FRESH NOTES
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Critical Water Shortages

Irrigation Guidelines for Deciduous Fruit Trees

Droughts require that each drop of water be used as economically and efficiently as possible. The greatest water savings can be made early and late in the season.

The principle is to conserve water during the cell division phase, namely from budding until 40 days after bloom in the case of pome fruit or from budding until the end of stone hardening in the case of stone fruit. During these stages of development, the tree is less sensitive to water stress, and controlled water deficit will not significantly affect fruit size. Furthermore, these periods in the season have lower evapotranspiration, reducing plant water demand. In the early part of the season, there is typically a root flush, and a drier soil profile can, in fact, help stimulate a better root flush, which will aid in more effective nutrient and water uptake later in the season. In pome fruit, mild water stress occurring before irrigation events during the first 40 days after full bloom can also help control excessive vegetative growth. From 40 to 60 days after full bloom, deficit irrigation can be applied to limit active shoot growth.

In a water-scarce year, excessive vegetative growth directly translates to greater transpiration and higher water use. Controlling early-season vigour through controlled water stress can also increase canopy light availability, improving next season's bud development.

The second phase, during which water can be saved, is after harvest, for both stone and pome fruits. This is the time when the tree supplements its reserves. Research conducted in the Koue Bokkeveld on water shortages during specific phenological stages of Golden Delicious apples found that a very dry period after harvest, under a water regime (90% withdrawal of plant-available water), had little effect on fruit size or yield in the following season. *(Note that 90% withdrawal is an extreme – not a target withdrawal.)* The extent of post-harvest water savings is directly related to the severity of water shortages or the block's post-harvest vigour. Avoid excessive water stress after harvest in stone fruit until mid-January, as bud initiation for the next season is underway.

After harvest, a significant root flush typically occurs. Depending on the severity of water limitations and soil conditions, longer, deeper irrigation, followed by a 5-10-day interval before the next irrigation, can encourage deeper root development. Improved root depth within the soil profile can enhance orchard resilience to future drought conditions.

The period during which the available water should be maximally utilised for irrigation is during the cell enlargement and maturation phases.

For pome fruit, this is roughly 40 to 60 days after bloom, from shoot growth cessation until harvest; for stone fruit, it is from pip hardening until harvest.

Important determining factors pertaining to irrigation during water shortages

- How much water is available for irrigation?
    - The amount of irrigation water available will determine the extent of water saving.
- Phenological phase
    - Water can be saved during the cell division phase and after harvest.

- The period when cell enlargement takes place in pome fruit (from roughly 40 to 60 days after full bloom), and stone hardening in stone fruit, must be determined on an orchard basis so that each orchard's irrigation scheduling can be customised and optimised.

- Prioritise orchards
  - Using the previous season's data, divide the orchard profit per hectare by the cubic meters of water applied per hectare. Rank your orchards accordingly.
  - The irrigation and orchard management strategies of highly profitable orchards will differ from those of less profitable orchards.
  - Fruit types for which the market is more sensitive to size, such as pears, plums and cherries, require more irrigation to achieve optimal fruit size than apples do.
  - This is the year when poor orchards should be removed and new developments reconsidered.

- Soil properties

  Soil properties strongly influence the amount and frequency of irrigation. The following factors often occur in combination and should be considered as a whole. Orchards on soils that are not well buffered against water shortages (low water-holding capacity or shallow soils) must be identified and managed appropriately.
  - Water holding capacity of the soil
    - Irrigation of soil with a higher silt and clay content (heavier soils) may commence later than that of sandier soils, with longer irrigation intervals, provided the soil was saturated at the start of the season.
    - Irrigation of soil with a high stone fraction should begin earlier, and

irrigation should be carried out more regularly than for soil with a low stone fraction, or when such a fraction is absent.

- During the irrigation season, it is important to understand how deep-water infiltrates with a specific quantity of water. Sandier and rockier soils have lower water-holding capacity and more rapid water infiltration. Deep percolation (drainage) of water past 80 cm must be avoided. As such, soil with a lower water-holding capacity will require shorter, more frequent irrigations to maintain soil moisture. They will also have a higher evaporative loss and should be prioritised for mulching.
- Soil moisture probes are very useful for determining how deep water infiltrates and the rate of depletion of soil moisture.

- Soil depth and root depth
  - Mature orchards utilise most of the soil volume until a limiting layer is reached. The size of the utilised soil volume directly affects the reservoir size from which the tree draws water and largely determines how much water must be provided and how often.
  - Focusing on postharvest irrigations (as discussed above) can help increase the rooting volume and thus decrease the return time pressure of the irrigation system.
  - Deeper irrigations (while avoiding deep drainage) allow for more effective irrigation as less water will evaporate from the soil surface. Focusing on developing deeper, healthier root systems is critical in this regard.
- Young orchards
  - The root system of a young tree is very small and initially does not utilise the full soil volume. Consequently, the water reservoir available to the tree is smaller, and, combined with the smaller leaf canopy, this affects

both the water demand and the irrigation frequency.

- Topography and slopes
  - Irrigation will probably commence later on the cooler southern slopes and in low-lying areas.
  - Warm northern and western slopes will probably need to be irrigated more frequently due to higher evapotranspiration.
  - Identify wet orchards or areas where irrigation will commence later.
  - Orchards in high-lying areas will probably dry out more quickly.

    It is therefore important to monitor each orchard individually and optimise its irrigation schedule, rather than applying a single irrigation recipe across all orchards.

Water saving practices

1. Exclude weed competition
   - Manage weeds on the wetted area.
   - Manage weeds in the tractor row.
   - Although weeds are additional transpiring leaves requiring water, they do have the benefit of decreasing surface evaporation and improving water infiltration into the soil and root zone. Therefore, rather than managing the types of weeds/cover crops and their heights.
   - Do not till the soil because it destroys surface roots that utilise dew and low rainfall events.

2. Reduce surface evaporation
   - Cover the ground with a mulch or coarse, dead plant material (straw, grass, prunings or rotted sawdust). Any mulch is better than none and can yield 15-20% water savings.

- Change to strip wetting, narrow range micros or drip irrigation in cases where water shortages are serious. Surface evaporation decreases as the wetted area decreases.

3. Fertilization
   - Follow normal fertilisation practices.
   - Fertilisation at bloom and six weeks thereafter must be applied together with the irrigation scheduled for that time.
   - The fertilisation at six weeks after full bloom should be adjusted if fruit is thinned more severely.
   - Guard against over-fertilisation with nitrogen, as lush growth is undesirable under water-limited conditions. Increased leaf area increases transpiration, which can exacerbate water stress.
   - If the period after harvest is dry, the nitrogen requirements of the tree can be partially supplied with urea sprays (1.5 kg/L). Repeat three to four times at intervals of 14 days. The after-harvest nutrient requirements cannot be replaced by sprays.
   - Should brackish conditions prevail, continually measure the EC of the water. The EC must be considered with the fertigation programme.

4. Effective irrigation design
   - Ensure that the irrigation system functions efficiently. Take note of filters, broken and blocked applicators, the position of the applicators, weeds and low branches that will interfere with water distribution.
   - Ensure that the irrigation system operates at the correct pressures. A block running at high pressure will produce misting, resulting in greater

evaporation losses, while a block running at too low a pressure will be insufficiently wetted. Pressures should be checked while the valves are operating, along with the other valves in the system.

- Follow up on the wetted widths of the micros. Ensure water is only placed where most of the fine roots are located, i.e., from tractor wheel to tractor wheel. Not wider. This means that orchards should be converted to a narrow-range emitter if plant spacing allows, and hanging micros should be set to the correct height to ensure water is not placed in the tractor row. High-hanging micros will also have higher evaporation losses.
- Irrigate during the night with micros when evaporation (wind, temperature and VPD) losses are far less than during the day. This will ensure every drop of water is more effectively infiltrated into the soil. Make sure, however, that periodically, orchards are irrigated during the day so that the systems can be walked through and emitters checked.
- Irrigate less frequently but apply longer irrigation events to reduce surface evaporation losses. Orchards with well-developed deep root systems will be more resilient under this approach. In contrast, orchards with shallow root systems require shorter, more frequent irrigations, resulting in higher evaporation losses. Care should be taken to not over-irrigate, as this can result in water loss through deep percolation beyond 80 cm. Do not pulse irrigate.
- Dig profile holes in the tree rows and determine where 80% of the trees' roots are concentrated. Only this area must be wetted during the season. Note that if your soil is already brackish or if irrigation water quality deteriorates, there may be an excessive buildup of salts in the root zone, which will need to be corrected when water is available again.
- Check the setup of groundwater measuring instruments (continuous

logging probes) and ensure that they are aligned with the soil properties and root distribution in the orchard. Ensure that all probes are in representative positions and that the probe lines have been meticulously checked.

- Keep a record of each irrigation so that you can set up a water budget. Ideally, irrigate in cubic meters per hectare (if you know the exact valve hectares) or in hours (if you monitor the valve pressures closely).

5. Irrigation scheduling
    - Dig profile holes, or use a soil auger weekly, and give the soil moisture at 20 cm, 40 cm and 60 cm a score out of 5, where 1 is dry, 5 is wet, and 3 is optimal. Keep a record of the evaluation of each profile hole.
    - Use water measuring instruments such as continuous logging probes, tensiometers, and neutron moisture probes.
    - Make use of data from a weather station together with historic irrigation records from each block to set up a water budget. This can be used to set up weekly irrigation budgets and link back to the water supplies available in the season.
    - To measure is to know.

6. Summer pruning
    - Remove all water shoots as early as possible. Leaves are the largest consumers of water; removing excess leaves reduces water consumption.
    - Control growth with growth retardants, such as Regalis®, early-season irrigation and mild water deficits.

7. Harvest control
   - Thinning must be carried out in such a manner that an acceptable fruit size and leaf/fruit ratio are obtained with the available water. Thinning must be done as early as possible, and rather more severely than normal, to minimise the negative effect of under-irrigation on fruit size.
   - Follow-up thinning ("grooming") should be carried out through to harvest to remove fruit that will not meet market requirements.

8. Irrigation of young trees
   - Significant water can be saved in the case of young trees that do not yet bear much. The crop on such trees must, however, not be removed entirely, as trees with fruit survive better than those without. Focus on deeper irrigation for young trees to develop a greater root volume and ensure micros are not hanging too high.
   - Move the micro sprinklers next to the tree and reduce the area to be wetted by reducing the wetting area of the rotator or static distributor. Be careful that no run-off takes place.
   - Cover the wetted area with a mulch to reduce surface evaporation.

9. Wind breaks
   - Place stopcocks on windbreaks or stop irrigation.
   - Trim off excessive growth on the sides of windbreaks.
   - Should the roots of the windbreak grow into the orchard, a ripper tine can be used to sever the roots, ensuring that the windbreak does not steal water from the orchard. This will temporarily reduce competition for water between the orchard and the windbreak.
   - Ineffective windbreaks can be removed and chipped for mulch.

10. Use boreholes and drainage water optimally
    - Pump drainage water back into dams.
    - First, confirm the quality of both water sources before use.
    - Monitor water quality carefully for EC and sodium levels.
11. Make use of an accurate weather predictor and weather station.
    - Plan scheduling prior to predicted heat waves by applying longer irrigation.
12. Prevent runoff.
    - Blocks that typically struggle with water infiltration will be more of a challenge in a year where water is limited, and the soil surface becomes drier.
13. Prioritise mulch, lower emitter deliveries, narrow wetted widths, a water-efficient cover crop, investigate soil chemistry, and possibly use a soil conditioning agent to improve soil structure and decrease soil crusting and compaction.
14. Restrict water use everywhere on the farm.
15. When in doubt, dig a hole.

Example of irrigation scheduling with 50% water

The following assumptions are made:

1. A Golden Delicious orchard requiring 8 000 m^3/ha/season. With only 50% water supply, there is therefore 4 000 m^3/ha/season available.
2. Suppose it is a Golden Delicious apple orchard in the Koue Bokkeveld with harvest on 7 March.
3. An irrigation that wets the entire root zone without deep drainage or water in the tractor row requires 200 m^3/ha (with a system delivery of 50 m^3/ha/hour, this is equivalent to 4 hours).
4. Therefore, with 4 000 m^3/ha available, there is water for 20 irrigations.

Proposed strategy:

1. Apply a thick mulch.
2. One irrigation during cell division and reserve one irrigation for after harvest (to wash in after harvest fertilisation) of 200 m^3/ha each.
3. The period from 40-60 days after full bloom until the end of harvest is 88 - 108 days, and there is water remaining for 18 irrigations at 200 m^3/ha per irrigation. The 18 irrigations must therefore be scheduled with about a five to six-day interval over the period, depending on the soil moisture and weather conditions.
4. Note that the evapotranspiration (temperature, length of day, wind, humidity, etc.) is higher in December and January. From mid-February, the evapotranspiration generally decreases quite quickly. As such, it will be important to monitor the soil moisture closely to optimise the exact timing of the 18 irrigations. It may be possible to spread the irrigations out further during the November, February, and March periods.

Note: The water retention capacity and thus irrigation intervals will differ for each scenario; calculations must be carried out for each scenario.

This article was compiled by Louis Reynolds of Fruitful Crop Advice, Ceres and Karen van der Westhuizen of MuddyBoots, Cape Town, from the following three sources, as well as from practical experience and lessons learnt in the 2017 drought season:

1. Droogtebestuurdokument (Eng: Drought control document), by M du Preez.
2. Orchard management during periods of limited irrigation water, by T. Volschenk (ARC Infruitec-Nietvoorbij 06-09-2000).

3. Irrigation strategies for apple production in the Koue Bokkeveld, by T. Volschenk (SA Fruit Journal April/May 2013).