Department of Agriculture
REVIEWED 2005
No. 48/92
Farmnote

Efficiency of sprinkler irrigation systems

By Tim Calder, Technical Officer, Irrigation Branch, South Perth

Shallow-rooted vegetable crops growing on sandy soils in hot, often windy summer weather, pose a difficult watering problem for most Western Australian vegetable growers.

During summer, regular and uniform water applications are needed to maintain growth. Irrigation systems should be able to cope with higher water requirements when hot, windy conditions occur.

The efficiency of a sprinkler system is measured by the amount of water available to the plants - after evaporation - as a percentage of the water applied. Observations of market garden sprinkler systems in and around Perth have indicated that many systems are inefficient.

Irregularities in wetting patterns are common, largely because of variations in sprinkler spacing and capacities. Wind effects are seldom taken into account in system design. The increasing popularity of knocker type sprinklers makes these considerations particularly important.

Water needs

To maintain satisfactory growth, water used by plants and lost through evaporation has to be replaced by the irrigation system. For best growth in the Perth region, the replacement rate is about 80 to 150 per cent of the measured evaporation rates summarised in Table 1.

Some vegetable crops need a replacement of more than 80 to 90 per cent of evaporation for optimum yield. For example, corn needs 100 per cent, leaf crops such as cabbage need 120 per cent, and lettuce need 150 per cent.

Table 1 shows that the water needs of a crop on an average January day will be 7.0 to 13.2 mm (80 to 150 per cent of average evaporation). For days with high evaporation conditions, the sprinkler system must be capable of supplying 11.0 to 20.6 mm.

Wind effects

Wind reduces sprinkler effectiveness because it increases evaporation and affects the watering pattern as shown by Table 2 and Figure 1. Since the interaction of wind velocity, temperature and humidity changes constantly, these figures are only approximations.

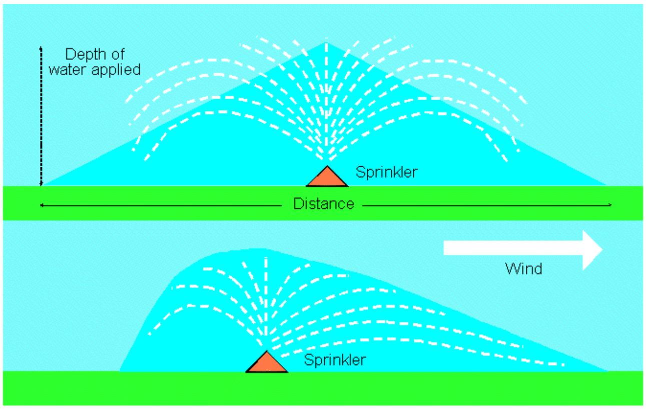

Figure 1. The effect of wind on a sprinkler pattern. Top: Sprinkler working under ideal conditions. Below: The same sprinkler under windy conditions.

For example, tests on a cool morning with no wind and high humidity showed water losses as low as 4 per cent, compared with similar tests on a hot day with no humidity and light winds, when the loss was over 40 per cent. Also, Table 2 does not take account of extreme conditions. If severe wind effects were added to the 40 per cent loss, efficiency could be reduced to less than 50 per cent.

Table 1. Average evaporation (mm) from a Class A pan evaporimeter at Perth

Wind velocity	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average	273	249	210	119	80	61	60	70	100	149	197	261
Highest	326.1	262.4	242.3	133.4	95.5	59.4	64.5	82.3	120.9	172.0	240.0	290.3
Highest day*	13.7	12.4	10.6	7.7	6.8	5.9	3.7	4.8	7.4	9.4	11.6	10.6
Average day	8.8	8.9	6.8	4.0	2.6	2.0	1.9	2.3	3.3	4.8	6.6	8.4

* At Swan Research Station, 30 mm in December and January, and 28 mm in February have been recorded.

Table 2 shows that on a normal day, even when relatively calm, only 67 per cent of water leaving the sprinkler reaches the ground. This percentage may improve as humidity builds up during watering, but losses remain high.

To supply 8 mm of water under hot, dry, windy conditions, up to 16 mm of water must be pumped out through the sprinkler system. For average conditions in January, when 7.0 to 13.2 mm of water are needed, a 67 per cent watering efficiency (under calm to 8 km/h winds) means that the sprinkler system must deliver 9.3 to 17.6 mm/day (93,000 to 176,000 L/ha) to ensure adequate moisture. This does not take account of water applied for cooling only.

Table 2. The effect of wind on the percentage of applied water available to plants (under normal summer temperature and humidity conditions)

Depth of water applied	Wind velocity		
	0 to 8 km/h	9 to 16 km/h	17 km/h and above
	%	%	%
25 mm	67	63	62
50 mm	69	67	65
100 mm	73	69	68
150 mm	78	72	70

Table 3. The effect of wind on sprinkler spacing

Wind velocity	Spacing requirement
No wind	65% of spray diameter
0 to 8 km/h	60% of spray diameter
9 to 16 km/h	50% of spray diameter
Above 17 km/h	22 to 30% of spray diameter

Spray patterns

Besides increasing water loss, wind affects sprinkler distribution patterns, as shown by Figure 1. Wind velocities are often above 17 km/h (and therefore exert severe effects on spray patterns) for much of the main irrigation season from September to March. Design the sprinkler layout and spacing to counteract this effect of wind velocities. Table 3 shows the sprinkler spacing needed with various wind velocities and Table 4 summarises the expected range of wind velocities for Perth.

For example, where winds over 17 km/h are expected, small knocker-type sprinklers with a spray diameter of 27 m should not be more than 8 m apart if they are to provide an efficient wetting pattern.

Sprinkler pressures

Table 5 shows the operating pressures for various jet sizes. If other sprinkler pressures are used, the spray pattern produced will be less efficient.

Table 5. Recommended pressures for a range of sprinkler jet sizes

Jet size	Pressure needed
2.4 to 4.8 mm	240 to 345 kPa
4.8 to 6.3 mm	310 to 415 kPa
6.3 to 9.5 mm	345 to 480 kPa

Testing sprinkler system output

Figure 2 shows a suggested layout for testing a sprinkler system. The area between sprinklers is divided into equal squares and a vertical-sided can is placed in each square. The system should then be started under typical weather conditions and the can contents measured at the end of the test period.

Table 4. Wind velocities for Perth: Chance of occurring (%)

Wind velocity		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
9 a.m.	Calm	2	4	4	3	5	8	5	5	3	5	1	2
	0 to 8 kin/b	16	16	20	29	28	20	27	33	24	25	23	13
	9 to 16 km/h	38	33	32	32	34	38	34	32	30	31	34	43
	Above 17 km/h	44	47	44	36	33	34	34	30	43	39	42	42
3 p.m.	Calm	0	0	1	1	2	2	2	1	0	0	0	0
	0 to 8 km/h	2	4	2	11	16	17	14	14	6	2	1	2
	9 to 16 km/h	24	26	27	37	37	30	33	37	30	26	22	21
	Above 17 km/h	74	70	70	51	45	51	51	48	64	72	77	7

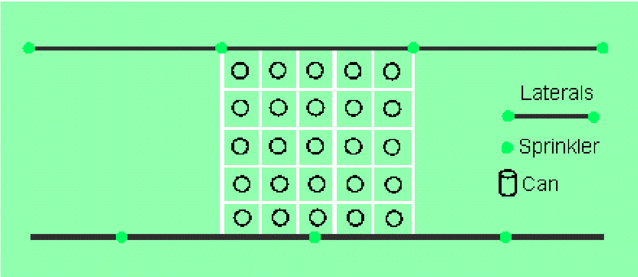

Figure 2. Layout for testing the output of a sprinkler system.

Operate the system for a given length of time, then use a twin rule to measure the water depth in each can. Calculate the time taken to supply the minimum water necessary from the water depth in the cans with least water.

While there will be problems with water shortages if distribution is uneven, fertiliser, if applied through the sprinklers, may run short in areas where the cans have least water. It is misleading therefore to average out the readings from all cans as a means of calculating running time.

Full account should be taken of the effects of wind, temperature and humidity on sprinkler spacings, pressures and delivery rates, when designing or re-designing a sprinkler system. The discharges of individual sprinklers on any one lateral should be uniform and not vary by more than 15 per cent.

ISSN 0726-934X