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By

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THERE ARE many variations and types of sprinkler irrigation systems for use on turfgrass; however, they are generally divided into three main types: portable, semipermanent, and permanent. The choice of any system should be made only after considering the total cost of the system (fixed and operating), labor costs and labor required, and availability and suitability for your specific operating conditions.

Portable Systems

There are three types of portable systems: high-volume sprinklers or guns; medium-pressure (40-60 psi) sprinklers; and traveling sprinklers. These systems have the lowest initial cost per acre, but labor requirements and labor costs are the highest of any system. They are well suited for turf nurseries, athletic fields, and areas not needing frequent irrigations.

Semipermanent Systems

Semipermanent systems have permanent mainlines and submains, while most of the laterals are portable. They are especially suited to large areas where line moving is difficult and requires extensive labor. Here, the mains and submains can be moved with relative ease. In general, semipermanent systems are the "happy medium" between a portable and a permanent system. They may be designed for high-volume guns or medium-pressure sprinklers.

Permanent Systems

Permanent systems have both the mains and laterals permanently installed and are often called "the solid set" systems. Equipment and installation costs are the highest of all sprinkler systems. However, labor requirements are the lowest of any system; this is their chief advantage. They are best suited for areas needing full-season irrigation and where labor is not desired. Industrial sites, cemeteries, parks, and small nurseries are well adapted for these systems.

Permanent systems can be installed that operate all the sprinklers in sequence, with time-clock and automatic valve mechanisms. A definite advantage of the sequencing system is the reduction in pipe size and pump and power requirements.

Labor requirements and approximate cost range of the different irrigation systems are summarized in Table 1 which is based on past experience and retail prices, subject to change.

Table 1. Types, approximate labor costs, and approximate cost of some conventional sprinkler irrigation systems for turf.

Type System	Initial Cost	Estimated Initial Cost* Per Acre	Annual Labor Use	Approximate Man-hours Per Acre-Inches
A. Portable				
1. Large Guns	Medium	$150-250	Medium	0.5 -0.75
2. Sprinklers Med. Pressure	Low Med.	$125-200	High	0.75-1.0
3. Traveling	Low	$100-150	Medium	No Est.
B. Permanent (Solid Set)	High	$500-1000	Very Low	Very Low

*including well, pump and motor

Irrigation Depends on Capabilities of Grasses

When and how much to irrigate depends on (1) the rate the grasses use water, usually expressed in inches per 24 hours, and (2) the water-holding capacity of the root zone in the soil. Grasses will use approximately 0.10 to 0.25 in. of water per day, depending on time of year, temperature, and day length.

Best growth and yield response may be expected if you begin to irrigate when 50% to 60% of the available moisture in the active root zone is depleted. This is usually expressed in inches of available water. The active root zone is usually from 18 to 24 inches deep.

To determine the net and gross amount of water needed at each irrigation period, the following factors must be known.

(1) Available moisture capacity of the soil, in inches of water per foot depth of soil (Table 2), and effective root zone (18-24 in.) depth.
(2) Number of acres to be irrigated.
(3) Moisture requirements of the type grass in inches per 24 hours.
(4) Application rate, and efficiency, (usually 70% for daytime operation and 80% for nighttime operation. Time of day and wind influence are also factors which cause high evaporation.
(5) Number of hours the irrigation system operates each day.

With this information, we can calcu-

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thletic Fields, Cemeteries, and Turf Nurseries

late the pump capacity (output) required in gallons per minute (GPM).

For Portable Systems:

$$GPM = \frac{453 \times I \times A}{H \times D}$$

Where I = Inches water to be applied
A = Acres to be covered
D = Days required to cover
H = Hours of operation per day
GPM = Pump capacity, in gallons per minute
453 = A constant

For Permanent Systems:

Precip. Rate Desired	GPM/Acre
0.15	67.5
0.20	90
0.25	112.5
0.30	135

Soil Holds Water

Before we begin to design an irrigation system, we must have certain information on soil moisture. We must know the available water-holding capacity of the soil in the root zone of the plant (inches of water per foot depth of soil). This helps determine the *amount of water to apply* each time you irrigate and the frequency or interval of irrigation. For example, assume that your soil type is Lakeland fine sand, which has a water capacity of 0.50 inch per foot depth, (Table 2), and your turfgrass has an effective root zone depth of 2 feet. Then, 0.5 inch/ft. depth × 2 ft. = 1.00 inch available water capacity. Then, ½ × 1.00 inch = 0.50 inch water to apply at each irrigation. However, since our irrigation efficiency in Florida is about 75%, we need to apply $\frac{0.50}{0.75}$ or about 0.65 inch per application.

Research has shown that the daily maximum consumption of water by certain grasses is about 0.25 inch per day. From June to August, then, our irrigation interval or frequency would be $\frac{0.65}{0.25}$, or about every 3 days. The frequency of irrigation is not a set figure but is based upon soil moisture and plant relations. There will be intervals 2 to 3 times as long between irrigations in winter months as in hot summer months.

Supplementary irrigation must be designed to have the capacity to apply the necessary depth of water to the area in a given time. Variation in the depth of water applied should not exceed 20%, to any part of the area, and any one part should not receive 15% more than other parts. Increasing the space between sprinklers is not a solution to an uneven coverage.

Losses in water pressure result from friction in mainlines, laterals, risers, and elevation changes. For a reasonably uniform distribution of water, pressure losses in lateral lines should not be more than 20% below the operating pressure. Total friction losses in both the mainlines and laterals should not exceed 25-30% of the operating pressure.

Many systems are sold in which 20 to 30 psi. pressure is lost in some mainlines. This happens when smaller sized pipe is used. Furthermore, even though a larger power unit may increase the pressure, the friction losses increase operating costs. In summation, ASAE standards should be strictly adhered to in allowable friction losses.

Sprinkler Spacings

Medium-pressure sprinkler nozzles should be spaced at intervals not greater than one-half the distance of their effective diameter if wind conditions are normal. Sprinklers spaced 70%

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Table 2. Approximate available moisture capacity of some typical Florida soils.

Soil Type	In. Water per 1 ft. Depth	In. Water per 2 ft. Depth	Amount Water to Apply Each Irrig.*
Ridge Soils:			
Lakewood fine sand	0.35	0.70	0.47 inch
Blanton fine sand	0.40	0.80	0.52 inch
Lakeland fine sand	0.50	1.00	0.65 inch
Ft. Meade fine sand	0.70	1.40	0.93 inch
Orlando fine sand	0.80	1.60	1.05 inch
Flatwood Soils:			
Pomello fine sand	0.2	0.40	0.27 inch
Adamsville fine sand	0.5	1.00	0.67 inch
Pompano fine sand	0.6	1.20	0.80 inch
Immokalee fine sand	0.7	1.40	0.93 inch
Scranton fine sand	0.7	1.40	0.93 inch
Leon fine sand	0.8	1.60	1.05 inch

*includes evaporation losses, at 75% efficiency.

What to Consider When You Plan Irrigation Systems

(from page 11)

to 80% of their effective diameter should not be expected to give any degree of uniform application consistent with good irrigation; 50% variations in water depth may be expected.

Large-volume guns should be spaced no greater than 50% of their effective diameter. Winds greatly distort their pattern because of their higher operating pressures and trajectory angle of the spray.

Power Unit Affects Output and Cost

The power unit has a direct relationship on pump output and operating costs of the entire system. The continuous brake-horsepower (c.b.h.p.) required of a pumping power unit is expressed as:

$$\text{c.b.h.p.} = \frac{\text{GPM} \times \text{TDH}}{3960 \times \text{Efficiency}}$$

TDH is the total dynamic head (distance, in feet, that a pump will push water in a pipe straight up); "Efficiency" of the pump is expressed as a decimal, and GPM = pump output, gallons per minute.

Selection of an engine for a power source of the pump should be based on the continuous service rating (c.b.h.p.), rather than the maximum brake-horsepower (BHP) rating. The engine should be loaded to no more than 80 or 85% of its maximum power. However, diesel engines can be driven harder.

Gasoline, diesel, LP-gas, and electric motors are all used for irrigation power units. Each has advantages and disadvantages, and Table 3 shows ratings of each type.

Gasoline engines have two principal advantages over diesel and LP-gas engines. These are (1) lower initial costs and (2) service is more readily available. On the other hand, diesels have a longer life. LP-gas engines require less maintenance than gasoline engines, and fuel is cheaper. Another advantage of LP-gas is that fuel cannot be taken by "night raiders." The cost of operating LP-gas engines is approximately the same as for gasoline engines if LP-gas is available for about 2/3 to 3/4 the price of gasoline.

When available at reasonable rates, electric motors are one of the most satisfactory sources of power. Their dependability and long life make them desirable. The most common electric motor used for pumping plants is the 60-cycle, 220-240 volt, 3-phase, squirrel cage induction motor. The speed of these motors under *full* load is nearly constant.

Single-phase motors are often used for loads up to and including 5 horsepower. However, 3-phase motors are more efficient. Above 5 horsepower, single-phase motors are not efficient enough for irrigation pumping. Electric motors above 5 horsepower generally should have an efficiency of between 88% and 90%. Most squirrel cage induction motors operate satisfactorily under a continuous 10% overload.

Electric motors should always be protected against excessive heating due to overloading or undervoltage. In addition, larger motors will require a starter or starting compensator.

The following formulas may be useful to compute pumping costs when you decide whether to use electricity or internal combustion engines. However, this is only on the basis of operating costs. Fixed costs should also be weighed before a final decision is made.

Table 3. Average performance of irrigation pumping units from Nebraska tests.

Power Unit	Max. Possible BHP Hrs./gal.	Avg. Fuel Consumption BHP Hrs./gal.	Annual Costs (Oper. & Maint./ 100 hrs.)***
Gasoline	11.2	6.9	$11.40
Diesel	15.2	11.2	$15.34
Propane	8.7	5.7	$10.99
Natural Gas	8.3*	5.4*	$11.50
Electricity	1.20**	0.93**	$ 1.00

*BHP—Hours/100 cu. ft. gas.
**BHP—Hours per KW.
***For 1000 or more hours use annually.

Pumping Costs:

(1) Internal Combustion Engines:
Hourly pumping costs =

$$\frac{Q \text{ x } h \text{ x } F_c \text{ x } d}{3960 \text{ x } E} \text{ (in cents)}$$

Where: Q = Discharge in GPM
h = Pumping head in feet
F_c = Fuel consumption in Gal. per HP hour
d = Cost of fuel in cents per gallon
E = Pump efficiency

(2) Electric Motors:
Hourly pumping costs =

$$\frac{Q \text{ x } h \text{ x } c}{5310 \text{ x } E \text{ x } e} \text{ (in cents)}$$

Where: Q = Discharge in GPM
h = Pumping head in feet
c = Cost of elec. in ¢ per KWH
E = Pump efficiency
e = Efficiency of electric motor

Consult Dealer Before Selecting Pump

Selection of a pump for an irrigation system should be a joint decision by you and a local reputable pump dealer. The trained pump dealer must be familiar with local well and water conditions. His recommendations should be based on three primary conditions: (1) the amount (rate) of water and pressure you need; (2) the specific water source and conditions; and (3) the size of investment you plan to make.

Two Pumps Used Most

Probably the two most common types of pumps used are (1) horizontal centrifugal pumps and (2) vertical centrifugal (or deep well turbine) pumps.

Horizontal centrifugal pumps are used where ample and dependable surface water is available from wells or lakes at suction lifts of less than 15 to 20 feet. This pump is generally used in irrigation because of its low initial cost and high operating efficiency. The pressure the pump develops depends on the rim speed and design of the impeller. They should always be operated at the recommended RPM; when we increase the speed one-third, the horsepower requirements are more than doubled.

The vertical or turbine pump has performance characteristics very similar to those of centrifugal pumps since they both operate under the centrifugal principle. Turbines, however, cannot operate at a high efficiency over the wide range of conditions that horizontal centrifugal pumps can.

Consider Pump Efficiency

Pumping at a rate of 450 GPM will deliver approximately one inch of water on one acre in one hour (one acre-inch). Thus, for a water requirement of one-half of an acre-inch per hour, a flow of ½ × 450 or 225 GPM is needed.

The efficiency of a pump is very important. Consider a 40-acre permanent system where the field is to be irrigated in quadrants, and the pump required is to have a 450-GPM output at a 250-foot TDH. If we select a pump with 70% efficiency, the horsepower requirements are 40 continuous brake-horsepower (c.b.h.p.). In the same situation, if we are careful and choose a pump with an efficiency of 83%, the horsepower required is reduced to 35. Operating 720 hours annually (9 irrigations each at 0.15-inch per hour), using an LP-gas engine with fuel at 12¢ per gallon, the annual fuel savings, alone, is approximately $100. This results by using the most efficient pump, and there are additional savings by purchasing the smaller motor.

Selection of an irrigation system should be based on all factors concerned. Determination of the soil moisture conditions, uniformity of application, sprinkler spacings, and both fixed and operational costs should be based upon current research and on good engineering concepts tempered by local field experience.

Know Your Species

STICKTIGHT

(Lappula echinata)

Sticktight was introduced from Europe and Asia and is now widespread in the United States. It is found growing commonly in dry or sandy soil near roadsides, wooded areas, fencerows, and in industrial waste areas.

L. echinata is classed as an annual or winter annual and reproduces by seeds only. Other common names for this species include blue stickseed, burweed, bluebur, and sheepbur.

Its root is a deeply penetrating taproot type with numerous lateral branches.

Stems (4) are rough and covered with short, white, fine hairs. These give the stalk a grayish appearance. The slender stem grows erect from 1 to 2 feet tall and branches widely at the top.

Leaves grow alternately from the stem and are also covered with soft white hairs. In the mature plant, leaves are from 1 to 2 inches long and from 1/16 to 3/16 inches wide. Young plants show a rosette form (3) of leaves which spread near the crown at ground level. Seedlings (1) have only 2 leaves.

Flowers are small and have 5 blue petals. They are borne in the leafy tips and leaf axils (7) of the upper branches of the plant. This plant generally blooms during June and July.

Seeds (5) are produced in nutlet form by four-lobed, female flowers. At maturity, the spiny flower splits into four segments (2), each composed of one burry nutlet seed. Each seed is about 1/8 inch long, grayishbrown, and has a narrow scar (6) along one side. Seeds are unsymmetrically pearshaped overall with a double row of barbed spines on each side. The spined nutlets readily stick to animal hair or human clothing, and thus seeds sometimes are carried great distances to new sites. Plants are seldom eaten by livestock. It has a disagreeable odor.

Sticktight can be effectively controlled by closely mowing the plants before seed matures. It does not survive under cultivation. In the autumn or early spring, young rosettes should be cut below the crown at ground level. If sprayed before bloom 1/2 to 3/4 pound of 2,4-D per acre will control this weed.

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