FACTORS WHICH INFLUENCE WATER DISTRIBUTION PATTERNS IN SOILS UNDER DRIP

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The purpose of an efficient irrigation system is to apply the water in such a way that the largest fraction thereof is available for beneficial use by the plant. This means that the water distribution in the soil should improve and support healthy and effective root development. In the case of overhead irrigation such as centre pivot or sprinkler systems, 100% of the soil surface (or crop canopy) is wetted.

However, in the case of localized wetting irrigation systems such as micro sprinkler or drip irrigation, only part of the soil surface is wetted, which is beneficial in the sense that there is less evaporation losses from the soil surface.

Figure 1: Root zone development if only part of the soil is wetted

Water movement in the soil

The wetted volume of water in the soil under a dripper consists of a combination of air and water, with a higher concentration of water occurring directly underneath the dripper in a horizontal plane, (Scholtz, 2003). The mixture of air and water along the vertical plane also varies in concentration, but changes over time due to the redistribution of the water as a result of gravity or capillary action.

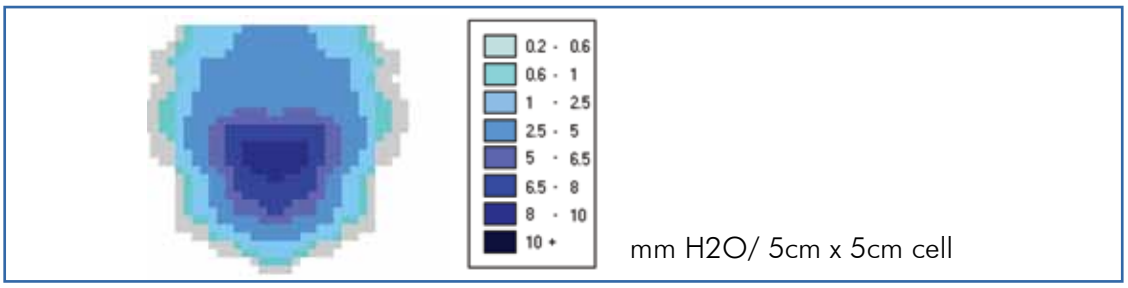

Figure 2: The distribution patterns of water in a soil 48 hours after application when applied from a point source

The influence of the amount of water applied on the wetted volume of a soil

The more the amount of water applied, the bigger the wetted volume of soil, as more soil pores are filled with water (Scholtz, 2003).

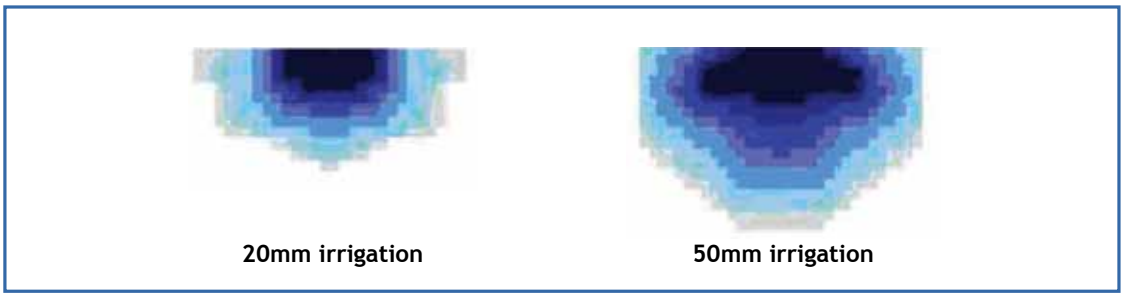

Figure 3: The influence of the amount of water applied on the wetted volume of a soil

The influence of soil texture on the wetted width and depth under drip irrigation

Research has shown that there is a definite relationship between wetted width and depth, and this is mainly determined by the soil texture (fractions of clay, silt and sand in the soil).

When water is applied to soil from a point source like in drip irrigation there are two forces that influence water distribution. Capillary action exerted by the micro pores in the soil and gravity. Soils with high clay and silt contents have more micro pores per unit volume than sandy soils. Therefore, the more the micro pores, water is likely to move more horizontally (sideways) due to capillary action than vertivally (downwards) due to gravity. In soils with high clay and silt contents the width to depth ratio of water distribution will therefore be bigger as compared to sandy soils if the same volume of water is applied.

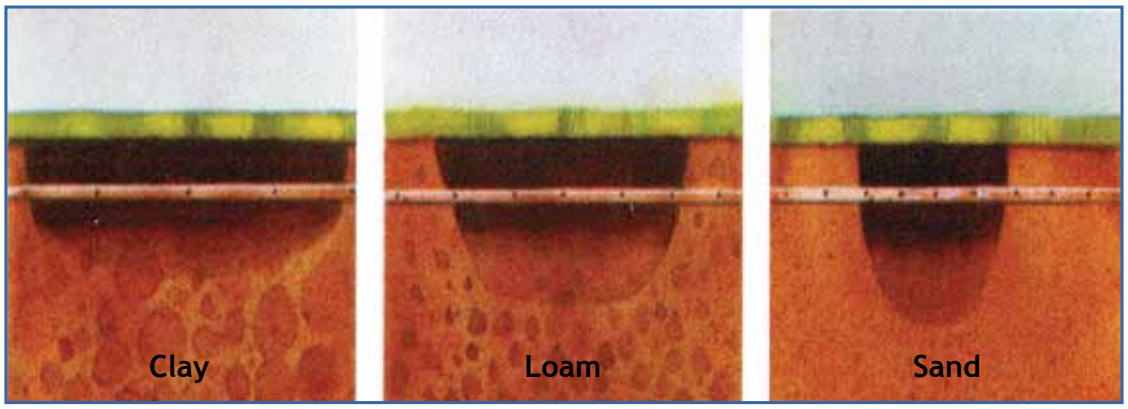

Figure 4: The influence of soil texture on the wetted width and depth under drip irrigation

The influence of emitter discharge on lateral water distribution

As far as the discharge of a dripper's effect on the width of the wetting pattern, conflicting results have been obtained locally and internationally. In the case of more sandy soils similar to those typically found in the Cape, it has been reported that the lower discharge drippers yield a better lateral water distribution. Scholtz (2003) found in the study conducted in the Free State on soils with the clay and silt fraction varying between 12% and 35% that the higher discharge of drippers resulted in a better lateral water distribution.

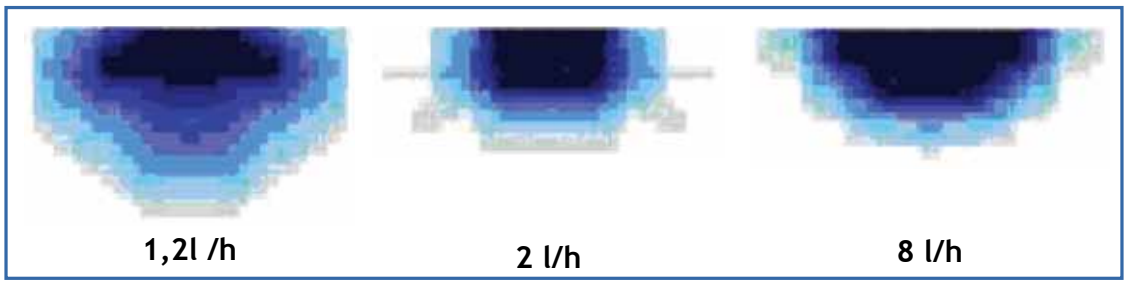

Figure 5a: The water distribution after 50mm application for a different dripper discharge

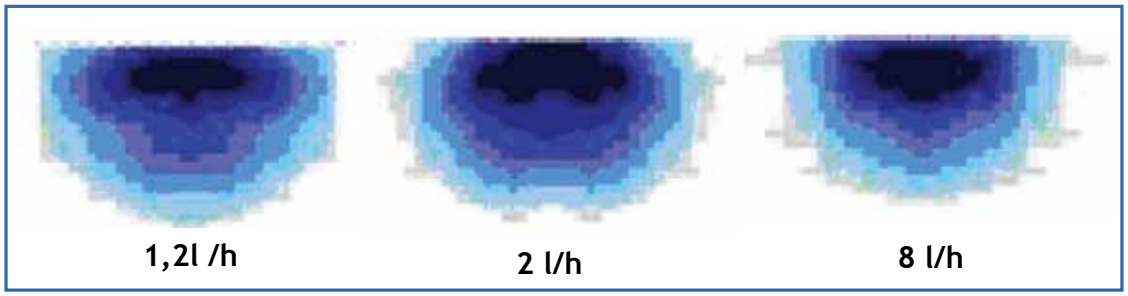

Figure 5b: Water distribution 3 days after 50mm application for a different dripper discharge

The influence of pulse irrigation and cycle length on lateral water distribution

Another practice that is sometimes used to promote lateral water distribution, is pulse irrigation where water is applied in small amounts at short intervals. Again, research is not conclusive as some studies showed no difference in water distribution patterns when irrigation was pulsed or non pulsed (1 min to 30 min) with comparable application rates.

Other studies showed however that with continual wetting and drying cycles, weekly irrigations tended to give better lateral water distribution than daily irrigation. In this case, the water requirement of the crop should however be monitored closely.

When working with a growing crop using drip irrigation, practical experience have shown that under or over irrigation can have a profound effect on the water distribution pattern under drippers. Sustained over irrigation will lead to very good lateral distribution but depleted oxygen levels and leaching of fertilizers in the active root zone. Here it is important to note that the effective rooting depth of the crop will determine the allowable irrigation depth and thereby the achievable lateral distribution as well.

Table 1: The wetted width to depth ratio for different discharge rates for soils in the Northern part of South Africa

Dripper discharge (l/h)	Width (m)	Depth (m)
1.2	2.12	1
2	1.84	1
4	1.60	1
8	1.30	1

Conclusions

The distribution of the water in the soil occurs along the hydraulic gradient between the wet and the dry soil, laterally by means of capillary action and vertically due to gravitation.

Under field conditions of continual wetting and drying, lateral water distribution depends on soil texture, dripper discharge as well as soil water management practices (cycle length, the amount of water applied and soil water content before irrigation):

Although these factors are to some degree individually quantifiable, their combined effect on the lateral water distribution of the soil as a medium, cannot be calculated theoretically. The only reliable method to determine these characteristics is by doing observations and measurements under field conditions using different discharge rates, dripper spacing and volumes.

- Dig longitudinal and cross profile trenches and do the necessary observations and measurements to determine the wetted depth and width for a specific soil texture and dripper spacing.
- Soil texture and depth of the eventual active root zone primarily determines spacing of drippers. The closer the spacing of the emitters the lower the dripper discharge. Very high and very low dripper discharge is not recommended.

When working with a irrigated growing crop:

- Over or under irrigation and not dripper discharge has the biggest influence on soil volume wetted underneath a dripper.
- Very dense active roots does influence water distribution in the soil. Other factors that will influence water distribution:
  - Fine sand fraction, crusts, algae mats, soil structure, compacted layers, textural changes in depth, sodicity.
  - Pulse irrigation.
- Drip irrigation on heavy soils does not have a well defined wetting front – this may result in problematic interpretation of scheduling data because of a lack of proper data peaks. Scheduling equipment should be installed as close as possible to observe changes in water content.

References

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Personal Communication

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