systemevaluation

COTTON CRC WATER TEAM

How to evaluate the performance of centre pivot and lateral move systems

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The performance of an irrigation system plays a significant part in the performance of your crop – it affects yield, water use efficiency and cost of production to name a few.

There has been much pressure on managers of surface irrigation systems to improve their performance. Many have done so by changing management practices and system configuration and design. Quite a few others have opted to change to centre pivot or lateral move systems on the basis that they are more efficient. But this is not necessarily true, even for newly installed systems.

From several simple field tests and a few calculations, you can check the uniformity, application depth, system capacity, speed and emitter performance of your overhead system.

Testing uniformity

For machines using sprinklers, the basic test is a catch can test. By laying out a row or two of containers and measuring the amount of water applied in each individual container, a lot of useful information can be determined. The process is not difficult and no special equipment is needed.

For machines using LEPA socks or bubblers, the same calculations can be performed by substituting the discharge at each outlet for the catch can data.

Catch can layout and centre pivot

When using catch cans:

- use relatively small containers, preferably all the same size and shape to make calculations easier. Plastic food containers with diameter 110-115mm, as used by takeaway Chinese food restaurants, are cheap and handy. Irrigation Australia sells calibrated catch cans complete with peg and holder. Rain gauges are okay if you can afford to buy enough of them.
- Choose a suitable location for the test so that catch cans are able to be placed across the pathway of the linear move or centre pivot. The location should be far enough ahead so that no water enters the catch cans before they are all set up. Often the first span or two of a centre pivot (no more than 20% of the machine length) are ignored as they can be difficult to set up and contribute little to the area under consideration.
- Lay the cans out in a row, spaced no more than 5m apart. For sprinklers with a smaller throw radius (such as static plate sprinklers) it is recommended that cans are no more than 3m apart. Avoid placing them where they will be damaged (eg. in wheel tracks), will receive excessive water (eg. directly under tower components) or be knocked over. If they're not pegged, it pays to put a small weight in each one eg. a stone.

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- Add at least two extra containers on each end to allow for changes in wind speed or direction.
- If rain is likely, place another can away from the boom to record rain during the test. Any rain must be deducted from the amount caught in **each** catch can.
- When the machine has completely passed over all of the catch cans, measure and record the volumes in **each** container. Each volume MUST be written in the space on the field record sheet that corresponds with its position. If there is no catch can or no reading at a position, leave it blank.

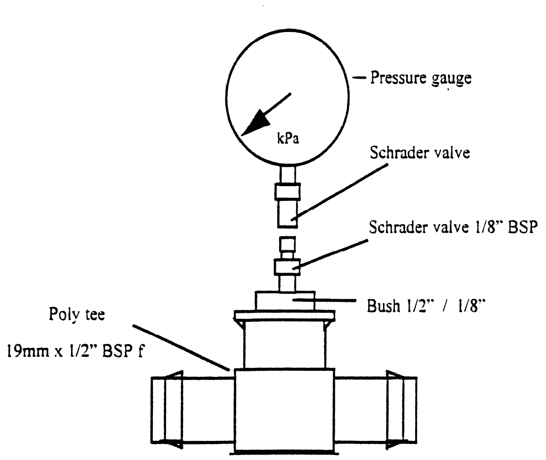
Performing system check on centre pivot

Testing Pressure

Obtain suitable tees and fittings to be installed above the pressure regulators or emitters (eg. Figure 1) sufficient for several emitters, and a suitable pressure gauge.

Attach fittings, etc. above the pressure regulator and emitter at a number of locations. Select several emitters, at least one on the first span, one on the last span and one in between.

Figure 1: Fittings and Schrader Valve



Record the make, model and nozzle size or colour of the emitters, and the outlet position number from the centre.

When the system is operating, record the pressure of the selected emitters using the pressure gauge. If possible, take a reading at the centre or cart too.

Checking emitter flow rate

When the system is operating, measure the flow rate by holding a fairly large container of known volume (eg. 10 L bucket) under one emitter and timing how long it takes to fill. (Don't forget your raincoat!) Record measurements from at least one emitter per span and note the span and outlet position numbers.

Measure the wetted diameter of these emitters. For a centre pivot, avoid the inner spans. Placing pegs or markers at the limits of throw in front and behind the boom, then measuring the distance between them after the machine has passed is the simplest way.

If a flow meter is fitted, take a reading of the flow delivered to the entire machine.

Centre pivot pressure check

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Measure the speed

- The irrigator must be moving (at its normal speed) throughout the test
- Record the control panel settings/readings for speed and application depth.
- Mark a point on the ground when you first arrive that is level with a specific point on the machine and record the time. For a centre pivot, it must be a point on the **outer** tower. When you have finished taking other measurements, mark where that point on the machine has now travelled to and record the time again.
- Measure the distance between your two marks (this distance should be at least 10 metres, otherwise come back and mark the second point later).

Other information

- Measure and record the tyre sizes and pressures – should be around 100 kPa (15 psi).
- Record wind speed and direction.

Calculations

From the catch can data, the Average Application per Pass and the Distribution Uniformity or Coefficient of Uniformity can be calculated. Spreadsheet calculators to reduce the time and complexity may be available from your irrigation advisor or agency.

- convert the volume measurement (mL) of each catch can into a depth measurement (mm).

Depth = Volume ÷ (3.14 x radius^2)

For catch cans of 110 to 115 mm diameter, simply dividing by 10 will be accurate enough.

Average Application Depth (AAD) = Total depths of all cans ÷ no. of cans

Compare this to the application depth specified on the control panel or operating schedule for that speed.

Distribution Uniformity (DU) = Average depth of Lowest Quarter cans ÷ AAD

For Centre Pivots, DU must be calculated by weighting each catch can result relative to its position. This is because each can represents a larger area as you move out from the centre, and the output should also increase as you move out from the centre. The Lowest Quarter average depth is obtained using the lowest quarter weighted catches. The calculations for this are complex and spreadsheets are available to do them.

Christiansen's Coefficient of Uniformity (CU) – compares depth for one catch can position to the average depth for all catch cans.

For Centre Pivots the modified Heermann and Hein uniformity *co*-efficient must be used (CU_{HH}). This calculation weights the catch can results relative to their position.

- CP&LM machines should be able to perform with a DU or CU_{HH} of 90% or greater.

Note that for LEPA systems the emitter discharges measured will be used for uniformity calculations instead of the catch can measurements.

Emitter flow rate = Container volume ÷ Time taken to fill

Compare the test results with the flow specified for each emitter in the manufacturer's specifications. Variations help to explain any poor uniformity and maybe due to worn sprinklers, faulty pressure regulators, emitters in wrong position, incorrect emitters fitted, overall flow rate too high or low, etc.

Pressure measurements

Compare the test results with the pressure specified for each emitter in the manufacturer's specifications.

For pressure regulators to work properly, the pressure above a regulator should be at least 35 kPa (5 psi) higher than the specified pressure.

Excessive pressure at the end of the machine is costing you money! Whilst the pressure needs to be greater than the value of the regulator, it should not be significantly higher as this pressure is being generated for no reason.

Don't forget that the pressure at the end of the machine will vary if you are operating on a hill.

System Capacity = Pump flow rate (L/day) ÷ Field irrigated area (m^2)
= Pump flow rate (ML/day) x 100 ÷ Field irrigated area (ha)

Compare this to the machine specifications and/or peak daily crop water use.

Travel speed = distance travelled during test ÷ time taken during test

Compare this to the speed specified on the control panel or operating schedule.

Average Application Rate (AAR) = Emitter Flow Rate ÷ Sprinkler Wetted Area

Compare this to soil's infiltration rate. If it is substantially larger, you will need to implement strategies to hold water on the surface (cracks, cultivation, furrow dykes, stubble retention, etc).

Comparing System Capacity, Travel Speed and Average Application Depth

Often average application depth and system capacity are confused. If the machine has a system capacity of 12mm/day, and it is set to a speed that has it covering the entire field, non-stop, in exactly 1 day, then it will apply 12mm of water.

If the machine is slowed down by exactly half, it will take 2 days to cover the whole field and will be applying a depth of 24mm water.

For Lateral Move systems:

$$\text{Application Depth (mm)} = \frac{\text{System Capacity (mm/day)}}{\text{field length (m)} \div \text{travel speed (m/day)}}$$

For Centre Pivot systems:

$$\text{Application Depth (mm)} = \frac{\text{System Capacity (mm/day)}}{\text{Field circumference (m)} \div \text{travel speed at circumference (m/day)}}$$

Checking flow rate at river pump

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