WaterWise on the Farm

Introduction to Irrigation Management

Evaluating your pressurised system

System 1
Travelling irrigators and rotating booms

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Aim

The aim of this workshop is to evaluate your travelling irrigation system. To do this you need to determine the rate that water is being applied, and how uniformly that water is being distributed over your irrigation area, by calculating the MAR and DU for your system. These worksheets outline the equipment and procedure needed for you to calculate these values.

Overview

Travelling irrigators

These irrigators come in two forms: with a soft hose/cable drum machine, or with a hard hose drum. Both incorporate a 'big gun' sprinkler. They are commonly used to irrigate pastures and lucerne, but machines with elevated wheels can be used on taller crops.

The **soft hose irrigator** is a self-propelled unit comprising chassis, wheels, hose reel, drive mechanism and sprinkler. The unit is moved by hydraulic cylinder or turbine drive though a lever action to a cable drum. A winch cable is anchored at the opposite end of field and the irrigator advances as the cable is wound onto the drum. Water supply is provided from the irrigation main though a heavy-duty drag hose pulled behind the irrigator. This hose may be 100 to 200 metres long. The water motor develops the pulling power across a range of operating conditions and speeds.

The **hard hose irrigator** remains stationary in the centre of the field and, when the drive mechanism is pressurised, the hose reel rotates and rewinds the hose, pulling the sprinkler unit across the paddock at the desired travel speed. The hose reel, which is mounted on a turntable, can then be rotated though 180^{o} so irrigation can be performed on the opposite side of the field. The drive mechanisms for these machines are either bellows or turbines. The bellows system ensures that all energy is directly utilised to drive the hose reel and can be activated by low pressures and flows.

Travelling irrigators only require one person to operate them. The nozzle size (with ring nozzles) and travel speed can be adjusted to suit the soil infiltration rate and crop water requirements.

The most efficient operating pressures to maintain sprinkler operation and develop pulling power are between 400 kPa and 600 kPa. The high pressure is the biggest disadvantage of these machines, because this means high pumping costs.

Rotary boom irrigators

Rotary boom irrigators are similar in concept to the soft hose travelling irrigator except that the big gun sprinkler is replaced by a galvanised boom fitted with medium to low pressure sprinklers.

The boom of the irrigator is rotated by the discharge from the sprinkler nozzles. This rotating boom then provides the energy to operate the drive mechanism and cable winch.

Various sprinkler combinations (big gun, rotating, and low pressure) can be used. Working pressures range from 70 kPa to 500 kPa.

Because these irrigators are large and self-propelled, they can only be used on clear, flat paddocks.

Equipment needed

- ***To measure pressure:***
    - an accurate pressure gauge that can be attached to the irrigator. It should have an appropriate scale so it works mid-range at normal pressures (say 0 to 1000 kPa)
- ***To measure coverage:***
    - catch cans (between 20 and 40 may be needed depending on your coverage width) (4-litre square ice-cream containers are good catch cans)
    - gravel pieces to place in containers to stop them blowing away
    - a 30-metre measuring tape
    - a shovel for smoothing areas to set catch cans
    - a measuring cylinder or jug with graduations in millilitres
    - a calculator, a pen and evaluation sheets
    - if possible, manufacturers performance charts giving showing pressure versus wetted diameter, pressure range, and output rates.

Evaluation method

To assess the performance of your travelling or rotary boom irrigator, you need to measure the pressure at various points in the system, the operating speed at the far end, and the output of the sprinklers using catch cans. To do this, work through the following procedure.

> **Occupational health and safety**
>
> Whilst working with travelling irrigators, you, and anyone assisting you, should at all times be aware of the inherent dangers associated with working near moving machinery and high pressure water. Safety should be the primary concern at all times.

1. Before starting the irrigator, fit the pressure gauge.
2. Record details of the make and model of the irrigator, and the type of nozzle attached (ring or tapered).
3. Select a test location for the catch cans about midway along the run. The location should be:
    - far enough ahead of the irrigator so no water reaches the catch cans before the test commences.
    - far enough from the end of the run so that the irrigator coverage has completely passed over all catch cans.
    - where the catch cans will be upright and stable. Set the catch cans in a straight line across the irrigators' towpath.
    - Place the containers 5 metres apart. Work out from the centre line with the first catch can being 2.5 metres from the centre line, then subsequent catch cans being 5 metres apart.
    - The outer catch cans should be at the edges of the wetted strip. Add two extra cans each side to allow for changes in wind conditions.
    - If there is the chance of rain during the test, place a further can out of range of the irrigator to collect rainfall. Any rainfall collected must be deducted from the amount collected in all other cans.
    - Weight the cans with stones to prevent them blowing away or being knocked over by the stream of water from the irrigator. Make sure grass or other foliage doesn't interfere with water entering them.
4. Measure the operating speed of the irrigator by placing a marker (a peg) next to one wheel and then 20 minutes (say) later placing another next to the same wheel.
    - Record the distance covered, and time.
5. At some convenient time
    - during the test, record the wind direction and approximate speed (see table on next page)
    - measure the operating pressure at the irrigator
    - measure the diameter of coverage of the irrigator
    - measure the distance between each run (or irrigation lane spacing)

6. When the irrigator has completely passed over all of the catch cans measure and record the volumes in EACH can. Each volume MUST be written in the correct space on the field record sheet.
7. Make sure all field data has been recorded and entered onto the field record sheet.

Wind speed guide		
Visible effect	**Wind description**	**Speed - knots**
Calm. Smoke rises vertically.	Calm.	00
Direction of wind shown by smoke drift but not wind vane.	Light air.	02
Wind felt on face. Leaves rustle. Vane moved by wind.	Light breeze.	05
Leaves and small twigs in constant motion. Wind extends light flag.	Gentle breeze.	09
Raises dust and loose paper. Small branches are moved.	Moderate breeze.	13
Small trees in leaf begin to sway. Crested wavelets on inland waters.	Fresh breeze.	18
Large branches in motion. Whistling heard in telegraph wires.	Strong breeze.	24
Whole trees in motion. Inconvenience felt when walking against wind.	Moderate gale.	30
Breaks twigs off trees. Generally impedes progress.	Fresh gale.	37
Slight structural damage occurs.	Strong gale.	44
Trees uprooted. Considerable structural damage. Seldom experienced inland.	Whole gale.	52
Very rarely experienced. Accompanied by widespread damage.	Storm. Hurricane.	60 68

Source: Bureau of Meteorology

Table 1 Converting mL to mm of irrigation

For catch-cans of 110 to 115 mm diameter across the top, just divide the collected amount by 10 to get mm of irrigation.

For instance if you collected 674 mL, this is equivalent to a depth of 67.4 mm.

If the size of the catch cans is different, or you wish to be more accurate, use the table alongside.

Divide the amount caught by the figure in the right hand column. For instance, if the diameter is 110 mm and you catch 674 mL this is 674 ÷ 9.5 = 71 mm

If you use 4 litre square plastic 'ice cream' containers,
1 litre collected in one of these is equivalent to 25 mm of irrigation.
On a calculator, use **"water collected in mL" ÷ 40 = mm**

Converting mL to mm

Diameter of catch can (mm)	Figure to divide the collected amount by
75	4.4
80	5.0
90	6.4
100	7.9
102	8.2
104	8.5
106	8.8
108	9.2
110	9.5
112	9.9
113	10.0
114	10.2
115	10.4
120	11.3
125	12.25
145	16.5
165	21.3
200	31.4
220	38.0

Data sheet	
Name	R T Fischal
Crop	Lucerne
Location/block	Paddock 2/3
Soil texture	loam
Effective root depth	0.8 m
Rootzone RAW	72 mm
Max. infiltration rate	30 mm/h
Type of irrigator	**Fixed** **Rotating boom** Big Gun
Irrigator make and model	Southern Cross 75
Sprinkler make	Nelson 150 series
Nozzle type/size	taper - 25 mm
Nominal operating pressure	440 kPa
Lane spacing (approx only)	m
Irrigation frequency	10–14 days
Sprinkler wetted diameter	80 metres
Irrigation run length	200 to 280 m
Test start time	9.15 am
Test end time	10.15 am
Test duration and distance covered	60 minutes to cover 35 metres
Wind direction & speed during test	

Field layout record

Irrigator direction of travel ↑

Step 1 **On this sheet draw two vertical lines to mark the TOWPATH position** (see heavy lines)

TOWPATH LANE SPACING (m): 80 | 70 | 60 | 50 | 40 | 30 | 20 | 10

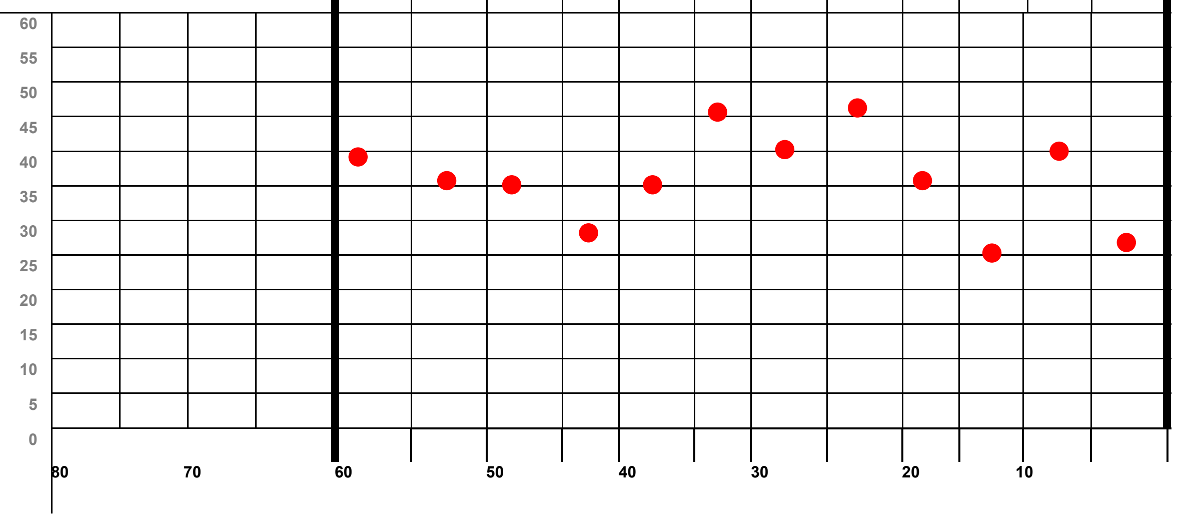
Left side of TOWPATH

	L16	L15	L14	L13	L12	L11	L10	L9	L8	L7	L6	L5	L4	L3	L2	L1
Catch can number: **Step 2** Enter the **Volume collected (mL)**	0	0	0	0	0	0	0	0	50	180	200	280	300	250	380	230
Catch can number: **Step 3** Convert volumes (mL) to depths (mm) - **Depth of irrigation (mm)**	0	0	0	0	0	0	0	0	5	18	20	28	30	25	38	23
Catch can number:					R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12
Step 4 **Copy right-hand depths to these boxes -** Commence with 'R1' to the right of the tow path line (mm)					39	36	36	27	30	28	22	19	7	0	0	0
Step 5 **Catch totals (mm)** Add left and right can depths between tow path lines					39	36	36	27 (circled)	35	46	42	47	37	25 (circled)	38	23 (circled)
Step 6 **Circle ¼ of the catch totals** that contain the smallest depths.																
Step 7 Add up all depths to obtain a **TOTAL APPLICATION DEPTH (mm)**					431 mm											

Right side of TOWPATH

	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	R15	R16
Step 2 Volume collected (mL)	390	360	360	270	300	280	220	190	70	0	0	0	0	0	0	0
Step 3 Depth of irrigation (mm)	39	36	36	27	30	28	22	19	7	0	0	0	0	0	0	0
Step 4 Catch can number:	R13	R14	R15	R16												
Step 4 (mm)	0	0	0	0												

Step 8 **Graph the catch totals on the chart below**
Enter the figures on the scale appropriate to your system (0 to 60, or 0 to 120 for instance)



Calculating the application amount

	Example	Your data
Total application depth collected [A]	**431 mm**	
Average application depth [B] **= [A] ÷ number of catch-totals within lane spacing** NB Not the number of catch cans	**= 431 ÷ 12** **= 35. 9 mm**	
Rootzone RAW (from data sheet)	**= 72 mm**	

This amount should be compared to the rootzone RAW on the data sheet. For the example, the application depth is half the RAW.

Calculating the mean application rate (MAR)

Irrigator test time	**60 mins**	
Distance travelled during test	**35 m**	
Travel speed [S] = distance ÷ time	**= 35 ÷ 60** **= 0.583 m/min** **= 0.583 x 60 m/h** **= 35 m/h**	
Sprinkler wetted diameter	**80 m**	
MAR = (B x S) ÷ wetted diameter	**= (35.9 x 35) ÷ 80** **= 1256.6 ÷ 80** **= 15.7 mm/h** **say 16 mm/h**	
Infiltration rate (from data sheet)	**= 30 mm/h**	

The MAR should be less than the infiltration rate.

If it is not then run-off is likely to be a problem.

Calculating distribution uniformity (DU)

	Example	Your data
Catch totals between laneways	=12	
A quarter of the number of catch totals [LQ] (If not a whole number, round down)	= 3	
On your field layout record sheet, highlight the lowest amounts for the appropriate number of LQ totals.		
Total the depths in the **LQ totals**	= 27 + 25+ 23 = 75 mm	
Average depth of LQ totals (Total of LQs ÷ number of LQs)	= 75 ÷ 3 = 25 mm	
DU = average LQ ÷ [B]	= 25 ÷ 35.9 = 0.696	
As a percentage, the DU is	= 0.696 x 100 = 69.6 % say 70 %	

A DU of 75 % is acceptable. If the DU is below this changes to improve DU need to be considered.

There are a range of factors that can change be attempted to change the application rate or improve the DU.

The best option will depend on your individual situation. Consider:

- increasing travel speed
- changing the lane spacing
- changing nozzle size and type, and pressure

Blank evaluation sheets

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If the size of the catch cans is different, or you wish to be more accurate, use the table alongside.

Divide the amount caught by the figure in the right hand column. For instance, if the diameter is 110 mm and you catch 674 mL this is 674 ÷ 9.5 = 71 mm

If you use 4 litre square plastic 'ice cream' containers, 1 Litre collected in one of these is equivalent to 25 mm of irrigation. On a calculator **"water collected in mL" ÷ 40 = mm**

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Name	
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Location/block	
Soil texture	
Effective root depth	m
Rootzone RAW	mm
Max. infiltration rate	mm/h
Type of irrigator	**Fixed** **Rotating boom** **Big Gun**
Irrigator make and model	
Sprinkler make	
Nozzle type/size	- mm
Nominal operating pressure	kPa
Lane spacing (approx only)	m
Irrigation frequency	days
Sprinkler wetted diameter	m
Irrigation run length	m
Test start time	am
Test end time	am
Test duration and distance covered	minutes to cover metres
Wind direction & speed during test	

Field layout record

Irrigator direction of travel

Step 9 **On this sheet draw two vertical lines to mark the TOWPATH position** (see heavy lines)

TOWPATH LANE SPACING (m)

80		70		60		50		40		30		20		10	

Left side of TOWPATH | **Right side of TOWPATH**

Catch can number	L16	L15	L14	L13	L12	L11	L10	L9	L8	L7	L6	L5	L4	L3	L2	L1	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	R15	R16
Step 10 Enter the **Volume collected (mL)**																																
Catch can number	L16	L15	L14	L13	L12	L11	L10	L9	L8	L7	L6	L5	L4	L3	L2	L1	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	R15	R16
Step 11 Convert volumes (mL) to depths (mm) - **Depth of irrigation (mm)**																																
Catch can number					R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	R15	R16												
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60
55
50
45
40
35
30
25
20
15
10
5
0

80 70 60 50 40 30 20 10

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Average depth of LQ totals **Total of LQs ÷ number of LQs**	**= 75 ÷ 3** **= 25 mm**	
DU = Average LQ ÷ [B]	**= 25 ÷ 35.9** **= 0.696**	
As a percentage the DU is	**= 0.696 x 100** **69.6 %** **say 70 %**	

A DU of 75 % is acceptable. If the DU is below this, changes to improve DU need to be considered.