capacity of 300 gallons per hour, and that the most distant sprinkler in the garden will be located 200 feet from the pump. What size pipe will be most efficient? In the horizontal scale for "flow in gallons per hour," at the bottom of Fig. 4, find the point for *300*—between "200" and "400." Read up the chart along the *300* line until you are directly across from *200* in the vertical scale, for "length of pipe in feet." The point where your vertical and horizontal readings intersect falls between the second and third curves

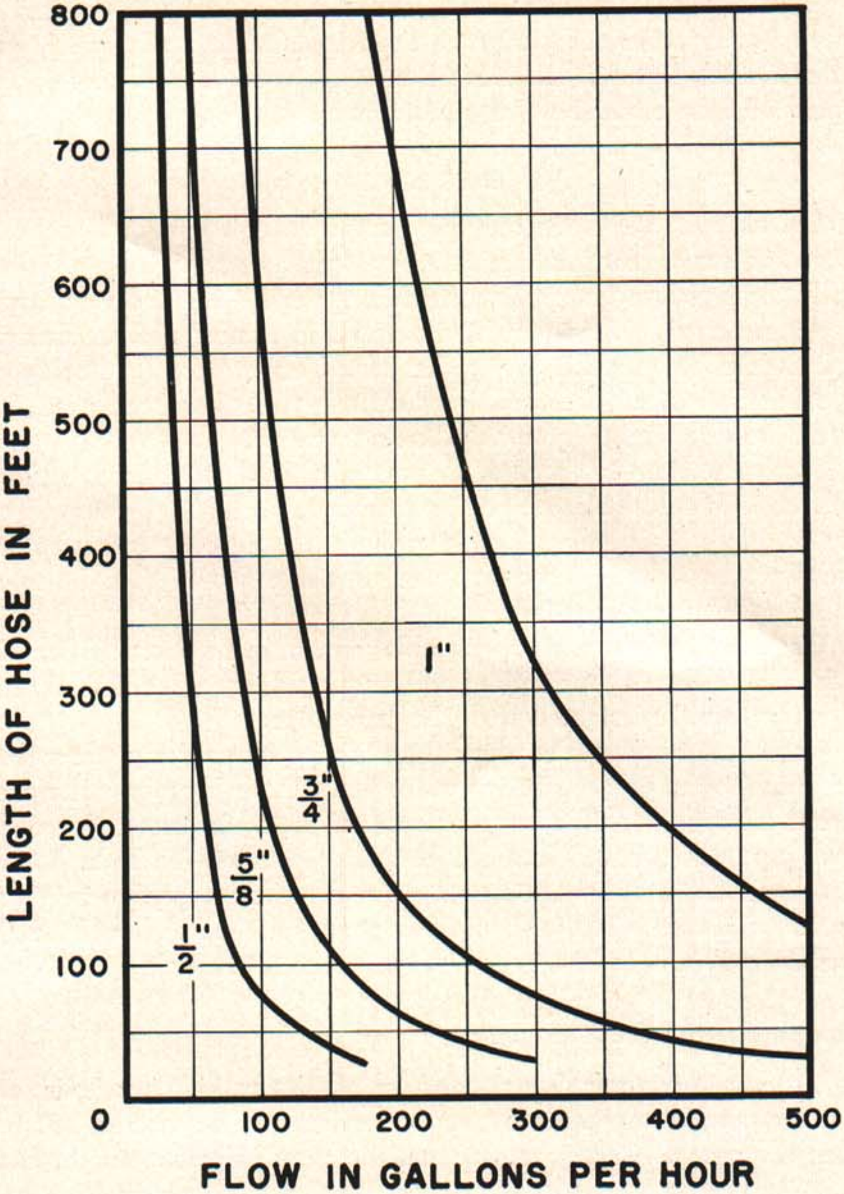


Fig. 5. "Hose selection chart." Use in the same manner as Fig. 4. (Both Figs. 4 and 5 are based on data originally compiled by J. E. Christiansen, Dean of Engineering, Utah State College, and used with his permission.)

on the chart; any point between those curves has the same value—*1-inch* (1″). This means that, to avoid excessive pressure-losses in getting the water to the irrigated area, a 1-inch pipe is recommended.

## HOSES

The use of hose for irrigation is limited, because pressure-losses in hose are higher than in the same size of metal pipe. The cost of most hose over ⅝-inch is usually higher than for the same size of galvanized steel pipe. Hoses have the advantage, however, in that they are more easily moved than rigid pipe. Hoses can be used for irrigating other locations, or for stock watering and such purposes—whereas piping may have limited applications.

Figure 5 will aid in selecting the proper size needed when hose is used to convey water to the irrigated area. This chart in Fig. 5 was prepared on the same basis, and is used in the same manner, as the pipe chart (Fig. 4). A flow of 300 gallons per hour, for a distance of 200 feet, requires a 1-inch hose, for example.

### "Plastic Pipe"

Just recently several manufacturers have put on the market a lightweight, flexible "plastic pipe." With this particular pipe, the pressure losses are lower than the losses in steel pipe. One manufacturer has stated that, in general, one size smaller diameter plastic pipe (as opposed to steel pipe) can be used at equivalent pressure for the same flow.

At the time this bulletin was printed, the initial cost of plastic was comparatively higher. However, its flexibility, durability, lightweight, and lower pressure loss may combine to outweigh the advantages of steel pipe in many cases. Future production of plastic pipe should make more of it available, and consequently may lower prices enough to place it in a more favorable competitive position with steel pipe.

Neither of the flow charts, Figure 4 or 5, is directly applicable for selecting "plastic pipe."

## COMBINATION OF PIPE AND HOSE

If hose is already available, it's usually more expedient to utilize it as much as possible. Using hose may reduce the number of pipe outlets required; it can also provide greater flexibility of the system. One method is to install pipe only as far as the field, and then use hose from there to the sprinkler. In a long field, it may be better to run the pipe into the field, at intervals installing tees and control valves or caps in the pipe for connecting the hose and sprinkler.

A single control valve outside the garden may be less expensive, and also easier to find at night without walking in the wet soil. A disadvantage would be that all sprinklers will then have to be turned off to move just one or two, thus losing time which could have been spent irrigating part of the area. The proper length of hose to use can be determined from the hose chart (Fig. 5). If the length of hose is close to the maximum allowable length for the particular flow, however, it is then desirable to make the *pipe* one size larger than the pipe chart shows.

For example, suppose the garden is 100 feet long and located 200 feet from the pump at the nearest point. That means 300 feet will be the minimum length which the water must travel to reach and irrigate the garden. One hundred feet of ¾-inch hose is available. The pump capacity is 300 gallons per hour. Can the hose be utilized?

According to the hose chart, for 300 gallons per hour only 75 feet of ¾-inch hose is recommended. This leaves 225 feet, which will have to be piped. And that pipe, according to the pipe chart, should be 1-inch pipe. But because 75 feet of ¾-inch hose at 300 gallons per hour is the maximum allowable length, the pipe size should be increased to 1¼-inch pipe. If only 25 feet of ¾-inch hose were to be used, it would not be necessary to increase the pipe size.

More than 50 feet of hose may be difficult to handle in a garden, unless two persons are available for moving the hose. A hose-reel might work satisfactorily to help move the hose in the garden and also from one area to another.

## WATER APPLICATION EQUIPMENT

### Oscillating Pipe

"Oscillating pipe" lines consist of ¾-inch to 1½-inch pipe, with small nozzles spaced every 2 to 4 feet along the pipe. (Fig. 6.) The pipes are mounted on standards above the top of the crop, and are rotated through a quarter-circle by a water-pressure motor attached to one end of the pipe. This system operates at 25- to 40-pounds pressure, and distributes the water about 25 feet on both sides of the pipe. The pipelines, therefore, should be spaced about 50 feet apart.

This equipment provides consistent distribution during the entire irrigation season, requires very little labor to operate, and is available for frost-control at a moment's notice. However, it has a higher initial cost than some installations and it may prove an obstacle to tillage operations.

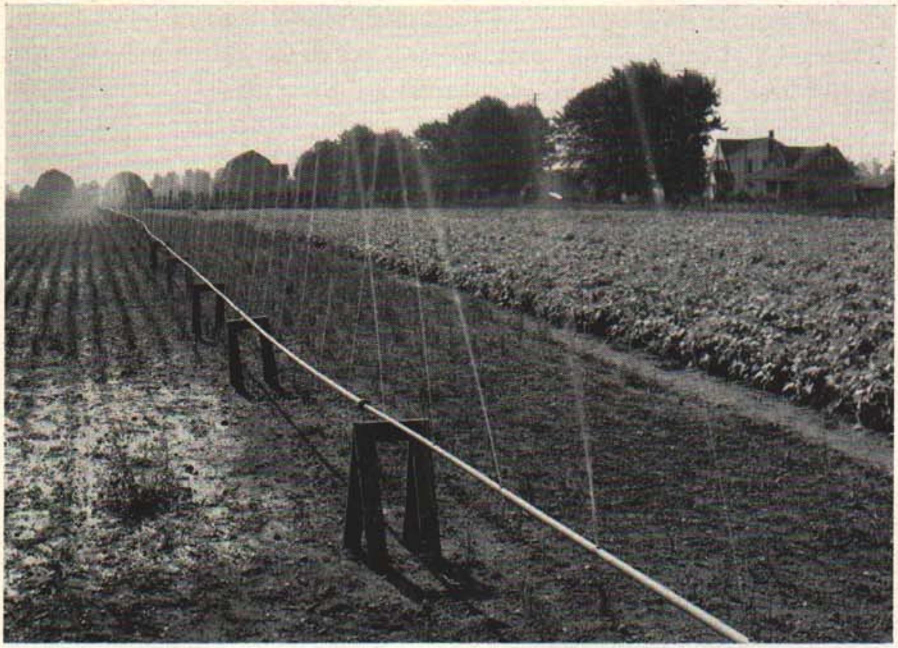

**Fig. 6. "Oscillating pipe" supported by sawhorses, in use for truck-garden irrigation. A motor at one end rotates the entire lateral through a quarter-circle for consistent water distribution.**

## Perforated Pipe

"Perforated pipe" is lightweight portable pipe. The water is distributed through small holes spaced in a pattern along the upper side of the pipe (Fig. 7). This system operates at pressures of 4 to 30 pounds, and distributes the water from 5 to 25 feet on each side of the pipe. The smallest size of perforated pipe is 2 inches in diameter. It is available in lengths of 5 to 40 feet; standard length is 20 feet.

This type of pipe provides an application rate of ½ to 2 inches per hour. That application rate may be too high for some fine-textured soils. However, good soil-tilth and crop-cover will always allow higher application rates, even on clayey soils.

The pipe should be placed approximately along the contour, preferably on a slight downhill grade in order to obtain the best water distribution. But the distribution is likely to be unsatisfactory when the pipe is placed on the ground in close-growing, overhanging crops. Some irrigators have eliminated that disadvantage by supporting the pipe on poles or standards, so that the crop will not interfere with the spray.

A perforated pipe system has the advantage of irrigating rectangular areas, and overlapping patterns are avoided. Pumping costs are usually low, because of the low operating pressure.

### Porous Canvas Hose

Hose from 2¾ to 3½ inches in diameter of 10 or 12-ounce canvas placed between rows, and operated at not over 20-pounds pressure per square inch, will irrigate the soil by allowing water to seep through the canvas into the soil. This hose can be made on a strong sewing machine, but has many disadvantages.

Commercial hose is expensive and, with care, may last 4 to 5 years. Shifting the hose from row to row is a wet, dirty, heavy job. In sandy soils the water does not readily spread out between the rows, so it may be necessary to place the hose next to the plants in the row.

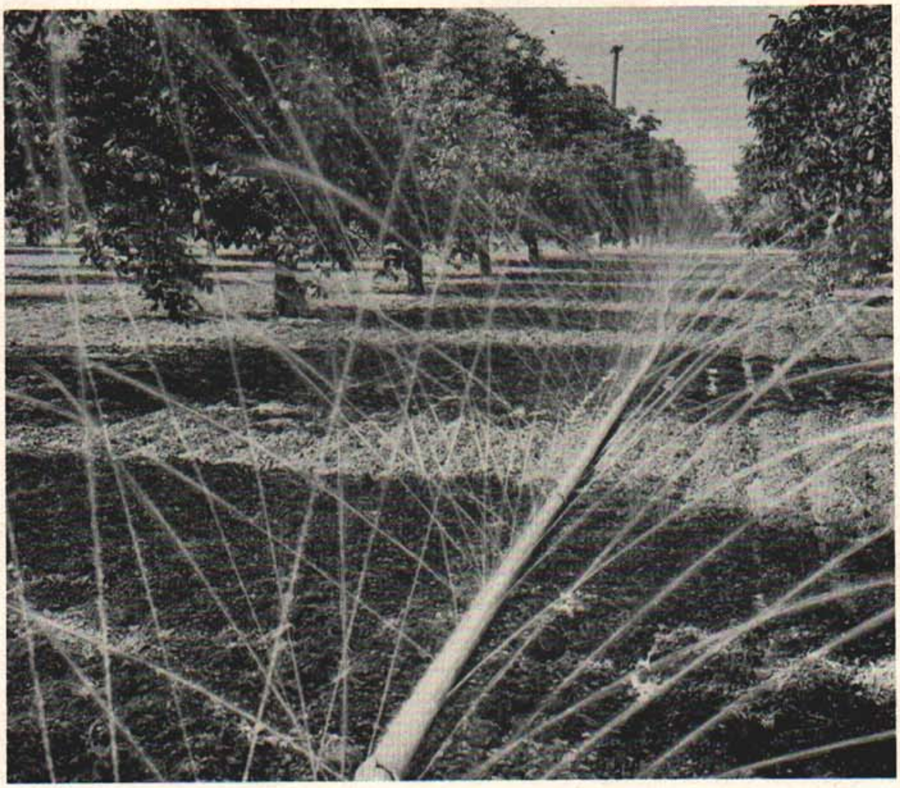

**Fig. 7. "Perforated pipe" laterals can irrigate rectangular areas, such as both grass and trees in an orchard row, without an overlapping spray pattern. Operating pressures and water spread can be varied considerably to allow use under a wide range of conditions.**

**Furrow or Ditch Method**

In this method, water is run onto the soil surface and permitted to flow in furrows between the rows down the length of the garden. It is not suitable to sandy soils which may absorb all the water before it reaches the end of furrow. Gentle, uniform slopes are necessary, and it will take some experimenting to adjust the flow properly so that the water will go no farther than the end of the furrow.

Frequent spading or boring is recommended during and after each irrigation to determine how deep the water is penetrating into the soil. If the water is penetrating deeper than 1⅓ times the root-zone-depth at the upper end of the furrow, the garden should be split into two areas. The water can then be run into furrows both at the end of the garden and at the middle of the area.

This method will require extra work and more water than sprinkling, but will take less equipment. One method of getting the water into the furrows requires only the use of a homemade V-shaped trough. The trough has holes bored in one side, spaced the width of the rows. It is placed level across and just above the rows—so that water will flow from the holes into the furrows. The length of the trough and the size of the holes should be adjusted to prevent the pump stopping, or the trough from overflowing, anytime during the irrigation.

An advantage of this method is that water under pressure is not a necessity. Water from streams or ditches may be diverted into a small channel running down to the garden area.

## SPRINKLERS: PROPER SELECTION AND USE

**Rotary Sprinklers**

In recent years, this has become the most common method of applying water. It does not require level land and is adaptable to any size of garden or water supply. There are two general groups of rotary sprinklers: (1) Those intended for lawn watering, and (2) those made for irrigation. (Fig. 8.) Generally, the lawn sprinklers water small areas irregularly at a high rate of application, which may encourage run-off and erosion in the garden. The irrigation-type sprinklers are well-built and will apply water over a large area, generally at a lower rate than the lawn sprinkler. "Part circle" irrigation sprinklers can be used to irrigate varying parts of a circle. This avoids the waste of water on buildings, roads, or other uncropped areas.

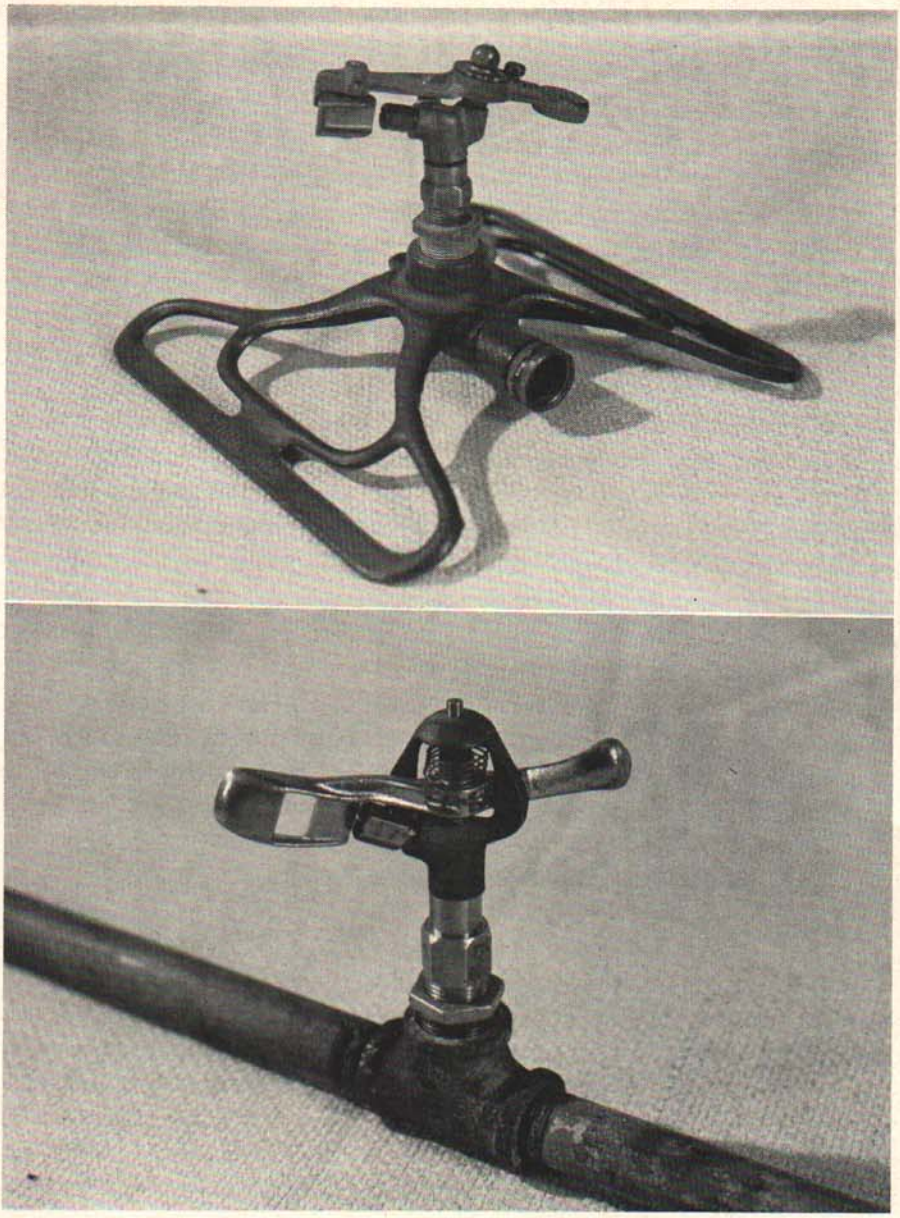

Fig. 8. Garden-size irrigation sprinklers. For use with hose (above), or adapted to steel pipe (below).

A comparison of lawn-sprinkler tests and irrigation-sprinkler performance charts shows that, generally, irrigation sprinklers are less expensive and are adaptable to a wider range of water pressures and capacities than lawn sprinklers. Irrigation sprinklers are available which operate at a pressure as low as 3 pounds per square inch. More commonly, however, only pressures as low as 15 to 20 pounds per square inch are used—as in the two types shown (Fig. 8).

The amount of water applied will normally decrease as the distance from the sprinkler increases. It is then necessary to overlap the sprinkler patterns to obtain some reasonable uniformity of application; that is, the water thrown from one sprinkler should overlap the area wetted by another sprinkler. A general rule is that the sprinklers are so spaced that water spray from one sprinkler will just reach the base of the adjacent sprinkler.

***TABLE 5—Water discharge through sprinkler nozzles***

| PRESSURE (pounds per sq. in.) | ⅛-inch nozzle | | 5/32-inch nozzle | | 3/16-inch nozzle | | 7/32-inch nozzle | |
|---|---|---|---|---|---|---|---|---|
| | *GPH** | *Diam.*† | *GPH** | *Diam.*† | *GPH** | *Diam.*† | *GPH** | *Diam.*† |
| 20 | 120 | 72 | 180 | 73 | 260 | 74 | 350 | 76 |
| 25 | 130 | 75 | 205 | 76 | 295 | 77 | 390 | 79 |
| 30 | 145 | 76 | 225 | 78 | 325 | 79 | 430 | 80 |
| 35 | 160 | 77 | 245 | 79 | 350 | 81 | 470 | 82 |
| 40 | 170 | 78 | 265 | 80 | 375 | 82 | 500 | 83 |
| 45 | 180 | 79 | 280 | 81 | 400 | 83 | 530 | 84 |

*GPH = gallons per hour †Diam. = Diameter covered by sprinkler

**Selecting Rotary Sprinklers**

The number of sprinklers which can be operated will depend on two things: the discharge of each individual sprinkler, and the discharge of the pump at the required operating pressure. Table 5 shows how much water is delivered through one of the common irrigation sprinklers, for various pressures and sprinkler nozzle sizes.

There is very little difference in the *area* covered by various nozzle sizes. The chief difference is in the *water discharge*, which in turn affects the *application rate*. Remember, to keep the pump running continuously, the sprinkler-pressure plus the pressure lost in the pipe or hose must be less than the pump cut-off pressure.

If the cut-off pressure is 40 pounds per square inch and the available quantity is 360 gallons per hour, for example, a good choice would be two ⅛-inch nozzle sprinklers operating at 30 pounds per square inch, spaced 40 feet apart. This would leave 70 gallons per hour for stock tanks or household needs. If the pipe and/or hose is selected correctly, allowing 5 pounds per square inch pressure-loss, then the total pressure would be about 35 pounds, and the pump would run continuously.

Suppose one 3/16-inch nozzle were chosen to run at 35 pounds per square inch pressure, delivering 350 gallons per hour. Allowing 5 pounds pressure-loss, the total pressure would be 40 pounds per square inch pressure, which is too close to the pump cut-off pressure to insure continuous operation.

However, actually resetting the controls each time may be simpler with certain types of pumps. The pressure-switch can be locked in the "on" position or adjusted for a higher cut-off pressure on centrifugal or centrifugal-jet pumps. These pumps require less power at higher pressures, but the amount of water discharged will also be decreased. Making such adjustment might be necessary to insure continuous operation of the pump while the garden is being irrigated.

Gardeners with a municipal water supply need not be concerned with that; the city engineer can furnish information on the approximate pressure in your area. But whether or not your water supply is from a well or a municipal system, it is necessary to provide a valve between the pump and the garden to control the water flow and regulate the pressure at the sprinkler.

The important factor in selection of an irrigation sprinkler is the application rate; water must be put on slowly enough so that all of it soaks in. Whether or not a sprinkler is accomplishing this must be determined by the irrigator the first time he irrigates. Because soils vary so widely, definite recommendations on application rates cannot be made. Wet soils will not permit the entry of water as readily as dry soils. Consequently, irrigators should make such observations only after the sprinkler has been in operation for about 1 to 1½ hours. If runoff does occur, the application rate can be reduced by using the shut-off valve to decrease the water flow.

Table 6 has been prepared to show the application rate and the time required to apply 1 inch of water, for various sprinkler discharges. The sprinkler spacing is assumed to be 40′ x 40′ (40-feet apart on the line, with the line settings 40-feet apart).

## Example of Proper Sprinkler Selection

To illustrate, if the pump is tested and will deliver 350 gallons per hour at 40 pounds per square inch cut-off pressure, two ⅛-inch sprinklers delivering 145 gallons per hour (from Table 5) could be selected. The valve in the line should be regulated so that, if the pump operates continuously, the sprinkler pressure will be about 30 pounds per square inch. According to Table 6, the rate of application for these sprinklers will then be .15 inch per hour. Therefore, 6⅔ hours (6 hrs. 40 min.) would be required to apply 1 inch of water.

Now from Table 4, we find that the area which could be irrigated (running the sprinklers 6⅔ hours per day) would be about 0.3 acre, if the system is operated for 4 days per week. This is an area equivalent to a garden of 100 by 130 feet. (See Fig. 9.) The size of the area could be either increased or decreased by changing the number of days of operation. If the gardener so wished, he could run the system for the 6⅔ hours, move the pipe or hose to a new location, and run for another 6⅔ hours—all in 1 day. The area irrigated in 4 days would then be 0.6 acre.

*TABLE 6—Rates of water application and time required to apply one inch of water, 40 x 40 feet spacing*

| Sprinkler discharge (in gallons per hour) | Rate of application (inches per hour) | Time required to apply one inch (in hours and minutes) | |
|---|---|---|---|
| 100 GPH | 0.10 in. | 10 hrs. | 0 min. |
| 125 | .13 | 7 | 40 |
| 150 | .15 | 6 | 40 |
| 175 | .18 | 5 | 35 |
| 200 | .20 | 5 | 0 |
| 225 | .23 | 4 | 20 |
| 250 | .25 | 4 | 0 |
| 275 | .28 | 3 | 35 |
| 300 | .30 | 3 | 20 |
| 325 | .33 | 3 | 0 |
| 350 | .35 | 2 | 50 |
| 375 | .38 | 2 | 40 |
| 400 | .40 | 2 | 30 |
| 425 | .43 | 2 | 20 |
| 450 | .45 | 2 | 15 |
| 475 | .48 | 2 | 5 |
| 500 | .50 | 2 | 0 |

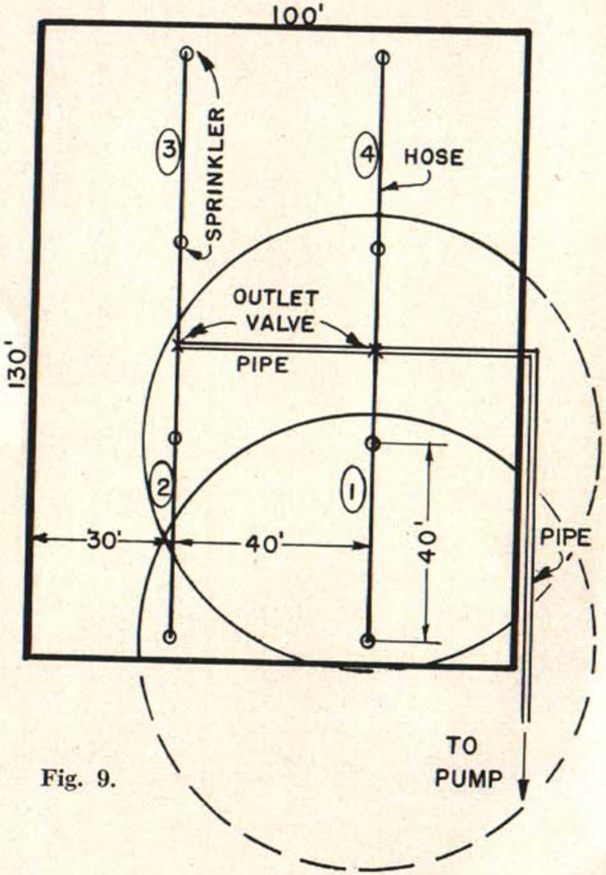


Fig. 9.

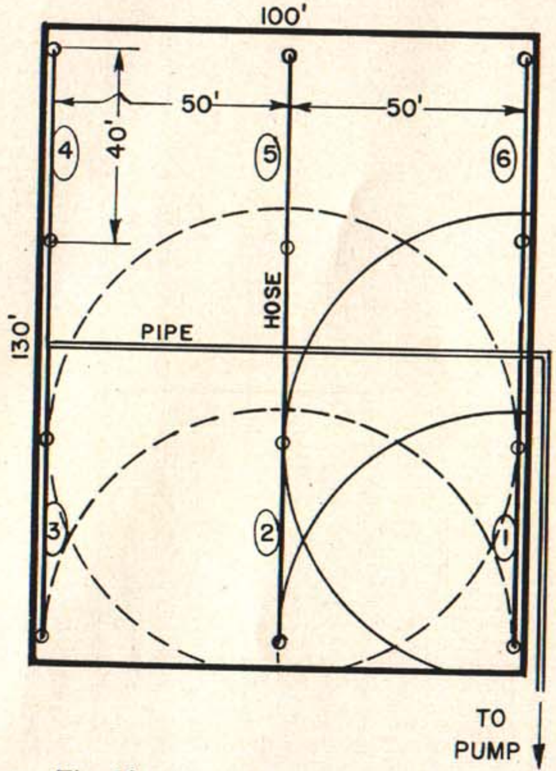


Fig. 10.

SPRINKLER EQUIPMENT LAYOUTS—*Fig. 9.* Using 2 full-circle sprinklers with 4 settings.
*Fig. 10.* With 2 part-circle sprinklers; 6 settings.

If runoff should occur during the 6⅔ hours, the discharge will have to be decreased and the running time increased accordingly. If the discharge-valve decreases the flow too much, it may be necessary to lock the pump pressure-switch in the "on" position to keep the pump motor running continuously. Empty oilcans or buckets can be placed at intervals in the sprinkler pattern to determine the amount of water being applied.

## FITTING THE EQUIPMENT TO THE AREA

Figure 9 illustrates the difficulties involved in trying to irrigate small areas with rotary sprinklers, such as the 100′ x 130′ field mentioned. If the sprinklers are spaced on a 40′ by 40′ basis, some water will be wasted on areas outside the garden. Another disadvantage to such an arrangement is that the garden will not receive a uniform application of water. The area between the two sprinkler lines will receive the proper amount and correct distribution of water—but the area between the edge of the garden and the lines will not.

Figure 10 shows a second possible arrangement for the same field, using part-circle sprinklers. The figures in Table 5 can still be applied to the part-circle sprinklers, but not Table 6 in this case. Because if only one-half a circle is being irrigated, as shown, the application rate would be about *double* that given in Table 6—since the same amount of water is being put on only half the area of a full circle. For similar reasons, a sprinkler in a corner has an application rate of about *four times* that shown in Table 6. This second arrangement would reduce the waste of water, but the garden still would not receive a uniform application. Total operating time using this equipment would be about the same as for the layout shown in Figure 9, but the sprinklers would have to be moved more frequently.

The third possibility is perhaps the best for small areas. It involves the use of oscillating or perforated pipe, as shown in Fig. 11 and Fig. 12. (See page 28.) The advantages of either type for such a field are (1) no water is lost in irrigating areas outside the garden, and (2) the water is applied uniformly throughout the entire garden. To achieve proper irrigation at lower pressures, the pipe lines would probably be moved to three different locations (Fig. 11). At higher pressures, however, probably only two locations would be necessary for the pipe (Fig. 12). Which scheme to use will depend on the available pressure, pumping capacity, the characteristics of the particular pipe, and the soil.

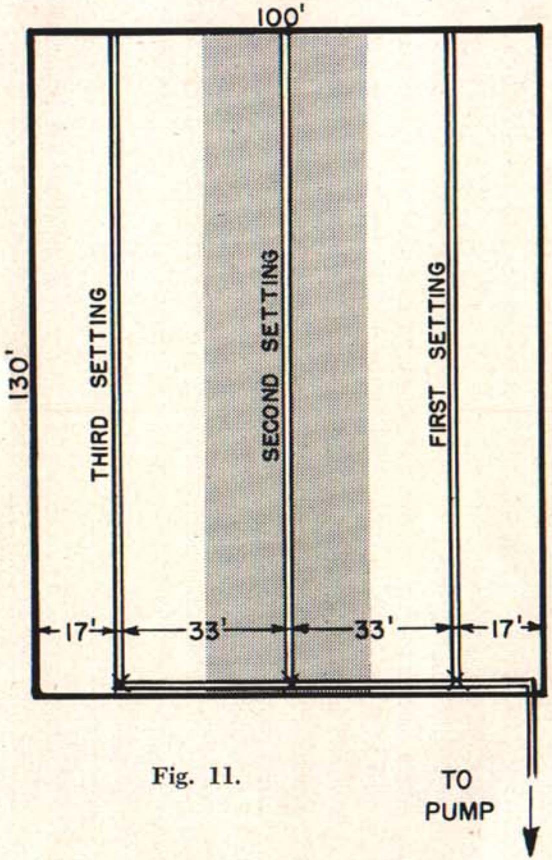


Fig. 11.

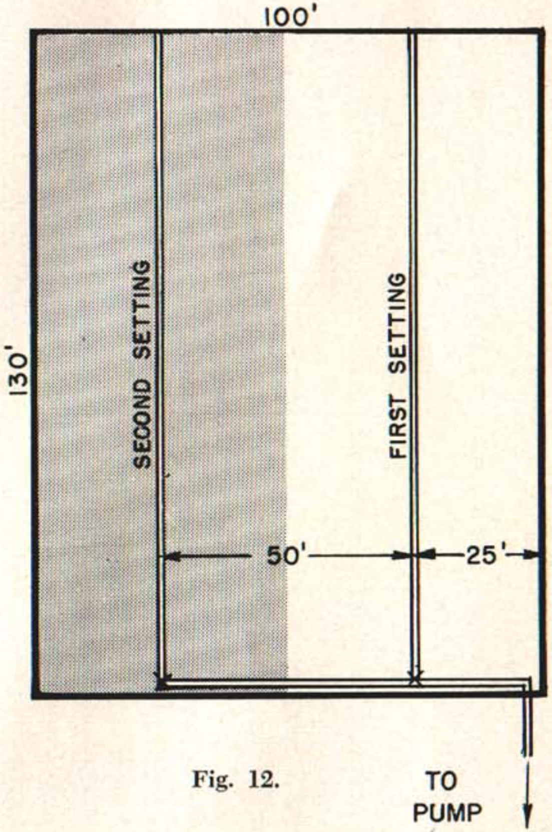


Fig. 12.

NON-SPRINKLER EQUIPMENT LAYOUTS—*Fig. 11.* Oscillating or perforated pipe, distributing water 16½ feet to each side; 3 settings. *Fig. 12.* The same, distributing 25 feet to each side; 2 settings.

It is always wisest to compare different makes of equipment and methods of irrigating first—then use those that appear to be the most economical and practical for the area actually under consideration. In that way, your small-acreage system will more likely do its job satisfactorily.

## FERTILIZATION INCREASES EFFICIENT USE OF WATER

Little definite information is available for Michigan on the response of irrigated crops to fertilizers. What information is available is quite variable, because of differences in soil fertility throughout the state. However, evidence has shown that, for most crops under irrigation, increased rates of fertilization will be profitable during good growing seasons. In addition to commercial fertilizers, organic matter such as manure or crop residue should be incorporated into the soil to promote good soil structure. Water-application-rates can be higher than normal when the soil is open, porous, and contains organic matter. As to how much fertilizer or manure to apply, that question can best be answered by someone thoroughly familiar with the local conditions—your County Agricultural Agent, M.S.C. Extension Specialist, or experienced irrigators in the neighborhood.

### USING SOLUBLE FERTILIZERS

Soluble fertilizers can be introduced into the sprinkler system to save the expense of spreading by hand or other methods. Materials commonly applied through the irrigation water are ammonium sulphate, ammonium nitrate, calcium nitrate, ammonium phosphate, sulphate of potash, and other liquid or water-soluble fertilizers.

Fertilization by this method is accomplished by adding liquid fertilizer to the water in the pipeline, after the plant foliage has been properly wetted. Such applications are finished in time for clear water to wash the fertilizer off the leaves and into the soil, before irrigating has been completed.

## FROST-CONTROL MAY BE POSSIBLE

Many truck-crop irrigators have stated that, on certain crops, the benefits from controlling frost by sprinkling have equalled—or have even exceeded—the benefits of irrigating during the summer. One strawberry grower has reported that preventing the damage from a late spring frost by irrigation meant the difference between a 20-percent crop and an 80-percent crop. Appreciable damage by frosts as low as 22° F. have been prevented by applying 0.15 inch of water per hour on strawberry plants in the spring, and on most vegetable crops in the fall.

*It is essential that all the equipment be in readiness during the frost season.* When the temperature at plant-level in the field drops down to 33° or 34° F., the system should be started. Once it has been started, the system should run continuously until all of the ice which has formed on the leaves has melted off. The sprinklers cannot be moved to another location during the night; they must apply water to that area continuously.

If water has to be applied several nights in succession, the soil may become water-logged. It may be beneficial, therefore, to apply additional fertilizer following the spring frost-control period, so as to replace nutrients which have been leached deeper into the soil.

If you don't have enough equipment to protect the entire garden, you will want to use the available equipment to the best advantage, probably on the highest-value crops. Normal summer operation usually provides an overlap of the wetted circles of each sprinkler. But for frost-control purposes, sprinklers and pipelines can be spaced to provide only a very small overlap—thus controlling frost over a larger area with the same equipment. Additional equipment can also be added to cover larger areas, so long as sufficient water is available to maintain the application rate at 0.15 inch per hour.

Observations have indicated that the sprinklers should rotate at least once every 15 to 30 seconds to provide proper temperature-control. It is doubtful that either small or large trees—or tall-growing crops, such as corn or pole beans—should be irrigated for frost control; the ice load following prolonged watering may break down the tree or plant.

## COSTS AND PROFITS OF IRRIGATION

If a small-acreage irrigation system is to pay for itself, the increased profit due to irrigation must exceed the annual cost of operating the equipment. Some of the costs involved will be charged to the system, even if it isn't used during a particular year. These are annual fixed-costs—including depreciation, interest, taxes, housing, and maintenance. For an approximation of the fixed-cost per year, take 15 percent of the original cost of the equipment.

The second part of the cost must be determined for each individual case. These are the costs for fuel and oil, or electricity and for labor. A rule of thumb for domestic pumps is that, for continuous service, 1000 gallons of water can be pumped for 2¢ to 5¢. Gasoline engines will usually require 0.1 gallon of fuel per horsepower-hour, 1 quart of oil every 10 operating hours, an oil change every 100 operating hours, and more maintenance than electric motors.

Labor costs will vary considerably; they will depend on how often the sprinklers must be moved, and the prevailing hourly wage. A labor requirement of 1 to 2 man-hours per acre, per irrigation, can be used as a guide. However, labor costs are often not considered in the family garden.

Sprinkling systems for larger acreages should be engineered by a reputable irrigation-equipment dealer. The dealer then assumes the responsibility for the performance and durability of the equipment. As in so many other fields, good planning and engineering mean economic installation and proper performance.

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