IRRIGATED AGRICULTURE

Advances in drip irrigation promises even more water savings to farmers

Low flow, low pressure drip irrigation is starting to make waves, though the mechanics behind the technology is still under investigation. Petro Kotzé investigates.

Farmers' attempts to work ever more efficiently with their share of water has gone hand in hand with improved irrigation technologies. The irrigation sector is by far the largest water user in South Africa, and improvements here ripple beyond the agricultural community to all other water user groups in the country.

Improvement of irrigation technology, in turn, results from better understanding of soil physics and crop water requirements. Accordingly, the future of drip irrigation has been described by some as low flow drip technology. This entails the delivery of a signigicantly low, consistent volume of water over a long period of time. Data on the implications are scarce, but it has now become the topic of a new research project on citrus.

Though some of the elements behind the success is not yet fully understood, farmers have already achieved substantial water savings, coupled with increased yields and smoother farming operations, as a result.

The development of low flow drip irrigation

There are various types of irrigation in use in South Africa. Of these, drip irrigation is widely recognised as the most water efficient. The technology started in the 1970s in water scarce countries such as South Africa, Israel, Australia and Mexico. It involves the delivery of water and fertilizer (fertigation) across a field in pipes called dripperlines, emitted through drippers. The enriched drops of water are delivered directly to the plant's

root-zone, in theory, in the right amount and at the right time.

Commonly, drippers emit flow rates of 3.5, 2.3 or 1.6 litres per hour. Research has shown, however, that we are irrigating too fast for the active root zone, especially in more sandy soil types. According to Chris Malan, South Africa's Agronomy Manager for global irrigation manufacturer and distributor, Netafim, this results in wasted water.

Dr Eduard Hoffman, head of the Department of Soil Sciences at the University of Stellenbosch, says that in gravelly or sandy soil in particular, the commonly applied 2.3 or 4 ℓ/h drippers result in the water running straight through the soil. As a consequence, some farmers prefer the less water-efficient micro spray system, where water is emitted through a small spray nozzle over a larger soil area than drip irrigation.

To combat the loss of water when practicing drip irrigation in sandy and gravelly soils, irrigation is scheduled to take place in short pulses of less than an hour per day. This practice has, however, led to its own challenges, including over saturated sub-soils, leaching of fertilizer, inefficient hydraulics systems, some water losses when the systems needs to be drained, and blockages in the pipes delivering water.

Now, low delivery rate drippers have been developed. In comparison, these emit less than one litre of water per hour over one irrigation shift that lasts several hours. This irrigation system applies water at the rate of the maximum daily water use of the crop over a day. Malan explains that a while a crop's water demand will typically follow a bell curve over the day, the rate of water emitted during continuous irrigation remains constant. There is thus an oversupply of water early and late in the day and an undersupply in mid-day, which coincides with the crop's peak water consumptive period. This is compensated for by the 'buffer' of water created before and after. In theory, water is thus applied at the same rate that the roots extract it.

The design of a continuous, low-flow irrigation system entails a number of changes to the farming operation. It runs from a central pump house, includes dedicated mainlines and is technology driven. Because of the lower amounts of water extracted, the technology also allows the entire field or farm under irrigation to be watered simultaneously.

Agronomist Gerhard Mostert, founding partner and consultant for Agriwiz, who has been spearheading the technology, explains that some of the big changes of the 'new' system are that there are no control valves in the field anymore. Instead, the entire system of irrigation and fertilization can be handled by a manager and an attendant in the pump house (where all the valves are located). Mostert says that the enriched water that is delivered to crops is another key to the system's success. "We are moving from volume-based application of fertilizer to applying the optimal concentration of fertilizer."

Malan explains that this creates conditions similar to those in a greenhouse, where a concentrated amount of fertilizer is provided, instead of simply the crop's required amount, in order to create the optimum production environment.

More developments include that peroxide is now regularly run through the pipe system, to prevent the headache of blockages, commonly associated with lower emission drippers.

The system promoted by Agriwiz is technology driven, and focuses on ultra-low flow, fertigation systems that include variable speed pumps and automated soil moisture probes. The fully automated system links farmers to a cloud-based research and development platform that helps create a comprehensive weekly irrigation plan moderated by the expected rainfall and temperatures for the week. It takes water use, yield, climate, history and soil types in mind.

Farmer and co-owner of ***Ysrivier Farm*** just outside Patensie, Merwe van der Watt, has been running this system on his citrus orchards for around three years. "I only set my irrigation programme twice a week," he says. Based on the weather forecast, I will irrigate 14 hours on some days, and as little as four on others."

"Once an orchard is established, it is more difficult and costly to switch to a new system."

Yet, Malan cautions that there are still questions that remain

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Low flow drip irrigation system in a citrus orchard.

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Dripperline for a low flow irrigation system.

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A low flow drip irrigation system installed in an avocado plantation.

to be answered around the technology. "We still need to understand exactly what we are working with," he says. For example, is it true and correct that water is over-supplied in the morning, for the plant to use the reserve later in the day? And, are the results really due to the shallow application of water close to the rootzone?

With support from Netafim, these questions will now be answered during a research project at the University of Stellenbosch's Department of Soil Sciences.

Investigating the mechanics of ultra-low flow drip irrigation

"I want to know exactly what the mechanisms are," explains Hoffman, in reference to their recently launched project. Hoffman, with student, Herbst van der Merwe, are investigating the water content distribution in soil during continuous drip irrigation under two sets of drippers; the first emitting 0.7 ℓ/h, and the second, 0.4 ℓ/h, both for eight to 12 hours at a time. Though the 0.7 ℓ/h emitters are available commercially, the 0.4 ℓ/h emitters are only experimental at this stage, says Malan, as they would like to investigate their performance.

Except for the distribution of water in the soil, the researchers will also investigate salt distribution as well as root growth and distribution. The testing ground is a plantation of Nadorcott mandaring trees established on sandy and gravelly soil in the Hex River Valley (Western Cape). Since most research on root growth and distribution under drip irrigation so far has been done on South Africa's main crops under irrigation, such as maize, wheat and tomatoes, the project will play an important role to fill the knowledge gap that exists in the characterisation and quantification of the root growth of citrus trees under low emitter discharge rates.

"We want to see where the water goes," says Hoffman. If they understand the vertical and horizontal movement of water in soil, they will be able to inform the ideal placement of the drippers, for example. Then, they will be looking at the plants' root development. Hoffman says that there is anecdotal evidence, for example, that the trees' roots concentrate in the upper soil initially and then developed deeper as it grows older.

Understanding irrigation is really about understanding soil physics, notes Hoffman, and the combination of water, light and chemicals. Should they decipher the movement and distribution of water in the soil during continuous drip irrigation, they will know if drainage and unnecessary leaching is taking place. Results will clarify if the root growth and distribution in the volume of wetted soil is enough to sustain good tree performance and how management can be adapted accordingly.

The research project will also shed light on the question if the trees experience stress during the mid-day, when the application rate of the enriched water stays the same regardless of increased evapotranspiration. Hoffman explains that this is only the first phase of the project. In future, they will investigate if evaporation increases from the soil, since it is constantly wet. If so, the question needs to be asked if we are really saving water, he says.

Still, though the technology can be applied to any crop, it might not work for all farmers.

A specialist system that needs expert management

The South African citrus industry experienced an era of tremendous growth, says Malan. This boom resulted in the new development and planting of large blocks of orchards, where new technologies like low flow drip irrigation could be installed. In places such as Israel, for example, they did not experience this boom, and concurrently, did not have the same opportunity to install new irrigation systems on large scales.

Ideally, the planning for this system should take place before the orchard is planted. Once an orchard is established, it is more difficult and costly to switch to a new system and for crops like vineyards, for example, only one block at a time would commonly be replanted.

Even in the citrus industry, low flow, continuous drip irrigation is probably best suited to the so-called 'leader' farmers, maintains Malan. These large-scale, commercial farmers are more likely able to apply the newest technologies, and justify the expenses with quicker returns in competitive export markets.

Furthermore, correct maintenance of the system is critical, as is technical knowledge of the various aspects of the system. "You have to know exactly what you are doing," explains Hoffman. The dripper lines must regularly be flushed out, and

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One of the benefits of continuous low flow irrigation is that the entire farm can be irrigated at once.

oxidation treatments applied. Because technology, and technical knowledge is so important for this to work, it might not be suitable for upcoming farmers, he says.

Though it leads to savings over time, as well as potential yield increases, the initial cost is also higher in comparison to more traditional drip irrigation systems. Speaking on the topic at a recent presentation at Stellenbosch on water savings in agriculture, Mostert pegs the cost at double that of a micro-irrigation system. The cost for a low flow drip irrigation would be around R65 000 to R70 000 per hectare in comparison to R35 000 for a micro-irrigation system, he notes. Yet, he points out that the capital cost leads to decreased running costs, including for management, labour, water and electricity. In his own experience, the only cost that increases, is for fertilizer.

However, for those that have successfully gone down the route of this new technology, the general consensus is that the benefits far outweigh the disadvantages.

Low flow irrigation shows good results

"It has changed my entire viewpoint of farming", says van der Watt of the system. It allows him to apply precision farming, and improved his use of resources like water and fertilizer. "The margin for error is getting smaller and smaller," he adds.

According to information supplied by Netafim, trials on tree crops showed that continuous irrigation solved many of the mentioned management challenges associated with drip irrigation. It has also shown that the actual water requirements of certain tree crops are much lower than traditionally thought as orchards are showing constant and even higher yields with much lower, yet more efficient water application. The concept has already found increasing application in the South African citrus and macadamia industries especially. Mostert says his clients have been running 0.7 litre per hour drippers for the past eight to nine years, resulting in water savings of up to 50%.

Van der Watt adds that he was motivated to switch to a lower flow irrigation system because he noticed that they were over-watering their trees, which can lead to root rot. Before installing his new irrigation system around three years ago, he was already familiar with the concept, having run his tobacco fields on 1 ℓ/h drippers with great success. Switching to that from spray irrigation led to enormous improvements in yield, he says.

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Part of the new system includes that all valves fertilizer is moved to a central pump house.

Benefits of switching to 0.7 ℓ/h drippers in his citrus orchards, for which he also built a new pumphouse to accommodate the new system, has led not only to water savings, but improved management of the irrigation system and concurrent resources used, he says. So far, he can say that the root development of the trees under 0.7 ℓ/h dripper are looking good.

In fact, due to the pressure on water resources, van der Watt is planning to experiment with 0.4 ℓ/h drippers in the near future, when he plants new orchards.

Is this the future of irrigation in South Africa?

Malan thinks carefully before answering. "We'd like to say that this is the future of tree irrigation," he says. According to Malan, the future does lie at low delivery drippers to keep water within the root zone. This, he adds, is open to any farmer that irrigates, regardless of the scale of his farming operation.

Yet, there is still some way to go forward. Malan explains that, except for research, training on the concept is necessary, and the approach to irrigation scheduling must change. Mostert agrees. "You cannot expect the farmers themselves to drive it." Instead, such a change to broad-scale adaptation of a new technology takes time, and many roleplayers, including the irrigation system designers, the fertilizer providers, researchers to provide data and support and consultants. Even with knowledge and leadership, it takes years to establish a new culture.

Yet, for farmers like van der Watt, it is clear in which direction they are moving. Ten years ago, farmers in the area didn't even want to try 1.6 ℓ/h hour drippers, he says, "but look at where we are now."

Sources:

Trends and Outlook: Agricultural Water Management in Southern Africa - Country Report South Africa by Joe Stevens and Barbara van Koppen (2015)
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