Principles for supplementary maize irrigation

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Although irrigation plays a significant role in higher maize yields in South Africa, there are a number of concerns regarding the availability of water for the sustainable cultivation of maize under irrigation.

South Africa is the food basket of sub-Saharan Africa, but rising temperatures, crippling drought, urbanisation (together with greater demand for municipal water) and more substantial mining activities are all factors that contribute to the depletion of groundwater. There simply is not enough rainfall or supplementation from other water catchment areas to adequately fill the aquifer.

Irrigation from the country's biggest rivers takes place daily and thousands of hectares across South Africa are also irrigated from boreholes. However, water from boreholes for irrigation is coming under increasing pressure due to factors such as industrialisation and higher electricity costs.

Many of the irrigation systems that are currently in use, are older generation centre pivot systems, which are unable to meet the daily evapotranspiration needs of plants. Compared to the irrigation methods of a few years ago, cultivating maize with limited water or supplementary irrigation is currently considered a prerequisite.

It is common knowledge that moisture stress is hybrid specific, but the impact of moisture stress is much more significant during certain stages of plant growth. Although accelerated vegetative growth occurs from V10, there is evidence that, should moisture stress occur during this time, it will result in a smaller leaf area index. Vegetative growth, such as root and stem growth, will still occur after pollination, given that surplus nutrients are available for absorption.

What is supplementary irrigation?

Supplementary irrigation is the productive management of water throughout the season. During critical growth stages, producers must irrigate in a bid to reduce stress. To do this, producers must understand how and when the maize plant reacts to moisture, how crop rotation should be applied and how certain practices influence the water requirements of plants.

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An irrigation management programme must be established to supply water during critical growth stages, such as the tassel formation phase and first reproductive phases. The application of full irrigation is common during the vegetative stages, resulting in there not being enough water available from tassel formation to grain fill. Producers cannot depend on seasonal rainfall; it should instead be viewed as a bonus to supplement root zone moisture.

Evapotranspiration and moisture

Evapotranspiration is the sum of the evaporation of water from the soil surface

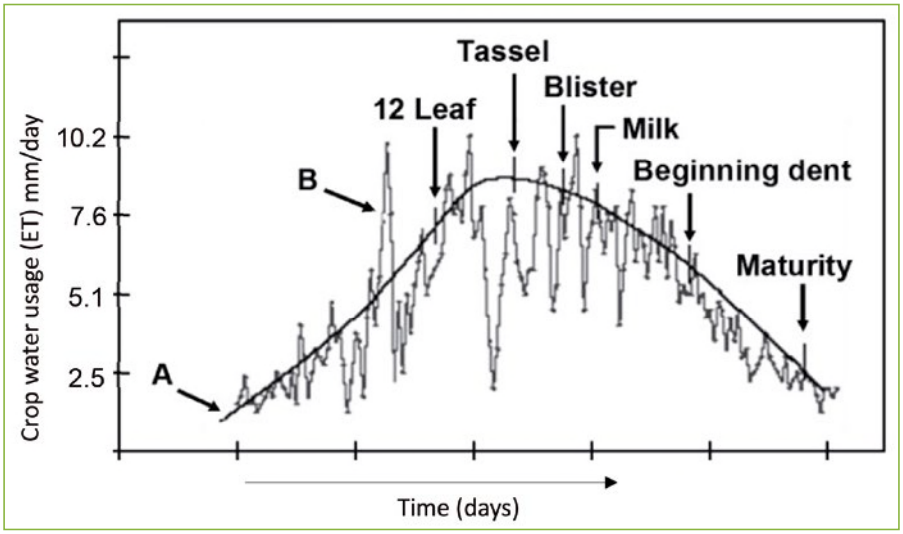
and the transpiration of moisture from plant surfaces. Evapotranspiration is responsible for good maize yields if factors such as soil fertility, diseases, pests and agronomic practices are properly managed.

Soil characteristics such as water retention, infiltration rate and restrictive layers have a major impact during irrigation. Plant characteristics include water use efficiency, drought tolerance and the hybrid's growth height. Environmental conditions include temperature, rainfall, wind and relative humidity.

These conditions are calculated using long-term measured data, which is used to modulate the plant's development and determine critical irrigation periods. The total amount of available water for the season is vital.

Figure 1 illustrates how evaporation from the soil surface contributes approximately 20 to 30% and transpiration from plants approximately 70 to 80% to the total evapotranspiration use in a maize plant's growing season. The curve remains the same across various hybrids. The primary variables are growth height, time per growth phase and water use efficiency of the specific hybrid.

Figure 1: Typical long-term daily average (A) vs varying individual daily water use (line B) in maize. (Source: Kranz *et al*. 2008)



Yield and irrigation timing

The crop's reaction to moisture stress varies widely during its growth cycle. Flowering, pollination and seed formation stages are the most vulnerable to moisture stress, which means the most substantial negative impact on yield occurs during this time. In cases where water is a limiting factor but the producer has control over when to irrigate, the best strategy is not to apply moisture when the plant is less susceptible to moisture stress, but rather to use stored water during times when moisture stress has the most profound impact on yield.

Stored water offers the greatest yield benefit when it is applied during the reproductive phases. If water is still available during the grain-filling stage (R4 to R5), quality will benefit.

The effect of moisture stress

Moisture stress at different stages of development will have varying effects on the phenotypical characteristics of the maize plant. It will influence traits such as plant height, leaf area index, grain yield per hectare, number of ears per plant, grain yield per ear and bushel weight.

In a three-year study, Cakir (2004) found that:

- All yield parameters were negatively influenced when moisture stress commenced during the sensitive tassel (VT) and ear formation stages (R1 to R4).
- Moisture stress during the vegetative and tassel stages was detrimental to plant height and leaf area index.
- Short periods of moisture stress during the accelerated vegetative growth stage (V10) resulted in a 28 to 32% loss in dry matter content.
- The highest yields were obtained under full irrigation and when moisture stress occurred during the vegetative stages.
- A missed irrigation cycle during one of the sensitive stages led to a yield loss of up to 40%. The yield loss was accompanied by extreme drought during one of the three years of the study.
- Yield losses of 60% and more can be expected if moisture stress persists during the tassel and ear formation stages (VT to R5).

Mulching or crop residues

Irrigating with limited water is a practice aimed at collecting all available water and storing it in the production system. Crop residues are an effective way in which to increase water storage capacity. It decreases run-off, increases infiltration and decreases evaporation from the soil surface.

Research has shown that crop residues can contribute 62mm of water due to a decrease in evaporation from the soil surface. Most of the saving will be realised before the maize plant reaches full coverage. The residues suppress the formation of a soil crust and increase infiltration. Water drops tend to destroy the soil structure, upon which a crust forms and seals the soil surface, resulting in a decrease of the infiltration rate.

Plant populations

Smaller maize stands can be planted when water is limited as it reduces competition for available moisture. This makes sense if rising input costs are also considered. However, to sufficiently meet evapotranspiration needs, stands must hold far less than 45 000 plants per hectare; this, of course, leads to lower yields.

When maize is cultivated under supplementary irrigation, one should select a hybrid with strong multiple ear characteristics. There are only a handful of hybrids in South Africa that have multiple ears at stands of 45 000. Most hybrids lose their multiple ear trait above 40 000.

PIONEER is currently in the process of selecting drought tolerant hybrids that will ensure high yields at larger stands.

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