INTRODUCTION

Rainfall is the principle source of water for North Carolina crops. However, many farmers are turning to irrigation to supplement precipitation. There are many types of irrigation systems. But, most farmers have limited choices for their particular farm or field. Some systems are inherently more water and energy efficient while others are designed to overcome limitations such as irregular field shapes, sloping land, or limited water supplies. All of these factors should be considered before selecting a particular type of system.
The self-propelled gun type traveler system is usually the most practical system for irrigating irregular shaped fields. Selection and management considerations for self-propelled gun type systems are discussed in this article. Selection and management criteria for other types of irrigation systems are presented in articles EBAE 91-151: Center Pivot and Linear-Move Type Systems; EBAE 91-152: Solid Set and Permanent Systems; and EBAE 91-153: Low Volume (Drip and Trickle) Systems.

Two types of self-propelled gun traveler irrigation systems are available. These are: 1) cable-tow traveler and 2) the hose-drag traveler sometimes referred to as the hose-pull or drum traveler. The cable-tow traveler was commercially available around 1970, but prototypes were in use during the late 1960's. The hose-drag traveler was first developed in Europe and was introduced in the United States around 1976. The cable-tow traveler was very popular for a few years, but it has been largely replaced by the hose-drag traveler.

**CABLE-TOW TRAVELER**

The cable-tow traveler consists of a single gun sprinkler mounted on a two-, three-, or four-wheel trailer with water being supplied through a flexible, synthetic fabric, rubber- or PVC-coated hose. Hose sizes typically vary from 2.5- to 5- inch inside diameter (ID) and hose lengths range from 330 to 1320 feet. Pressure rating on the hose is normally 160 psi. There is also a small turf unit that uses a 1- or 1.25-inch ID rubber hose in lengths up to 200 feet.

The machine follows a steel cable that has one end anchored at the end of the field and the other attached to a cable drum on the machine. As the machine moves through the field, dragging the hose behind it, the cable winds around the cable drum. Power to rotate the cable drum is supplied by water power, either a water turbine, water piston, water propeller, or small sprinkler. An internal combustion engine either directly driving the unit or that powers a hydraulic pump can also be used to rotate the drum.

Most units have a hose reel on the machine. To move the machine from alley to alley, the hose is purged of water and wound onto the reel with the tractor power take-off (PTO) shaft. If the machine has more than 660 feet of hose, two hose reels are required. Hose reels may be horizontal or vertical.

A minimum six-foot alley is required for machine travel and to allow space for the hose to double back beside the machine. On low growing crops, the machine can travel over the crops with little or no damage. Wider alleys may be required for large hoses. Alleys should be grassed, with rocks and other abrasive materials removed. Distance between alleys will vary, depending on capacity. With 2.5- inch ID hose, distance between alleys or lanes will be approximately 180 feet and for 4.5- inch and 5.0-inch ID hoses, lane spacing can be up to 330 feet. A 660-foot long hose will irrigate a row length up to 1320 feet. Normal alley spacing is 70-80 percent of sprinkler coverage diameter.

Sprinklers can be operated in a part- or full-circle mode. It is best not to apply water directly in front of the machine so that the alley remains dry until after the gun passes a particular point. Typical sprinkler pressure ranges from 60 to 100 psi depending on the size of the gun sprinkler. Sprinkler pressure generally increases as the gun size (capacity) increases.
Travel speed of the machine can be adjusted to apply varying amounts of total irrigation. The total amount of water applied is affected by lane spacing, sprinkler capacity and machine travel speed. The total water applied is computed from the formula shown below.

$$\text{Water Applied} = \frac{[19.26 \times \text{Flow}]}{[\text{Lane Spacing} \times \text{Travel Speed}]}$$

where:

- Water Applied is in inches,
- Flow is in gallons per minute (GPM),
- Lane Spacing is in feet,
- Travel Speed is in inches per minute.

*Formula used to compute total water applied when using a gun type traveler.

The acres of cropland that can be irrigated per week will depend on the sprinkler capacity (gpm), the amount of total irrigation to be applied per acre (inches per acre), and the number of hours per week the machine is operated. In operating the machine, the machine is initially positioned 60 to 100 feet from the end of the field. The cable is attached to an anchor on the other end of the field. One end of the hose is attached to a hydrant on the main line and the other end is attached to the traveler. There should be about 30 feet of hose behind the machine at the start. The water is turned on and the sprinkler operates for 30 to 45 minutes before the machine is put in gear to begin its travel through the field. This irrigates the end of the field. After traveling the length of the field, the machine stops and the sprinkler is operated 30 to 45 minutes to irrigate that end of the field. Figure 1 shows a typical layout for a cable-tow traveler.
Figure 1. Schematic of layout for a cable tow traveler. Travel lanes are 180 to 330 feet apart depending on sprinkler capacity and diameter of coverage.

**HOSE DRAG TRAVELER**

The hose-drag traveler consists of a hose drum, a medium-density polyethylene (PE) hose and a gun type sprinkler. The hose drum is mounted on a multi-wheel trailer or wagon. The gun sprinkler is mounted on a wheel or sled type cart referred to as the gun cart. Normally only one gun is mounted on the gun cart, but a few systems utilize two gun sprinklers on the same cart. One of the PE hose is attached to hose drum and the other end attached to the sprinkler cart. The hose is used to supply water to the sprinkler and also to pull the sprinkler cart toward the drum. The hose drum is rotated by a water turbine, water piston, water bellows, or by an internal combustion engine. As the drum is rotated, the hose is wound onto the drum and the sprinkler cart is drawn toward the drum. Hose sizes vary from 1- to 5-inch ID. Hose lengths vary from 200 to 1320 feet. Pressure rating of the hose is typically 160 psi.

There are several United States and foreign manufacturers of hose drag sprinklers. Some companies offer a variety of sizes of machines with different hose sizes and lengths. Other companies offer a more limited range of machine sizes. Some machines are designed for small turf uses and others for larger agricultural applications.

At least one manufacturer offers a hose-pull traveler that has small sprinklers or spray nozzles mounted on a boom rather than using one- or two-gun sprinklers. The small sprinklers operate at lower pressure than gun sprinklers. They do, however, have a higher instantaneous application rate. This higher rate can result in runoff and erosion on soils that have a slow intake rate.

In operation, the hose-drag traveler is somewhat similar to the cable-tow traveler. With low growing crops, the sprinkler cart will travel over the crops and no travel lane is required. Lane spacing is a function of sprinkler capacity or length of the boom.

The hose winds onto the drum as the sprinkler cart is pulled in. Once the sprinkler cart reaches the drum, the entire machine can be moved. The machine is moved from lane to lane with a tractor. The sprinkler cart and hose are pulled out from the machine by a tractor. Some of the machines have a 360 degree turntable on which the drum is mounted. (With the turntable machine, it is possible to irrigate fields on either side of the machine.)

The length of field that can be irrigated is equal to the hose length plus 60 to 120 feet. Spacing between lanes will depend on sprinkler diameter. Normal spacing is 70-80 percent of sprinkler diameter. Sprinklers can be operated in a part- or full-circle mode. The area directly in front of the sprinkler cart is usually left dry. Normal sprinkler pressure is in the range of 60 to 100 psi.

The amount of irrigation applied to an area at one time can be varied by adjusting cart travel speed. Lane spacing and sprinkler capacity are also variables. The total acreage of land that can be irrigated per week will depend on the amount of irrigation applied per acre, the number of hours per week the machine is operated, and sprinkler capacity. Figure 2 shows a typical layout for a hose-drag traveler.
ADVANTAGES AND DISADVANTAGES

The hose-drag traveler is more adaptable to sloping terrain than is the cable-tow traveler. The hose and sprinkler cart will operate around most terraces. With the cable-tow traveler, this is more difficult and requires additional equipment. For the hose-drag traveler, only the amount of hose needed to irrigate the field length must be unwound off the reel. For the cable-tow traveler, all the hose must be unwound off the reel. More time is required to move the cable-tow machine, lay out hose and cable, and anchor the cable than is required for the hose-pull machine. However, the hose-pull machine with the same capacity as the cable-tow will be more expensive, heavier, and require more pressure to operate.

Most cable-tow and hose-drag machines have speed compensation that adjusts the travel speed of the machine or sprinkler cart through the field to insure that it is uniform as more cable or hose builds up on the cable drum or hose drum.

The travelers were originally designed for irrigating fresh water onto cropland. However, several hose-drag travelers have been used recently to land apply nutrient-rich effluent (wastewater). Effluent that contains limited amounts of solids can be applied with water drive machines, but if any appreciable amount of solids is present, auxiliary engine drives should be used.

The hose-drag traveler is adaptable to odd-shaped fields and varying row lengths. Both machines are transportable and can easily be moved to other fields.

ENERGY REQUIREMENTS

The hose-pull traveler with gun sprinklers requires the greatest amount of energy of all irrigation systems. For the same capacity machine, the cable-tow traveler uses about 10-15 percent less energy as the hose-drag traveler. This is due to the difference in the pressure losses in the two different hose
types (flexible vs. PE hose). In either case, however, operating pressures are higher than for any other type(s) of irrigation system.

The introduction of the boom sprinkler for the hose-drag traveler was an attempt to reduce energy requirements. However, this machine is best adapted to flat topography, low growing crops, and high infiltration rate soils. The machine is not easily transported between farms. Also, the boom sprinkler is not well adapted for land application of nutrient-rich effluent that contains an appreciable amount of solids.

There are several ways that growers can reduce energy requirements for travelers. These include using larger hose on the machine, using shorter lengths of hose, using larger supply pipe, and using lower pressure at the sprinkler. However, there are trade-offs on each of these energy-saving methods. The major trade-off is higher initial cost for system components that must be balanced against savings in energy. Using lower pressure at the sprinkler can result in reduced irrigated area (wetted diameter), larger droplet size, and potentially, more soil compaction and runoff.

As an example, consider a properly tuned diesel engine connected to a properly matched pump. For each 16- to 17.5- horsepower of engine horsepower, one gallon of diesel fuel will be consumed per hour. An average figure is 16 horsepower (Hp) per gallon of fuel. By using methods to reduce pump pressure, such as larger diameter main line, larger hose on the machine, or lower sprinkler pressure, it is possible to reduce horsepower requirements and, therefore, fuel consumption.

Table 1 gives data for pressure (head) requirements for hose-drag travelers supplied by one manufacturer. The comparison shown in Table 1 assumes:

- sprinkler capacity is 475 gallons per minute
- nozzle pressure is 90 psi
- there is a 20-foot elevation difference between the water supply and the highest point in the field to be irrigated
- the sprinkler nozzle is 9 feet above the ground
- the drive mechanism for the traveler is a water turbine with a pressure loss of 12 psi across the turbine

<table>
<thead>
<tr>
<th>Pressure (psi)</th>
<th>Minimum</th>
<th>Maximum</th>
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<tbody>
<tr>
<td>1</td>
<td>5</td>
<td>15</td>
</tr>
<tr>
<td>2</td>
<td>7</td>
<td>20</td>
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</table>

Table 1: Pressure (head) requirements for hose-drag travelers supplied by one manufacturer.
Two hose sizes, 4.0-inch ID and 4.5-inch ID, and two main line sizes, 6-inch ID Class 200 PVC pipe and 8-inch ID Class 200 PVC pipe, are used. The 4-inch ID hose is 1250 feet long and the 4.5-inch ID hose is 1300 feet long. The main line is 3000 feet for both the 6-inch and 8-inch.

The difference in purchase price between the two travelers is approximately $3700. The difference in installed cost between the 6-inch and 8 inch ID main line pipe is approximately $1.50 per foot or $4500. Assuming a machine life of 12 years and 10 percent interest, the annual difference in ownership cost between the 4-inch ID hose and 4.5-inch ID hose machine is $543.00.

Assuming a pipe life of 25 years and 10 percent interest, the annual difference in ownership between the 6-inch and 8-inch ID main line pipe is $496.00. To justify purchasing the larger hose or larger pipe, the fuel savings should at least equal the additional ownership cost.

Fuel cost (savings) are computed based on the energy required to deliver the required flow rate at the desired operating pressure. To compute horsepower (HP) requirements, use the formula shown below.

\[
\text{Horsepower} = \frac{[\text{TDH (feet) x GPM}] / 3960 \times \text{Pump Efficiency}}{2.31}
\]

After assuming a certain efficiency pump, compute horsepower requirements and fuel consumption. Table 2 gives horsepower requirements and fuel consumption for three pump efficiencies, based on

<table>
<thead>
<tr>
<th>Sprinkler Pressure</th>
<th>90.0</th>
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<th>90.0</th>
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<tr>
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<td>56.7</td>
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<td>Friction Loss in Main Line</td>
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<td>19.0</td>
<td>5.7</td>
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<td>Friction Loss in Turbine Drive</td>
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<td>Elevation Difference</td>
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<td>8.7</td>
<td>8.7</td>
<td>8.7</td>
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<tr>
<td>Riser Height</td>
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<td>3.9 (9/2.31)</td>
<td>3.9</td>
<td>3.9</td>
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<td>TDH (psi)</td>
<td>190.3</td>
<td>166.9</td>
<td>176.6</td>
<td>153.1</td>
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</table>

*Elevations expressed in feet are converted to PSI by dividing by 2.31.*

Two hose sizes, 4.0-inch ID and 4.5-inch ID, and two main line sizes, 6-inch ID Class 200 PVC pipe and 8-inch ID Class 200 PVC pipe, are used. The 4-inch ID hose is 1250 feet long and the 4.5-inch ID hose is 1300 feet long. The main line is 3000 feet for both the 6-inch and 8-inch.
16.66 water horsepower per gallon of diesel fuel for the four combinations of traveler sizes and supply pipe sizes.

<table>
<thead>
<tr>
<th>Pump Efficiency</th>
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<tr>
<td>Percent</td>
<td>Fuel HP Cons. (gal/hr)</td>
<td>Fuel HP Cons. (gal/hr)</td>
<td>Fuel HP Cons. (gal/hr)</td>
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<tr>
<td>65</td>
<td>116 6.96</td>
<td>101 6.06</td>
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<td>70</td>
<td>108 6.48</td>
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<td>75</td>
<td>100 6.00</td>
<td>88 5.48</td>
<td>93 5.58</td>
<td>81 4.86</td>
</tr>
</tbody>
</table>

(1) - 4.0-inch ID Hose Size, 1250 ft. long, 3000 feet of 6-inch ID Class 200 PVC pipe
(2) - 4.5-inch ID Hose Size, 1300 ft. long, 3000 feet of 6-inch ID Class 200 PVC pipe
(3) - 4.0-inch ID Hose Size, 1250 feet long, 3000 feet of 8-inch ID Class 200 PVC pipe
(4) - 4.5-inch ID Hose Size, 1300 feet long, 3000 feet of 8-inch ID Class 200 PVC pipe

* Power and fuel usage based on 475 gpm sprinkler. Refer to Table 1 for TDH for each combination.

Figuring the farm cost of diesel fuel at $.90 per gallon and the traveler operating 584 hours per year (6 inches of irrigation on 75 acres of cropland), the fuel savings between the smaller hose and smaller pipe size and the larger hose and larger pipe size would be approximately $725.00 per year for the 65 percent efficient pump. The annual difference in cost of ownership of the two systems is $1039.00. Therefore, the fuel savings do not cover the additional cost of ownership. Also, fuel costs are paid annually whereas the initial investment is an up-front cost.

Similar comparisons can be made for other machines and hose sizes.

**SUMMARY**

At current energy prices, it is difficult to justify the cost of energy reducing alternatives on self-propelled gun traveler machines. The energy savings (at current prices) from using larger supply pipe or hose generally will not offset the higher ownership cost of the larger pipe and hose. Reducing pressure at the sprinkler increases average droplet size and therefore, potential soil compaction. Application rate may be increased, leading to increased runoff. The boom sprinkler is only adapted to flat terrain and high intake-rate soils. This machine is also more difficult to move from field to field. It may be possible to substitute other types of irrigation systems, but for some growers and some applications, the traveler is still the most economical machine when initial cost, operating cost, and
labor required are all considered.

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