Testing Irrigation System Uniformity

Uneven water distribution is a factor universal to all sprinkler irrigation systems and can create potential problems for seedling culturing. For instance, most growers irrigate for the driest areas and in doing so, will over-irrigate all other areas. This not only wastes water and causes the over-irrigated areas to become saturated but it also over-applies any material being added though the irrigation system. In heavier media, the over-irrigated portion of the crop may be injured from having too little oxygen available to the roots. Over-irrigation can also leach out soluble fertilizers from the growing media.

If you are trying to apply materials such as fertilizers and pesticides through the irrigation system, variations in available moisture, oxygen, nutrients, pesticides due to poor uniformity of your irrigation system may explain a lot about the performance of your crop. Some of these effects are clearly visible in the nursery showing definite patterns tied to the locations of the irrigation nozzles (Figure 1) while others are less obvious .

The best way to check irrigation system uniformity is by placing containers in a grid pattern across a representative location in your nursery and measuring the amount of water in each container after a typical irrigation (Figure 2). We will describe this procedure and show how this information can be used to determine irrigation uniformity.
Procedures for testing your system (Adapted from Merriam, 1978)

1. Equipment needed:

Pressure gauge(s) – In addition to the gauge mounted on your irrigation system to monitor water pressure at the controls, you will want a hand held gauge that you can use to monitor pressure along irrigation lines. Depending upon the design of your sprinkler nozzles, you may need to add a small device called a “pitot tube” which can be inserted into the water stream in the nozzle to measure water pressure.

Hose and Container – A hose that will fit over the nozzle and gather all discharged water into a container. Measuring this discharged volume within a specified time will allow calculation of nozzle output rates. This is useful to check nozzle performance against manufacturer specifications to determine nozzle wear.

Water collection containers - Up to 50 or more containers (can) will be needed depending upon size and density of your grid (Figure 2). Each container must have identical sized openings and vertical sides. Paper or plastic cups

Figure 1

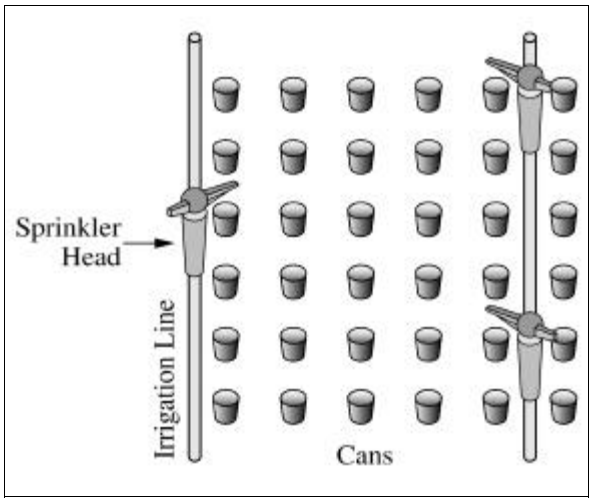

Figure 2

work well. For traveling booms, consider using a row of pill cups or test tubes that fit inside a row of empty cells placed parallel to the boom.

Tape Measure - Used to set out collection containers on the established grid. Also needed to measure the top opening of the collection containers.

Paper - A preprinted form containing notes, section with grid marks to draw the grid, etc. Also needed to record trial results. (Figure 3)

Watch - To time the duration of each irrigation.

Graduated cylinder - To measure collected water. Should be accurate to 2 ml.

Calculator or Computer - Using raw collection data, a calculator or computer can be used to determine the average volume, percent of variation from the average, and the coefficient of uniformity. A computer spreadsheet allows easy storage of records and the ability to graph the results.

Compass and anemometer – If wind is a factor during measurements, wind direction and speed must be taken. This information can be taken with a compass and anemometer.

2. Lay out a grid of collection containers. - Design a grid pattern between two or more sprinkler heads. The actual spacing of the grid needs to fit the seedling bed or container table and can be varied depending upon the degree of detail needed. For instance, in a typical container bench situation, a 60 cm or even a 90 cm grid can be used to get a quick picture. Then a 15 to 25 cm grid may be chosen to fine-tune the system. Once the grid spacing is determined, it is critical to place the collection containers at exact intervals with their tops level.

3. Record notes and sketch the grid onto a form. - Develop a form onto which all data about the system and the test can be recorded for later reference (Figure 3). Include the "Test Identification Number".
A number containing the year, month, day, and sequential test on that day (e.g. 2001-01-15-01) is recommended. This type of system will provide for easy reference and, if used as a computer file name, will store your tests in the correct order in the file. Include a sketch of the grid being used. Sketch a north-facing arrow to show the orientation of the seedling bed and the collection containers. Draw in the location of the sprinklers.

4. Test the system. - Irrigate for a typical length of time and record this duration. Measure and record the amount of water collected in each container. Use a graduated cylinder to obtain an accurate measurement of volume in each collection container. Record the collected quantities directly to the paper grid (Figure 3). This will prevent confusion over where the collections were made and can provide a quick visual analysis of the irrigation distribution pattern. For open-type facilities like shelterhouse and shadehouse structures, you will need to consider wind conditions under which the system is operated. Be sure to record the wind direction, speed and time of day during each test.

Data analysis

Distribution variability: To determine the variability in irrigation application, calculate the coefficient of uniformity using collection container test data in the following formula:

$$CU = 100 [1.0 - (B / A)]$$

Where: CU = coefficient of uniformity (%)
B = sum of deviations of individual values from the mean value
A = sum of the individual values

Irrigation System Test Record

Test Number_____

Nursery _____ House or Bed _____
Name of Nursery — Name or Code of Shelter house, seedbed, polybag bed, etc.

Irrigation System _____Nozzles_____ Spacing ____/____Type _____
Type of system i.e. (Solid Set or Traveling boom) — Make and model — Distance between lines/nozzles — Rectangular or triangular

Location of Grid_____
Specific location of grid layout (EXAMPLE: Waterline #4, between sprinklers #8 and #9.

Collection Container _____ Inside Diameter of Top _____
Type of Container (i.e. 4 Oz. Plastic Dixie Cup) — mm

Duration of Test _____ min. Wind _____ System Pressure_____
Length of time water collected — Speed and direction of wind — During test

Technician _____Date_____ Time_____
Name of person(s) performing test — Date — Time of day

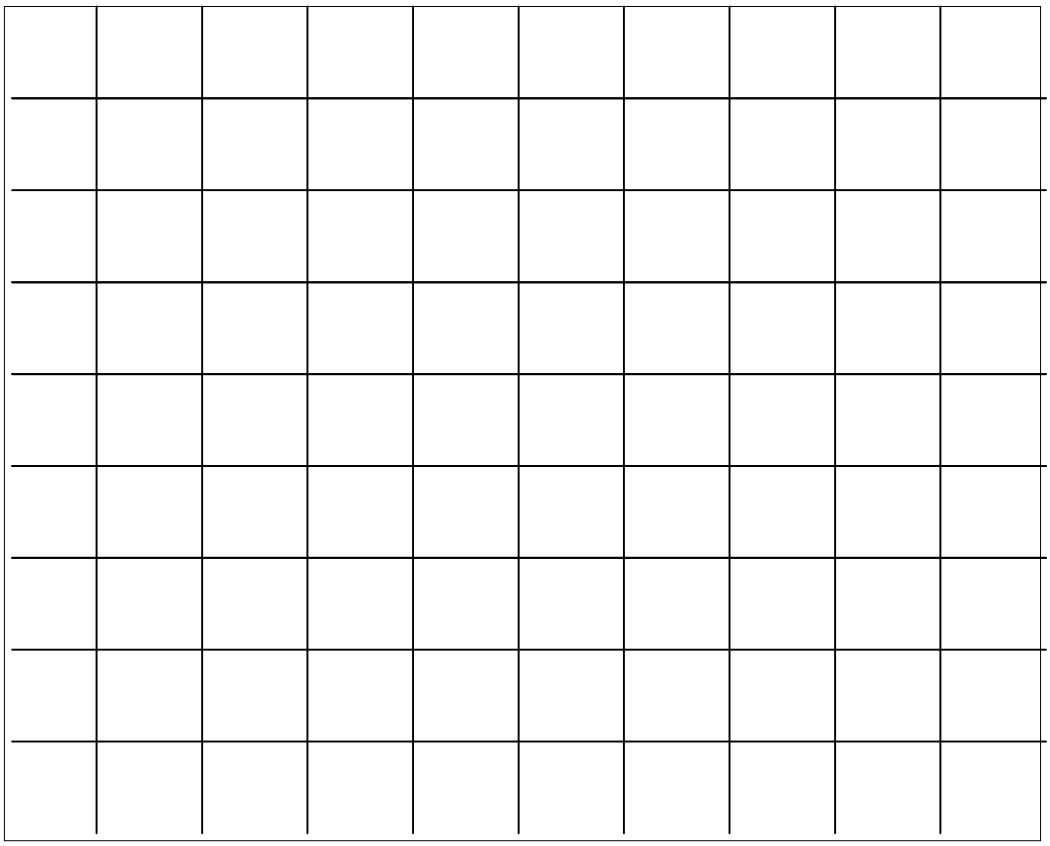

Figure 3

A completely uniform irrigation pattern will produce a CU of 100%, and the lower the CU, the more variable the irrigation. The standard target for most agricultural irrigation systems is a CU of 85%, which also works well for forest and conservation crops.

Distribution patterns: Determine the average cup volume and subtract it from the volume of each individual cup. Place these values on your paper grid. Negative numbers indicate points where rates are less than the average and positive numbers are greater than average. You might see a pattern of wetter and drier spots associated with the location of the sprinkler heads.

Irrigation rates: To find the average delivery rate (inches or centimeters of water per hour) of your system, sum all cup volumes and divide by the total collection area (area of cup opening multiplied by the number of collection cups), then divide by the hours the system was tested. This value can be used to determine timing and application rates.

Fine Tuning Your System

- Check Location of Nozzles. They should be located at equal distances along the supply line.

- Check the Alignment of Nozzles. For most nozzles to operate properly, they must be installed exactly above (or below) the supply line. Any that are tilted may be causing distribution problems. Reinstall nozzles that are tilted.

- Adjust the System. Water distribution of both solid set and traveling boom type irrigation systems can be adjusted by raising or lowering the height of the nozzles above the crop surface and/or adjusting the water pressure. Water distribution will change dramatically as the crop grows higher and intercepts the water at different levels. Rather than waiting until you notice dry spots or actual growth differences in your crop, try some "pre-crop" checks with the cups raised to different levels. This will provide you with data to know when to raise the booms or sprinklers as the crop grows in height. Remember to periodically clean all filters of the irrigation system to assure that uniform water pressure is being emitted from each nozzle.

- Other Corrective Measures. If the coverage is still not acceptable, try installing different nozzles. Last and most drastic would be to change the spacing of the nozzles or the type of system being used. Changes being considered for a solid set system can be tested using a small "model" system of two supply lines with four nozzles. Test the water distribution of the trial system the same way you tested the production system.

After fine-tuning collect water volume data again and compare coefficient of uniformity values and distribution variability. If the adjustment worked, there should be a higher coefficient value. Periodic checks of your irrigation system are required at a minimum at the beginning of each crop. The orifice of all nozzles wear over time, especially nozzles of a soft material such as plastic or brass. Wettable powders such as fungicides are known to increase nozzle wear.
Consider having your data analyzed by others. There are university programs and irrigation system vendors who utilize sophisticated computer analysis programs to calculate factors such as uniformity coefficient, distribution uniformity and scheduling coefficient. They may also provide "3D" graphics or "density" diagrams allowing visual analysis of irrigation distribution. However, these programs are likely to have certain data collection protocols for the programs to work properly, so be aware that data you collect on your own may not fit into their program. If there is a chance that you will be working with a university specialist or a vendor, it is highly advisable that you contact these sources before you begin testing.

Some newer programs only require a single sprinkler and one or two lines of collection containers. The computer program will do the rest, filling in overlapping sprinklers, etc. These programs are intended to save you time and effort. However, these programs rely mostly upon theory. Uneven pressure at individual nozzles and even the collision of water droplets can cause actual distribution to vary from the theoretical. You may want to make your collections exactly as required by the program but also run a couple of "check" tests of the system using a full grid