Improvement in crop yield per liter using Measured Irrigation

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Measured Irrigation (MI) was invented by Dr Bernie Omodei in late 2010.Dr Omodei gave a presentation on MI at the International Symposium on Rainwater Harvesting in Addis Ababa, Ethiopia, June 2015. He was also a Keynote Speaker at the 4thInternational Conference on Agriculture and Horticulture in Beijing, 13thto 15thJuly 2015. The title of his address is "Measured Irrigation - Improving the water-efficiency of irrigation by changing the irrigation paradigm".
In October 2016, Bernie was invited to Kenyaby ICRAF (World Agroforestry Centre) to participate in a workshop in Machakos County to train farmers and extension workers in the use of MI.
On 18 April 2017, Dr Omodei had a successful meeting with World Vision Australia. Following trials in Kenya, Dr Rob Kelly from World Vision circulated an article endorsing the DIY Solar Drip Irrigation Kit. The title of the article is "Game-changing technology for dryland farmers in eastern Kenya".
More information about MI is available from the website www.measuredirrigation.com.au.
It is recommend that you watch the following video DIY Solar Drip Irrigation Kit and download the *DIY Measured Irrigation Training Manual for Smallholders* from the MI website.

Summary

A gravity feed pilot trial in Adelaide evaluated the crop yield per litre using Measured Irrigation (MI) scheduling compared with programmed irrigation scheduling as recommended by Amiran in Kenya.
The results indicate that for medium soils MI scheduling may improve the yield per litre by more than 100%, and for sandy soils MI scheduling may improve the yield per litre by more than 400%.
The results are for a preliminary trial only, and further independent trials are needed to more accurately estimate the improvement in crop yield per litre for various crops under various conditions.

Introduction

The dominant irrigation scheduling paradigm for controlling the volume of water emitted by a dripper is to control both the flow rate of the dripper and the duration of the irrigation event. MI provides a radically different irrigation scheduling paradigm whereby:
(i) The application rate for each dripper (for example, liters per week) is controlled by controlling emitted volumes directly without needing to control the flow rate or the duration of the irrigation event. By replacing the control of 2 parameters (namely, flow rate and time) by one parameter (namely, volume), the control of the application rate for each dripper is independent of the head of water in the header tank for the gravity feed application.
(ii) Temporal variations in the application rate for each dripper are controlled by the prevailing weather conditions: the application rate is directly proportional to the net evaporation rate (evaporation minus rainfall).

Methodology

A pilot trial was conducted on 4 garden beds in Adelaide from 7 November 2016 to 5 February 2017. Each garden bed was approximately 2 m x 2 m with 4 driplines in each bed alternating between MI scheduling and Amiran programmed irrigation scheduling. Two beds used medium soil (70% loan, 30% compost) and the other two beds used sandy soil (70% sand, 20% loam, 10% compost). The drip line used throughout the trial was Netafim Landline 8 with 30 cm spacing between the drippers, and the spacing between the driplines was 50 cm. The water supply for all garden beds was a header tank with a constant 1.3 m head relative to the soil in the beds.

MI scheduling

For each garden bed a suitable evaporator was chosen with a surface are of at least 0.08 m2 and one of the MI drippers was positioned so that it would drip water into the evaporator during the irrigation event. This dripper is called the control dripper. All drippers in the garden bed including the control dripper should be at approximately the same level. A level line was marked on the inside of the evaporator about 3 cm below the overflow level. The evaporator was filled with water to the level line. During the day the water level in the evaporator falls due to evaporation, and the water level rises when it rains. The irrigation is started at sunset each day provided that the water level in the evaporator is below the level line. The irrigation is stopped when the water level reaches the level line.

Figure 1. One of the MI drippers drips water into the evaporator during the irrigation event.

Figure 2. The volume of water emitted by a MI dripper is measured by collecting the emitted water in a measuring cup as shown.

Adjusting the surface area of evaporation

The amount of water that plants need depends upon many factors in addition to the weather (for example, type of plant, stage of growth, crop canopy, and soil type). To take account of these additional factors, a length of steel pipe is used to check the moisture level in the soil profile after irrigation. An angle grinder can be used to cut out some slots in the pipe so that soil inside the pipe can be inspected. Early in the morning after irrigation the night before, the steel pipe is hammered into the soil near a dripper. The pipe is then removed from the soil with the core sample inside the pipe. By checking the

Figure 3. The surface area of evaporation may be reduced by placing full bottles of water in the evaporator.

moisture level in the core sample through the slots, one can decide whether the plants have been irrigated the night before with too much or too little water. It may be helpful to use the slots to remove a small sample of soil and to squeeze it between your fingers. If you decide that the plants have been given too much water, the water usage can be reduced by reducing the surface area of evaporation (for example, by placing full bottles of water in the evaporator). On the other hand, if you decide the plants have not been given enough water, then the surface area of evaporation needs to be increased. After irrigation and adjustments to the surface area over several days, the surface area or evaporation should stabilize at an appropriate level for the plants in the garden bed at their current stage of growth.

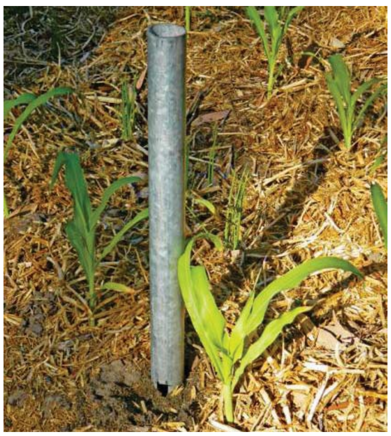

Figure 4. The steel pipe is hammered into the soil near a dripper.

Figure 5. Check the moisture level in the core.

Amiran programmed irrigation scheduling

Amiran is the major supplier of gravity feed drip irrigation kits to smallholders in Kenya. They publish separate instruction booklets for growing tomatoes, capsicums and cabbages (or kale). Each booklet provides an irrigation regime for heavy/medium soil or sandy soil, immediately after transplanting and 6 weeks after transplanting. The regime is summarized in the table below.

Table 1. Amiran irrigation regime

	Growth Phase 1: after transplanting	Growth Phase 2: 6 weeks after transplanting
Heavy/medium soil	Wait 6 days after transplanting, then two hours early in the morning every third day	Two hours early in the morning every second day
Sandy soil	Wait two days after transplanting, then one hour early in the morning and one hour at noon every day	Two hours early in the morning and two hours a noon every day

On rainy days, the next scheduled irrigation is delayed by one day.

The dripper on the drip line supplied by Amiran to smallholders is the Netafim Super Typhoon 12125 which has flow rate of 1.6 L/H with a head of 10 m, and the spacing between the drippers is 30 cm. The dripper on Netafim Landline 8 has a flow rate of 2.0 L/H with a head of 10 m. Therefore, when following Amiran programmed irrigation scheduling, an adjustment needs to be made to the irrigation times to take account of the slightly higher flow rate for Netafim Landline 8 compared with Netafim Super Typhoon 12125. For example, one hour of irrigation with Super Typhoon 12125 is equivalent to 48 minutes with Landline 8. It is assumed that the average head of water for Amiran irrigation in Kenya is the same as that used for the trial in Adelaide, namely, 1.3 m. When the head of water is 1.3 m, the Netafim Super Typhoon 12125 dripper has flow rate of 0.58 L/H and the Netafim Landline 8 dripper has a flow rate of 0.72 L/H.

Results

Each plant was planted as close as possible to a dripper. All the plants included in these results are listed below.

Figure 6. Garden Bed 1 at the end of the trial on 6 February after some of the yield had been harvested.

Garden Bed 1: Sandy soil
5 egg plants using MI scheduling and 5 egg plants using Amiran scheduling
Surface area of evaporation for Growth Phase 1: 0.62 m^2
Surface area of evaporation for Growth Phase 2: 0.62 m^2

Garden Bed 2: Medium soil
10 sweet corn plants using MI scheduling and 10 sweet corn plants using Amiran scheduling
Surface area of evaporation for Growth Phase 1: 0.43 m^2
Surface area of evaporation for Growth Phase 2: 0.52 m^2

Figure 7. Garden Bed 2 at the end of the trial on 6 February after the yield had been harvested.

Figure 8. Evaporator for Garden Bed 2 showing the control dripper and a surface area of evaporation of 0.52 m^2.

Garden Bed 3: Medium soil
8 tomato plants using MI scheduling and 8 tomato plants using Amiran scheduling
Surface area of evaporation for Growth Phase 1: 0.43 m^2
Surface area of evaporation for Growth Phase 2: 0.75 m^2

Figure 9.Garden Bed 3 on 6 December during Growth Phase 1.

Figure 10. Garden Bed 3 at the end of the trial on 6 February after most of the yield had been harvested.

Garden Bed 4: Sandy soil
7 capsicum plants using MI scheduling and 7 capsicum plants using Amiran scheduling
1 tomato plant using MI scheduling and 1 tomato plant using Amiran scheduling
1 egg plant using MI scheduling and 1 egg plant using Amiran scheduling
Surface area of evaporation for Growth Phase 1: 0.62 m^2
Surface area of evaporation for Growth Phase 2: 0.62 m^2

Figure 11. Garden Bed 4 at the end of the trial on 6 February after some of the yield had been harvested.

Using visual inspection only throughout the growing period for all garden beds, there was no significant difference between the size of the plants irrigated by MI scheduling and the size of the plants irrigated by Amiran programmed irrigation scheduling. Using visual inspection only for all garden beds, there was no significant difference between the yield for plants irrigated by MI scheduling and the yield for plants irrigated by Amiran programmed irrigation scheduling. Hence the calculation of the percentage improvement in the yield per liter in Table 4 for MI scheduling compared with Amiran scheduling, assumes that the yield is the same.

Table 2. Irrigation volumes per dripper for Growth Phase 1, 7 November to 13 December

	Garden Bed 1 Egg plant Sandy soil	Garden Bed 2 Sweet corn Medium soil	Garden Bed 3 Tomatoes Medium soil	Garden Bed 4 Capsicum Sandy soil
Total liters per Amirandripper in Phase 1 (33 days)	29.9	9.6	10.2	30.5
Total liters per MI dripper inPhase 1 (33 days)	5.8	4.7	5.3	7.1
Average liters per Amirandripper per day in Phase 1	0.91	0.29	0.31	0.92
Average liters per MI dripperper day in Phase 1	0.18	0.14	0.16	0.22

Table 3. Irrigation volumes per dripper for Growth Phase 2, 14 December to 5 February

	Garden Bed 1 Egg plant Sandy soil	Garden Bed 2 Sweet corn Medium soil	Garden Bed 3 Tomatoes Medium soil	Garden Bed 4 Capsicum Sandy soil
Total liters per Amirandripper in Phase 2 (53 days)	112.8	28.8	28.8	112.8
Total liters per MI dripper inPhase 2 (53 days)	12.5	11.1	14.7	12.3
Average liters per Amirandripper per day in Phase 2	2.13	0.54	0.54	2.13
Average liters per MI dripperper day in Phase 2	0.24	0.21	0.28	0.23

Table 4. Irrigation volumes per dripper for Growth Phases 1 and 2 combined, 7 November to 5 February

	Garden Bed 1 Egg plant Sandy soil	Garden Bed 2 Sweet corn Medium soil	Garden Bed 3 Tomatoes Medium soil	Garden Bed 4 Capsicum Sandy soil
Total liters per Amirandripper (86 days)	142.7	38.4	39.0	143.3
Total liters per MI dripper(86 days)	18.4	15.8	20.0	19.4
Average liters per Amirandripper per day	1.66	0.45	0.45	1.67
Average liters per MI dripperper day	0.21	0.18	0.23	0.23
Percentageimprovement in yield per liter using MIscheduling (assuming thatthe yield is the same)	676%	143%	95%	639%

Conclusion

A gravity feed pilot trial in Adelaide evaluated the crop yield per liter using MI scheduling compared with programmed irrigation scheduling as recommended by Amiran. The results in Table 4 indicate that for medium soils MI scheduling may improve the yield per liter by more than 100%, and for sandy soils MI scheduling may improve the yield per liter by more than 400%.

The Amiran irrigation regime uses approximately 4 times as much waterfor sandy soil compared with heavy/medium soil. The results in Table 4 indicate that the Amiran irrigation regime for sandy soil may be reduced significantly without compromising the crop yield. These results are for a preliminary trial only, and further independent trials are needed to more accurately estimate the improvement in crop yield per liter for various crops under various conditions.

The improvement in crop yield per liter using MI scheduling is highly dependent upon the existing regime for irrigation scheduling. Independent trials are needed to compare the crop yield per liter for MI scheduling with the current best practice for irrigation scheduling for various crops in different regions of the world.

The cost of increasing the crop yield per liter using MI scheduling is simply the cost of the evaporator and the steel pole.