Orchard irrigation performance – hand shift pipes

By Dan Bloomer, Page Bloomer Associates, and Andrew Curtis, Hawke's Bay Regional Council

In the last month we have taken a look at a couple of common temporary irrigation systems; hand shift pipes and travelling under-tree irrigators. Predominantly used on leased orchard blocks, both systems have obvious advantages – capital outlay is lower and the systems are easily removed once the lease has expired. But how do they stack up performance-wise?

In short, the answer was not too well. The main thing limiting performance for both systems was the uneven application. In fact in both cases, the outer rows in each pass got far less water than those beside the sprinklers. So in both cases, over wide shift spacing was a serious issue.

The purpose of an on-orchard evaluation is to assess current performance, identify issues detracting from best performance, and to propose actions that can improve performance. Performance includes evenness of watering, adequacy of watering, and efficiency of water and energy use.

Evenness of watering is important if each plant is to receive the same (correct) amount of irrigation. It depends on having the correct combination of sprinkler or emitter performance, spacing and run times.

In this article we will focus on the hand shift pipes. We'll discuss the travelling irrigator next time.

The evaluations are part of a series, conducted under a Sustainable Farming Fund Project. Supported by Hawke's Bay Regional Council, Pipfruit New Zealand and Summerfruit New Zealand, it is investigating the performance of a range of irrigation system types used on orchards in Hawke's Bay.

Hand shift pipes

This irrigation system uses a tractor-mounted pump to take water from a bore and run the sprinklers. The engine is set to run at a pre-determined speed. Aluminium pipes take the water along the headland to a Tee. A sprayline runs each way from the mainline with each watering four rows of trees at a time. The sprinklers are mounted directly on the aluminium pipes without the usual riser.

To evaluate the performance of the hand shift pipes, a grid of 96 collectors was set up. The collectors were arranged in six rows along the sprayline, each row extending the full wetting width either side. In this case we used disposal plastic wine glasses because the trajectory from the sprinklers was very low and we needed to collect water as near ground level as possible.

We checked the pressures in sprinklers along both spraylines, and found the sprinklers were operating at the lower end of their operating pressure range. We checked the flows from a number. We noted that different sized nozzles were fitted, and that these affected the flow, and therefore the amount of water trees would receive.

We also noted there was variable distance between sprinklers (the pipe lengths had been altered). This also affects the amount of irrigation being applied.

After two hours of irrigation the volume of water collected was measured and the depth of water applied calculated. We assumed the pattern measured in the collector grid is repeated from one shift to the next, and used a computer to calculate the effect of overlapping. In this case there was none – the sprinklers did not get the water to the edge of the irrigation strip.

Figure 1. shows how much irrigation would be received at various distances from the sprinkler pipeline. The different coloured shapes show the depths collected in each of six lines of collectors. Each point represents an individual reading or rain gauge depth.

View of orchard showing one sprinkler spray-line.

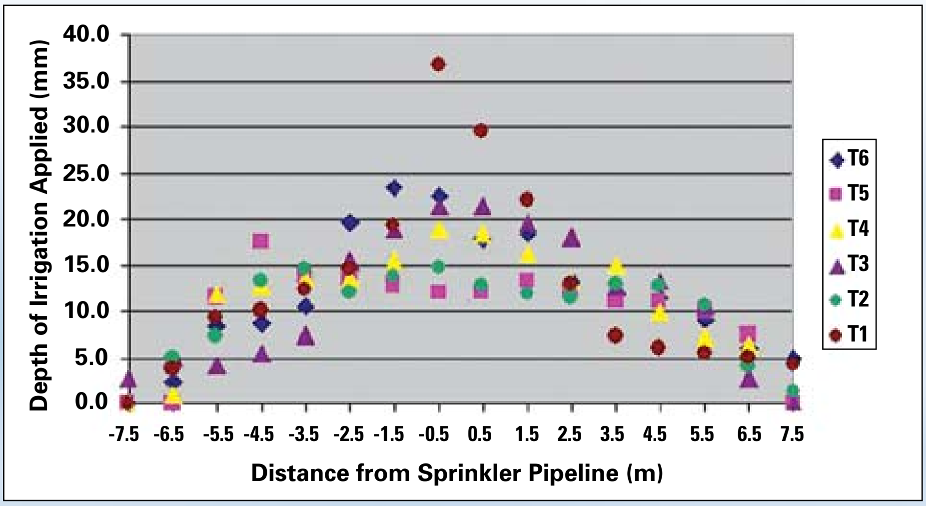

Figure 1. Graph showing depth of irrigation applied in a grid around the sprayline.

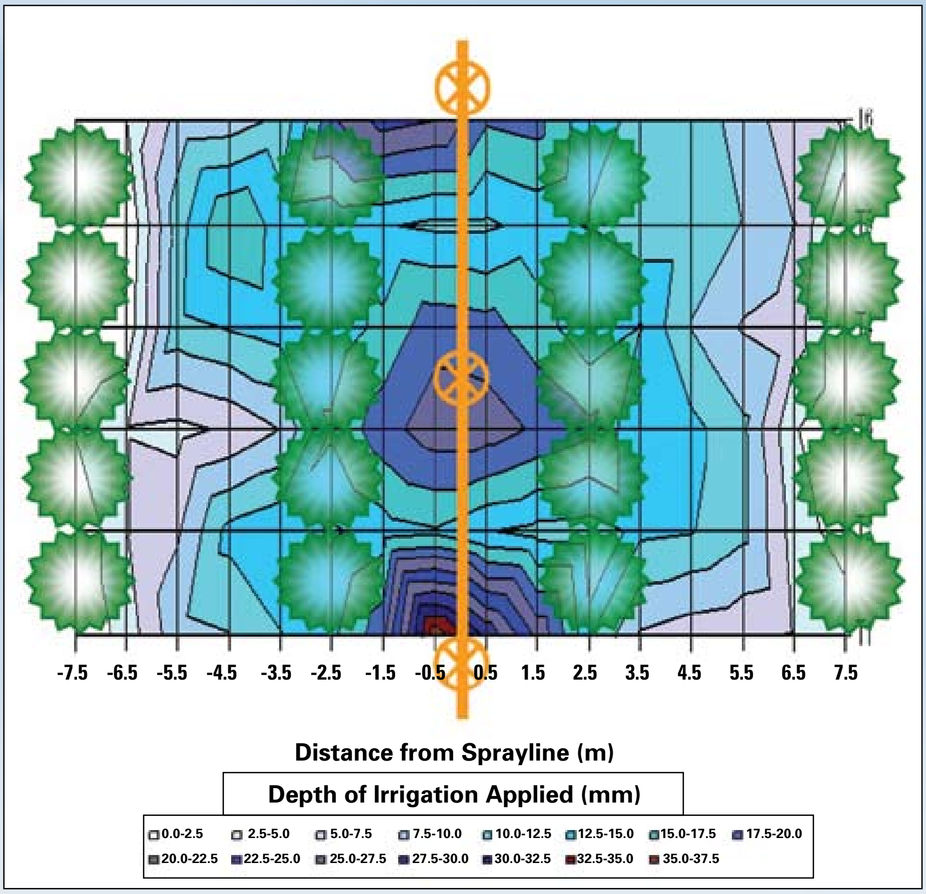

Figure 2. "Contour map" of applied irrigation.

Figure 2. shows the same information as a "contour map" of irrigation applied depths. The highest applications were beside the sprinklers, with little or none reaching the outer edges.

As shown, the areas around the trees in the two near rows are receiving much more water than the area under the two outer rows. In fact one eighth of the area is receiving 20% or less of the average amount applied, an extremely poor distribution uniformity DU_{GRID} = 0.19.

It is trees we are interested in, not just collectors. It is reasonable to assume each tree's root system would extend at least as much as the canopy above, so they access water from a number of points in our grid. When we look at the applied water this way, we find the average depth applied to the inner two rows is about 15mm while the average amount applied to the outer two rows is only about 5mm – one third of the amount.

Doing our maths on the numbers, we get a low quarter uniformity of DU_{TREE} = 0.40. This is still a long way short of a DU_{TREE} = 0.80, the widely accepted benchmark for 'good' irrigation system performance.

A DU of 0.40 implies that two and a half times the target depth of water would need to be applied to ensure that 7/8ths of the trees got at least the target amount. The trees receiving most water would be very wet indeed.

In energy terms the system was found to be pretty good. The pipeline size is sufficient to avoid much headloss, and there are no contraining points in the lines. We monitored fuel use and found the system used about 0.9L of diesel per hectare for every millimetre of irrigation applied.

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Figure 3: Measuring water collected in disposable wineglass, collectors in grid visible in background.

How can things be improved?

A number of things could be done which would greatly improve performance:

Increase the sprinkler pressure and therefore throw.

Increasing the pressure will immediately increase the distance wetted and get more water out to the furthest trees. The best way to get the pressure correct for this system would be to have a pressure gauge or pressure test point fitted at the Tee on the end on the mainline where the spraylines begin.

Then an operator could adjust the tractor PTO revs until the correct pressure was being achieved. Relying on an assumed rev setting is unreliable. Trying to judge pressure by tractor engine revs is unreliable and therefore not advisable!!

An alternative would be to decrease the set spacings (shift spacing) to improve the overlap. This option would not work very well in this case – it would be far more sensible to get the pressures right.

Use alternate sets, i.e. change the irrigation row for each irrigation

Alternate sets mean that the areas receiving the most water during one irrigation event get the least the next time, and vice versa. This can mean the return time needs to be reduced so the drier areas don't run out before you get back to irrigate again.

Other potential improvements

Make sure the sprinklers are as vertical as possible. Crooked sprinklers will squirt water straight into the ground on one side but much further on the other. They must be set correctly for good performance.

Put risers on the sprinklers to increase their throw. Unfortunately this would probably cause canopy interference – the most likely reason they are currently missing.

Standardise pipe lengths and nozzle sizes. The same nozzles should be used in all sprinklers to ensure even flows. To get the correct overlapping, the correct sprinkler spacing is required, so the pipes should all be the correct length. Keep the weed strip and inter-row 'tall' weed free to prevent interference with the irrigation application.

Conclusion

Hand shift pipes are a reasonable choice, especially for leased blocks where permanent systems cannot be financially justified. But they do need correct operation if they are to do the job that is wanted. And that means making sure the components are right, and the pressure if right.

And the thing we haven't talked about in this article – the irrigation has to be turned on at the right time, and off at the right time. Scheduling must be correct to optimise growth and maximise energy and water-use efficiency.

Measuring the fuel used to apply irrigation.