Orchard irrigation performance – an under-tree travelling irrigator

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In the last of this series of irrigation system evaluations, we take a look at a travelling under tree irrigator. On this machine, the usual gun has been replaced by four ground-level nozzles jetting water sideways under the canopy. The design aims to water three rows either side of the nozzle carriage and hose.

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.

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Figure 1: Under-tree travelling irrigator.

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.

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

Figure 2: Irrigation ponding as a result of very high application rates.

Under-tree travelling irrigator

We measured this system on two separate occasions. How did it stack up performance wise? In short, not too well.

The main things limiting performance were uneven application and extremely high irrigation application rates. Together these led to different trees receiving quite different amounts of water.

This irrigation system takes water from a bore through a system of hydrants along a permanent mainline. Aluminium pipes connect the hydrant to the machine. We only measured the performance at one hydrant. If there are big pressure differences between hydrants, performance could be quite different in other areas.

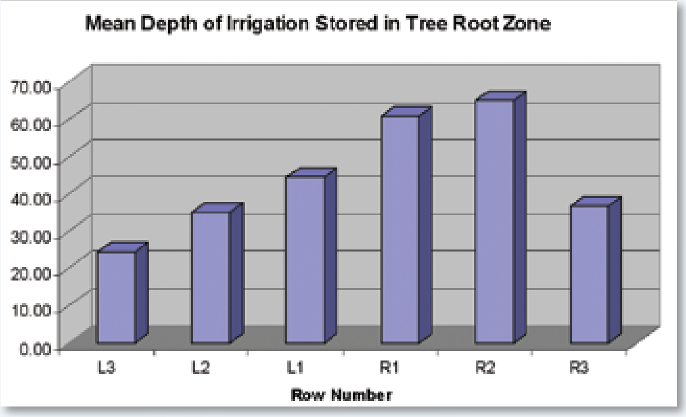

Figure 3: Graph showing the depth of water retained in the root depth of six trees.

Test 1 results

The first test applied 35mm of irrigation on average across the block. But the amount we found stored in the root zone of individual trees 24 hours later was quite variable as shown in Figure 3.

We also checked the flow rate and the irrigator speed near the beginning, middle and end of the run. The flow from the pump stayed very constant, but the machine sped up as the hose was rolled in.

The result of this was a variable applied depth along the run. At the start the irrigator applied about 37.6mm but at the end only 32.9, a drop of 12.5%.

Test 2 results

We rechecked the performance of the machine a few weeks later. In the mean time the orchardist had changed the nozzle set up slightly to get more water to the outer rows.

This time we measured how much water reached different places, how long those places stayed ponded, and how much water soaked in and was stored in the root zone.

Three transects across the line of travel were set up. Each transect had 24 collectors, arranged at 1m intervals away from the hose line. The trajectory of the jets was very low and the force very high. We used a big soil corer to extract cores, and set plastic food containers into them to collect water as near ground level as possible (see figures 5).

After the irrigator had passed each transect, the volume of water collected was measured and the depth of water applied calculated as shown in Figure 7. The set-up did not get the water to the edge of the irrigation strip so the outer rows received a little less water. With the nozzle set up, the inside rows also appear to miss out – the jets shot straight past them.

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Figure 4: Distribution from under tree travelling irrigator.

Figures 5: Dan Bloomer installing the TDR rods to measure soil moisture content.

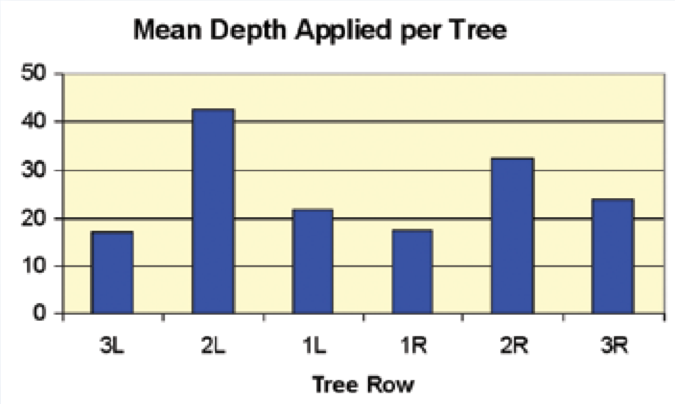

Figure 6: Average depth of water received in each row.

We also set out 72 sets of TDR rods to measure the change in soil moisture. Our rods were 60cm long, so they correspond to the rooting depth of the trees.

We checked soil moisture before irrigating, and again 24 hours later. The results are shown in Figure 8.

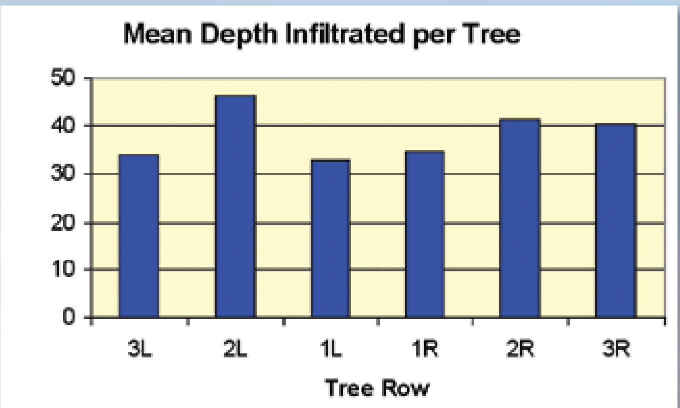

Figure 7: Average depth of water infiltrated in each row.

The two graphs show different patterns. The soil storage appears more even than the applied depths would suggest. There are several possible explanations.

The two measurements (collectors and soil probes) were not in exactly the same places. So interference by tree trunks and branches affects them differently.

We had a lot of trouble actually catching the water in our collectors. Even half buried, some were blown right out of the ground and ended up a couple of rows away. The amount we collected was less than the amount applied.

Also, because the system applies water much faster than it can soak in, there is a lot of redistribution. Ponded water runs to lower areas. It seems in this case that this may actually have helped get water out to the rows furthest away from the irrigator.

Doing our maths on the results, we find the Distribution Uniformity is about 0.65. This is a poor result, and implies that one and a half times the target depth has to be applied if most of the trees are going to get enough water. Some will be very wet by then.

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.

An alternative would be to decrease the set spacings (shift spacing) to improve the overlap. In this case, watering five rows at a time would give a better overlap.

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.

Apply less water more often
Our second test ran the irrigator at a faster speed, so less water was applied. We noticed this appeared to reduce the amount of free water flowing to lower areas.

Avoid canopy interference
We noticed the low hanging branches stopped water getting across to the outer rows.

Conclusion

The system is not perhaps as bad as first impressions would suggest. But it is not doing an excellent job either. Many people (and regional councils) expect irrigation to be about 80% efficient. This system does not measure up to that standard.