WaterWise on the Farm

Introduction to Irrigation Management

Evaluating your pressurised system

System 7

Non-overlapping under-canopy spray system

160501

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CONTENTS

Aim

To assess your irrigation system you need to determine the rate that water is being applied, and how uniformly that water is being distributed. To check these you need to know the MAR and DC for your system. These worksheets outline the equipment and procedure needed for you to do this for a non-overlapping under-canopy spray system.

System overview

Non-overlapping under-canopy irrigation is a form of micro-irrigation which has been around since the 1950s. It is used mainly for irrigating tree crops, orchards, some vegetables, nurseries and urban parks and gardens.

With this form of irrigation individual sprinklers are placed adjacent to trees or vines so as to deliver water to the plant rootzone rather than water the entire field.

There are a great number and variety of micro-sprinklers on the market suitable for non-overlapping under-canopy irrigation. These micro-sprinklers come in various sizes, perform various duties, have differing discharges, pressures, diameter of throw and distribution of throw.

The design and selection of the correct micro-sprinkler, filter, mainlines and other components for your requirements is therefore essential for the efficient operation of your irrigation system.

Sprinklers operate within a pressure range between 50 kPa and 300 kPa. The maximum working head of 300 kPa is adopted where low-density polyethylene pipe is used in the laterals.

Discharge rate can vary from 20 litres per hour to over 300 litres per hour. Sprinkler discharges over any operating block are generally designed with a pressure differential tolerance of +/- 10%, so as to maintain a near uniform flow distribution. Pressure compensating sprinklers have aided this over recent years.

Filtration is an integral part of any micro-irrigation system and needs to be able to filter out any particles 1/3 to 1/6 of the smallest nozzle orifice. Filter selection will vary depending upon the quality of the water supply source.

Irrigation systems can be fully automated or manually controlled, thus giving better control over the frequency of application.

Equipment needed

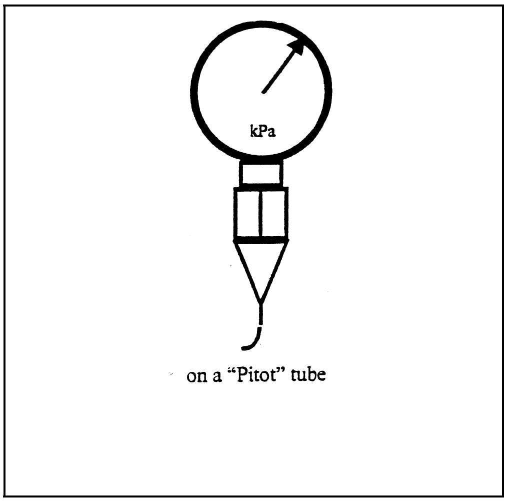
To measure sprinkler coverage:

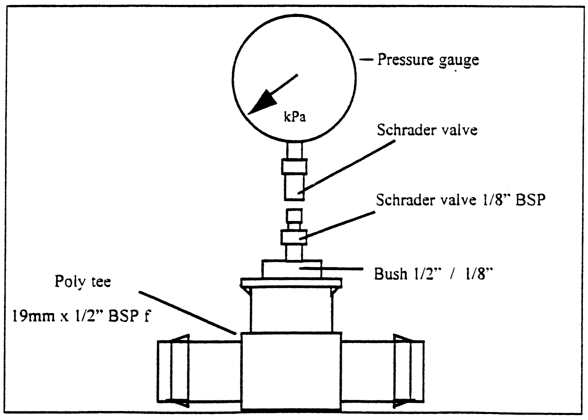
- catch cans
- weights to prevent catch cans blowing away
- a shovel to smooth catch can area, and where necessary for partially burying the cans
- a measuring cylinder or jug with graduations in millilitres
- a 30-metre measuring tape; and possibly a short rule
- a calculator, a pen and evaluation sheets
- manufacturer's sprinkler performance charts

To measure pressure:

- an accurate pressure gauge with an appropriate scale so it works mid-range at your normal pressures (say 0 to 400 kPa) to 1000 kPa
- a pitot tube attachment (pronounced pit-oh), or a theaded 15 mm PVC tee and fittings such as reducing bushes for small low-level sprinklers, or a Schader valve, or a needle valve fitting

Figure 1, a and b





Schrader valve

To measure flow:

- plastic tubing that can be placed over the sprinkler nozzles and long enough to go from the sprinkler to a container
- a measuring cylinder, jug or bucket, clearly marked in litres

- a watch capable of measuring seconds

Kits containing some of this equipment are available on loan from your WaterWise on the Farm facilitator.

Evaluation method

To assess the performance of your system, you need to measure the pressure and flow at various points in the system and, to measure evenness of application, collect the output of the sprinklers using catch cans. Work through the following procedure.

Step 1 Measure the output rate (flow) and pressure of sprinklers at the extremities of the block being irrigated. This will show the variability across the block.

Measure the flow and pressure of the first and last sprinklers of the first and last laterals in the block (see figure 2) by directing the output into a container marked with volume measurements. (Alternatively use any suitable container and then transfer the water into a measuring cylinder.)

Step 2 Choose rows and sprinklers to be used for the catch can test. Make sure water can be caught from only one sprinkler (no overlap). It's a good idea to select sprinklers for which you have recently checked the pressure and flow – if they are suitable.

Step 3 Give the rows an identification number (Row A, Row B with the can nearest the sprinkler being A1 out to A6). Draw a sketch of the layout so you know which can is where.

Step 4 Decide on the spacing you will use for your catch cans. Place the catch cans in a row across the diameter of the sprinkler's wetted circle as shown in figure 3 with the first can at **half this spacing** from the sprinkler (this is important!). As an example, if the catch cans are to be 0.5 m apart the first can should be 0.25 m from the sprinkler.

Use enough cans to collect to the edge of the wetted circle of the sprinkler. (The more closely spaced your cans are, the more accurate your result will be.)

Make sure the catch cans are upright and stable. If necessary, weight them down with stones or gravel. With certain types of sprinkler it will be necessary to sink the cans into the ground.

Make sure that grass and other foliage does not interfere with water entering the catch cans, and make sure the sprinkler is sitting vertically.

Step 5 Record the brand, type, model, colour nozzle sizes and operating pressures of the sprinklers to be used as well as the spacings of the sprinklers and catch cans.

Step 6 Turn on the water to fill and pressurise the lines. Make sure the system is operating at normal pressure.

Step 7 **Start the test and leave the sprinklers running for an hour.** (If you run for a different time you will need to adjust your calculation to simulate an hour-long test.)

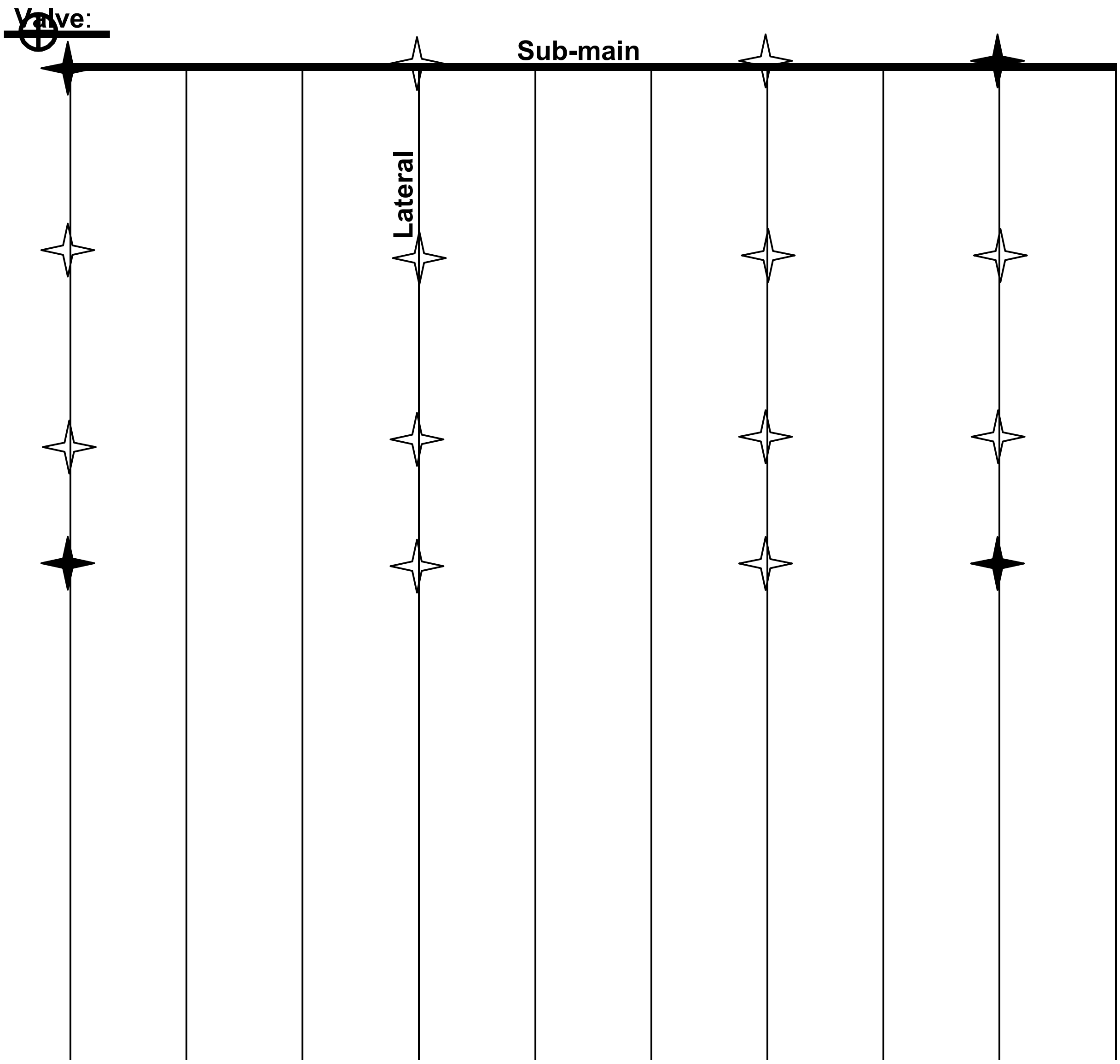
Step 8 At the end of the test period, accurately measure the volumes of water collected by pouring the contents of each catch can into a graduated jug or measuring cylinder and recording the results on the record sheet.

If/when time permits:

Step 9 Repeat the test for several sites.

Figure 2. Layout of selected sprinklers

Selected sprinklers are 'black'.



In a large block you may wish to test more sprinklers. Similarly, if you find a large variation you should test some additional ones. You could select sprinklers in (say) laterals 5 and 10, or just at random across the block.

Field record sheet

(example data partially entered)

Name: Tony Hellyer	Location: Bathurst	Date: July 3 2000
Crop: Peaches & Plums	Soil type/texture:	RAW for crop: mm
Effective root depth: m	Sprinkler make: EINTAL	Sprinkler model: MICROJET 35 L/h
Tree pattern: row spacing __5 ____ m tree spacing __4_____ m	Nozzle size: mm	Lateral spacing: m
Sprinkler distance to tree: m	Sprinkler height: 180 mm	Sprinkler wetted diameter: m
Sprinkler spacing in row: m	Usual frequency of irrigation: days	Usual length of irrigation: hours

Pressure and flow record sheet

Sprinkler locations >>>	Fill in details of lateral and sprinkler/emitter positions below Example				
Sprinkler output (L)	180 mL (0.18 L)				
Test time (minutes)	18 s (0.3 min)				
Wetted diameter (m)	4.0 m				
Flow rate (litres/hour) $= \frac{\text{Output (L)}}{\text{Test time}} \times 60$	$\frac{0.18}{0.3} \times 60$ =36 L/h				
Pressure (kPa)	250 kPa				

NB Volumes are in Litres and times in minutes. If you use other units, don't forget to convert them!

Figure 3. Positioning for two rows of catch cans

[figure to come]

Note: If there are unusual conditions such as strong wind or a steep slope, use four rows of cans. Call these Row C and Row D.

Figure 4. Positioning for four rows of catch cans

[figure to come]

System 7. Non-overlapping under-canopy spray system

Catch can record sheet- (example data)						Data conversion sheet				
Catch can position	Distance from sprinkler (m) [A]	Row A	Row B	Row C (optional)	Row D (optional)	Totals for each position (mL) [B]	Totals converted per hour (mL/h) [B]	Average output / row B / 2 or B / 4 (mL/h) [C]	Depth of applic. (mm) [D]	Dist. from sprinkler x Depth A × D
1	0.25	78	76			154	154	77	7.7	1.9
2	0.75	66	70			136	136	68	6.8	5.1
3	1.25	25	39			64	64	32	3.2	4.0
4	1.75	0	8			8	8	4	0.4	0.7
5	2.25	0	0			0	0	0	0	0
6										
7										
8										
9										
10										
11										
12										

Start time : 11.25 **Finish time:** 12.25. **Length of test:** 1 hour

Total>>> 11.7 **E]**

Completing the data conversion sheet

Step 1 Complete the totals column **[B]** of the catch can record sheet by adding the volumes from the two or four rows. If your test was not for exactly one hour, convert the totals to a per-hour rate in the second **[B]** column.

Step 2 Calculate the average volume collected for each position **[C]** by dividing the total volume **[B]** by the number of rows (two or four).

Step 3 Convert the average volume **[C]** to depth of irrigation using the data in table 1.

Step 4 You now need to multiply the distance from the sprinkler **[A]** by the depth of application **[D]** to get the values for the final column.

Step 5 Add up all of the figures in the final column to obtain **[E].**

(This figure is needed to enable the MAR and DC to be calculated later.)

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 table 1.

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**

Table 1: Converting mL to mm of irrigation

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

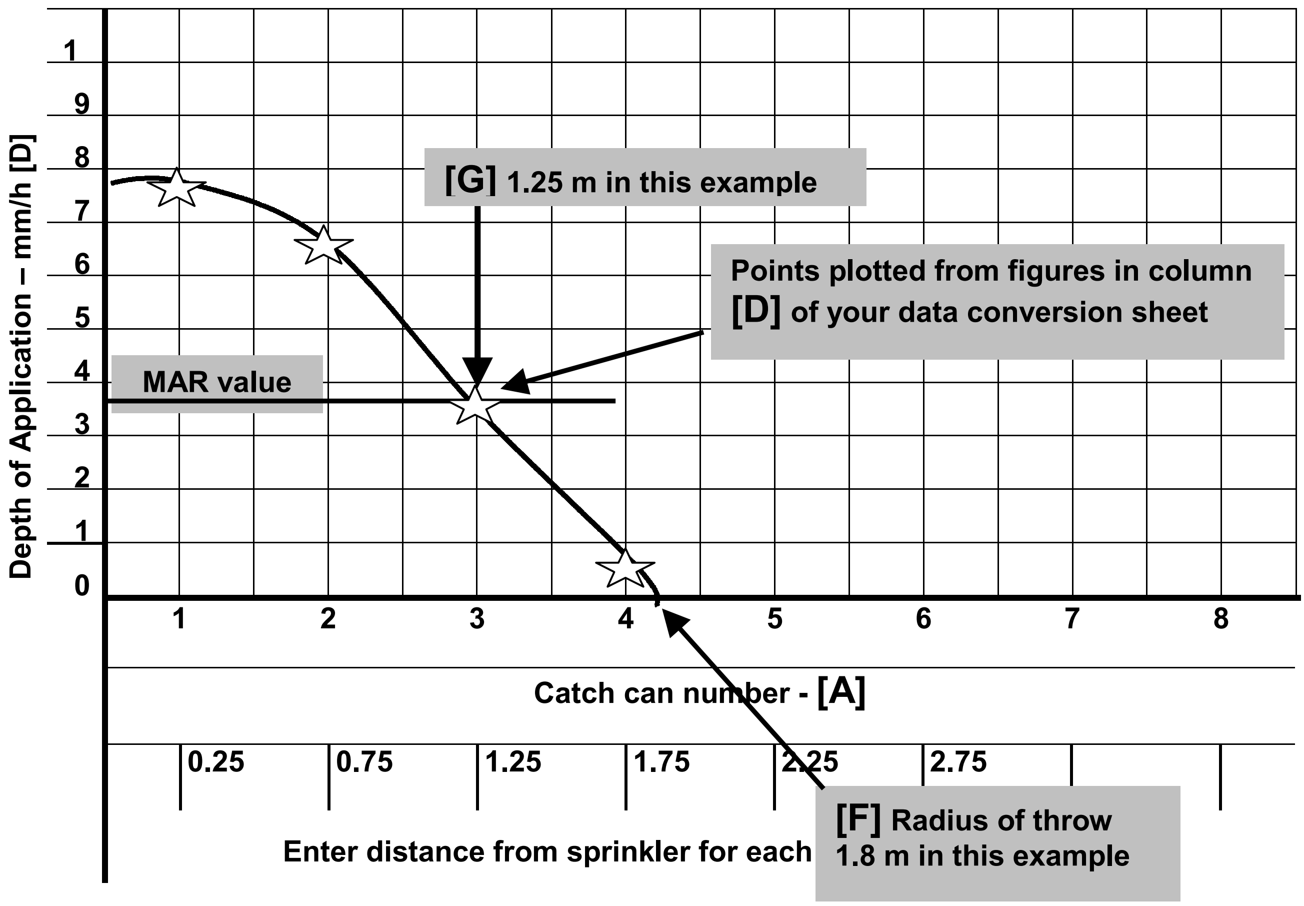
Graphing your data

To enable evenness of sprinkler coverage to be calculated you now need to graph the sprinkler output, as shown in the example below.

Step 1 Take the readings of depth [D] from your data conversion sheet and on a blank graph, mark the output for each position moving away from the sprinkler.

Step 2 Join the points to form an application curve. **Later**, after you've done the next section, you'll add the horizontal MAR line to the chart and mark position [G].

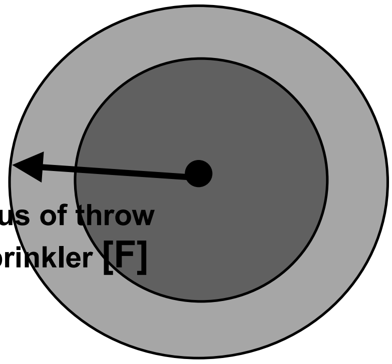
Figure 5. Graphing your data



The ideal shape for the graph above would be flat, showing that all areas were getting an equal coverage of water. In reality most systems will be similar to that shown in the example, with coverage falling further from the sprinkler/emitter.

Calculating MAR

Step 1 Note the radius of throw either by looking at the catch can record sheet, and noting where the coverage cuts off, or by noting point **[F]** on the graph you plotted.



Effective radius of coverage [F] = .1.8m.

Step 2 Take **[E]** from the data conversion sheet and divide it by **[F] twice.** Call the result **[I].**

If the catch cans are spaced at 0.5 m, then [I] is the MAR.

If the catch cans are **not** spaced at 0.5 m, then multiply [I] by twice the catch can spacing to obtain the MAR (see the example below).

	Example	**Your data**
	Assume [E] is 11.7 and [F] is 1.8	
[I] is If catch cans are spaced at 0.5 metres apart **[I] = MAR**	= [E] ÷ [F] ÷ [F] **= 11.7 ÷ 1.8 ÷ 1.8** **= 3.6 mm/h**	
If catch cans are **not** spaced at 0.5 m apart: MAR	**=[I] x 2 x catch can spacing (m)**	

Calculating DC (distribution co-efficient)

Step 1 Go back to the sprinkler graph you drew earlier and draw a horizontal line across the graph at the MAR value.

Step 2 Mark the point where this line crosses your application curve.

Step 3 Read down from this intersection point to the catch can position axis. The distance in metres from the sprinkler to this catch can position gives us the **[G]** figure needed below (at the can 3 position).

(This distance from the sprinkler would be a good location for a tensiometer or other soil moisture monitoring device.)

Step 4 Using the values of **[F]** and **[G]** you can now determine the DC.

The DC is a comparison between the area that has received the **average** depth, with the total wetted area. It is **only** used in non-overlapping irrigation systems.

Because we are dealing with circles we need to multiply **[G]** by itself (G x G), and then **[F]** by itself (F x F), then divide the two results as shown below.

	Example	**Your data**
	Assume [G] = 1.25 m and [F] = 1.8m	
[G] x [G]	**1.25 x 1.25 = 1.56**	
[F] x [F]	**1.8 x 1.8 = 3.24**	
DC% = $\frac{[G] \times [G]}{[F] \times [F]}$ x 100	**= $\frac{1.56}{3.24}$ x 100** **= 48.1% (say 48%)**	

A DC value greater than 50% is acceptable. If the DC value is below 50%, there is room for improvement in the system. Failure to make improvements will mean some areas will not get enough water. If you increase irrigation time to compensate for this, you will overwater some parts, resulting in waterlogging and run-off, and pumping costs will increase.

How long to irrigate

Using the MAR value and the RAW value for the crop on this soil, you can now estimate how long you need to irrigate to ensure adequate wetting from this sprinkler.

	Example	**Your data**
	Assume RAW for the example is 15 mm	
Irrigation time	**= RAW ÷ MAR** **= 15 ÷ 3.6** **= 4.2 hours**	

How much of the crop area is wetted?

It is sometimes useful to know is how much of the total crop area is wetted by your irrigation system. The example below shows how to work this out.

	Example	**Your data**
Wetted area %	**= 3.14 x [G] ÷ (tree & row spacing) × 100**	
	Assuming tree and row spacing are 3 m and 5 m: **= 3.14 x 1.25 x 1.25 ÷ (3 x 5) x 100** **= 4.91 ÷ 15 x 100** **32.7%**	

A minimum of 25% wetted area is an acceptable percentage for most tree crops and soil types.

Blank evaluation sheets

System 7. Non-overlapping under-canopy spray system

Field record sheet

Name:	Location:	Date:
Crop:	Soil type/texture:	RAW for crop: mm
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Tree pattern: row spacing _________ m tree spacing ________ m	Nozzle size: mm	Lateral spacing: m
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Sprinkler locations >>>	**Example**				
Sprinkler output (L)	**180mL (0.18L)**				
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Flow rate (litres/hour) $= \frac{\text{Output (L)}}{\text{Test time}} \times 60$	$\frac{0.18}{0.3} \times 60$ **=36 L/h**				
Pressure (kPa)	**250 kPa**				

NB Volumes are in Litres and times in minutes. If you use other units don't forget to convert them!

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 table 1.

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

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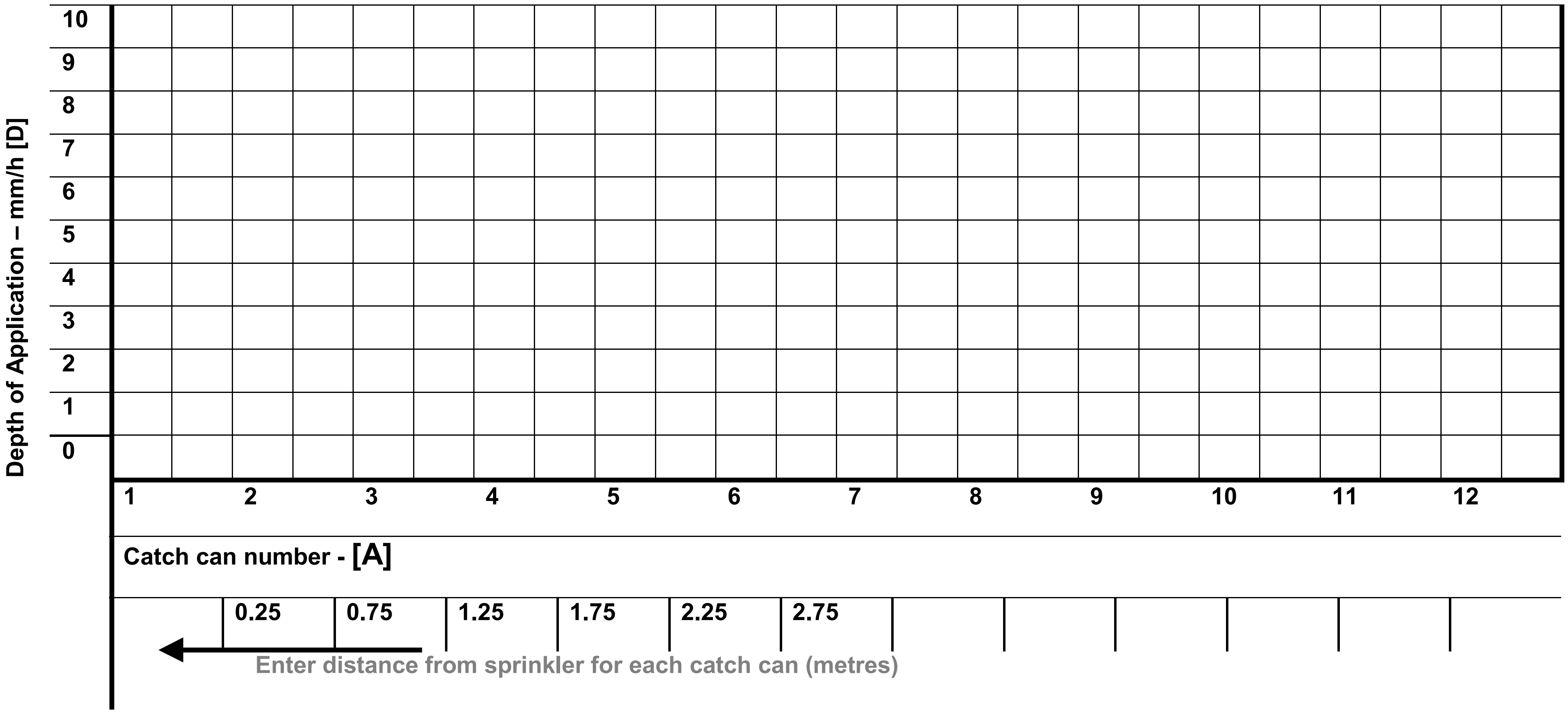
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										

Test start time : **Test finish time:** **Length of test:**

Total>>> [E]

Graphing your data - Sprinkler application chart



x

Calculating MAR

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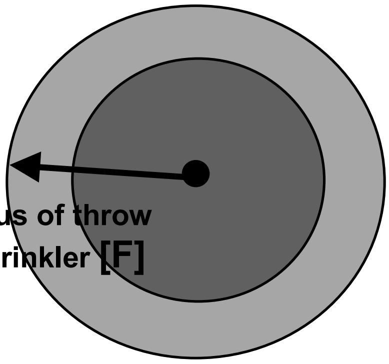
Effective radius of coverage [F] = ………



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If catch cans are NOT spaced at 0.5 m apart. MAR is	**=[I] x 2 x catch can spacing (m)**	

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[F] x [F]	**= 1.8 x 1.8** **= 3.24**	
$DC\% = \frac{[G] \times [G]}{[F] \times [F]} \times 100$	$= \frac{1.56}{3.24} \times 100$ **= 48.1% say 48%**	

How long to irrigate

	Example	Your data
	Assume RAW for the example is 15 mm	
Irrigation time	= RAW ÷ MAR = 15 ÷ 3.6 = 4.2 hours	

How much of the crop area is wetted?

	Example	Your data
Wetted area %	= 3.14 x [G] ÷ (tree & row spacing) × 100	
	assuming tree and row spacing are 3m and 5m = 3.14 x 1.25 x 1.25 ÷ (3 x 5) x 100 = 4.91 ÷ 15 x 100 32.7%	

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