IRRIGATION OF CITRUS WITH REFERENCE TO WATER SHORTAGES AND POOR WATER QUALITY

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Water is a powerful tool that can be used to manipulate vegetative growth, reproduction, fruit quality like size, colour, sugar-, acid-, and juice content, sunburn and can even change the root distribution pattern on the soil. Water scheduling has an important effect on nutrient uptake, transport of elements to the active sites and also the transport of photosynthates especially to the target organs (fruit). Water is the single most important molecule in plants because it drives the metabolismic machinery of the plant. The target should therefore be to use this tool to optimize production and quality without wasting our most important resource.

IDEAL SCHEDULING

Regarding irrigation scheduling the citrus tree phenology can be divided in to five phases.

The recuperation phase after harvest can be quite long for early varieties like Satsumas or almost non-existent for late varieties like Valencias. The first two to three weeks directly after harvest is an important period to recuperate lost reserves and enough water is important for nutrient uptake.

The tree can resist some water stress but take care of too much stress in the flower initiation period (April, May). A slight regulated water deficit prior to flower initiation can promote more flowers for the next season but again, take care not to loose on fruit size on varieties with fruit on the tree during this period. Use 50-60% extraction of Total Available Water (TAW) for cropped varieties and 35-40% for non-cropped cultivars.

The reactivation phase (budswell to first flower) needs enough water and nutrients to force a strong, even new flush with flowers. Good root temperatures (15-25°C) and enough oxygen (8-10%) are also imperative. So, the idea is to apply enough water but not too wet to allow good rootzone temperature and oxygen levels. Water extractions of 40-50% of TAW should be used.

During the flowering, set and cell division stage (flowering to final fruit drop in late November) water must be held back but without stress to force the tree to set fruit and to control unnecessary shootgrowth. The cell divisions are not sensitive to slight water deficits. Stress can however cause Absisic Acid (ABA) production in the root system, which will be transported to the canopy with the next irrigation, and will cause fruit drop. The October/November shoot flush will also compete with the small fruits for photosynthates and hormones (cytokinins) and can therefore cause poor fruit set. This flush is also not important for the next crop (except for young trees that need to fill space). Holding back water but without causing stress (like wilting) to contain growth and set fruit is the objective with scheduling during this critical 2 – 3 months. The only way to do it is by means of helplines. Install a line on 10-12 trees delivering only half of the designed flow and to 10 – 12 other trees a double line. Apply the water in such a way that the half-line shows some stress but no stress on the normal orchard lines. No flush on the normal lines and some flush on the double lines.

The fruit enlargement stage (final fruit drop until 3 weeks before harvest) needs a lot of water to grow big fruit. Irrigate according to the double line. Measure fruit growth during this period. If the double line gives better fruit size, increase the water until such time that the normal line has the biggest fruit. Water extractions of no more than 30-40% of TAW should be allowed.

Less water can be applied in the ripening period (from three weeks before harvest and during harvest) to concentrate more sugars, burn high acids and to force colour development. Be careful not to stress the trees too much if this period falls within the flower initiation period. Extractions of 50% of TAW can be implemented.

The following crop factors (CF = Kc x Kp) can be used as guidelines for irrigation with normal quality water:

CROP FACTORS (CF = Kc X Kp)			
Month	**Satsuma**	**Clementines**	**Valencia/Lemons**
July	0.10	0.10	0.10
August	0.15	0.15	0.15
September	0.25	0.25	0.25
October	0.30	0.30	0.30
November	0.40	0.35	0.35
December	0.45	0.45	0.45
January	0.50	0.45	0.45
February	0.35	0.50	0.50
March	0.30	0.45	0.45
April	0.35	0.45	0.45
May	0.30	0.30	0.35
June	0.15	0.20	0.30

IRRIGATION SCHEDULING DURING CRITICAL WATER SHORTAGES

Droughts necessitate the effective and optimum and use of each droplet of water. The biggest savings can be achieved after the recuperation phase, even the reactivation phase (still cool temperatures) but especially during the long cell division phase and lastly during the ripening phase. Very little savings can be made during cell enlargement.

The following guidelines are only valid in cases of necessity and only until the water situation is restored.

Trees that were irrigated and fed optimally in the past have a better chance to survive. Orchards on soil with higher water holding capacity and cooler slopes/areas can also resist droughts better than those on sandy soils and hot slopes/areas.

Wine grapes can resist water deficiencies much better than table grapes followed by citrus, pome fruit, nectarines, peaches, plums and cherries.

Apply the following water saving strategies:

1. Full cover weed control. No mechanical cultivation because it kills roots close to the surface and prevents utilization of small rains and irrigation. Use chemical mowing in the work row (600ml Roundup/ha) and keep any cover crop short.

2. Mulch the welted strip with any kind of dead organic material (straw, grass, compost, sawdust, bark, leaves, etc). Be careful with material reflecting heat into the tree (white straw, etc). Any cover is better than nothing.

3. Fertilization must be reduced where thinning was more aggressive. Maintain optimum potassium levels because it is imperative for maintenance of cell turgor and water balance in the plant. Potassium is also important for stomata conductance but don't apply too much because high salt levels in the soil cause more negative water potential. Never over fertilize with nitrogen because vigorous growth is fatal and too much fertilizer increases the EC of the soil solution and decreases water uptake.

4. Make sure the irrigation system is effective. Check filters, broken and blocked emitters, position of emitters, weeds, low hanging branches preventing good water distribution and make sure the system works at the designed pressure. Irrigate at night to fill the reservoir. Identify cooler and wet areas on the farm and use a longer scheduling interval on this part. Utilize all drainage water if suitable. Drains can even be blocked as an emergency measure. Change to under tree strip wetting or even drip irrigation to lower the evaporation component. Do not guess, make sure where the roots are concentrated and make sure you wet the rootzone properly with every irrigation. Prevent over irrigation (leaching) and utilize water tables where possible.

5. Reduce the canopy if necessary but never in the flowering to final fruit drop period. It can be done in Jan/Feb or May-August.

6. Control growth even with growth retardants if registered.

7. Crop control. Thin for acceptable fruit size and leaf / fruit ratio for the available water. Citrus trees need 17 - 20 leaves per fruit to reach optimum size and leaves are the biggest consumer of water. It is not advisable to thin of all fruit except in severe cases where survival of the trees are important. Sacrifice fruit from orchards with low production, young orchards and varieties with low profitability. Always leave some fruit on the tree because trees with some fruit survive better than trees without fruit.

8. Control Nematodes.

9. Make small dams around young trees, mulch and put the micro jets flat in the little dam to survive young trees.

10. Stop irrigating windbreaks.

11. Cut orchards with marginal income, top work to new varieties and survive the trees by applying water in little dams as described under point 9 above.

12. When water becomes extremely limited the trees can be survived by wetting them during the night just to keep the leaf activity going. Minimum twice a week during critical hot periods. The next step will be to remove the canopy and paint the trees with PVA. It takes three years to get back into normal production.

13. Irrigate according to percentage water restriction.

75% OF SEASONAL REQUIREMENT:
Apply water saving practices and schedule according to plant needs. Apply water in dams around young trees.

60% OF SEASONAL REQUIREMENT:
Select high producing/income orchards, apply water saving strategies and irrigate according to plant needs. Apply all water saving practices and crop control to the rest and irrigate to reactivate, hold water strongly during set to fruit drop period and apply at 60% level during cell enlargement period. Irrigate trees that need survival only once a month or when it shows severe stress.

40% OF SEASONAL REQUIREMENT:
Select the best orchards, apply water saving practices, reduce crop by thinning and irrigate as follows:

- Reactivation: when trees show slight wilting.
- Cell division: just at first signs of stress i.e. leaf colour change, leaves start curling in the tops.
- Cell enlargement: keep fruit growth on ideal growth curve.
- Ripening period: only on visual stress.

Survive other orchards irrigating in dams or reducing the canopy or both and do heavy fruit thinning.

20% OF SEASONAL REQUIREMENT:
Select only the one or two most economic blocks for own survival, apply water saving strategy, thin properly and irrigate as described under 40% of seasonal requirement.

Remove canopy of other orchards and paint white. Irrigate in dams once a month to survive the trees.

Cut and top work uneconomic blocks and survive the small new trees irrigating in dams only at visible signals of stress.

Remove uneconomic old blocks.

LESS THAN 20% OF SEASONAL REQUIREMENT:
The only option is to survive the trees by irrigating in dams, reducing / removing the canopy and painting the trees.

IRRIGATING WITH POOR WATER QUALITY
Four parameters are normally used to evaluate irrigation water for its suitability for irrigation namely pH, Electrical Conductivity (EC) and toxic elements for a specific crop like sodium and chlorine and sodium absorption ratio (SAR). Most important therefore is to have a reliable water analysis and if possible for different times of the year and especially for the period of highest water use by the specific crop. The least you can do is to try and balance the water and to reduce the risk of stress and damage to the tree.

1. pH. The aim should be to lower the pH of high pH waters to about 6.0 by adding acid. The most common way is to neutralize the bicarbonate (and carbonate) in the water ($HCO_3^- + H^+ \rightarrow H_2O + CO_2$)

   ml 98% H_2SO_4/m3 of water = 27.28 x me/lit HCO_3^- or = 0.447 x mg/lit HCO_3^-

   Acids are usually diluted in bigger tanks (acid applied to water not other way around) and injected at say 4 - 6 lit/m3 irrigation water. Add more or less to reach the desired pH.

2. EC. The EC gives an indication of the total salt load in the water. The higher the EC the more salt it contains and the higher the osmotic pressure against which the tree must take up the water

   mS/cm x 360 = osmotic pressure in kPa.

   (eg. 2.99 x 360 = 1070 kPa)

   Most researchers use 0.8 - 1.2 mS/cm as safe upper limits which coincides with 510 - 770 mg/lit TDS.

   The USSL (1977) uses the following formula to determine the relative yield (y%) for soil salinity exceeding the threshold ECe of 1.7 mS/cm for oranges.

   y = 100 - 16 (ECe - 1.7 mS/cm)

   For example at a soil water ECe of 3.26 mS/cm you will experience a 25% crop loss. So the soil ECe should not exceed 1.7 mS/cm. The only way to reduce the EC is to dilute the irrigation water with better quality water with a lower EC.

SODIUM (Na^+): Levels in excess of 200 ppm (8.7 me/lit) are considered too high for citrus. The solution is to balance Na^+ by adding equivalent amounts of $SO_4^=$ in the form of sulphuric acid, potassium sulphate, magnesium sulphate etc. This can only be done if you have a proper fertigation system. Gypsum can also be added to the soil.

CHLORINE (Cl^-): Levels of more than 200 ppm (5.6 me/lit) limit production. The only way is to balance the water with equivalent amounts of calcium and magnesium if too low and unbalanced. Calcium can preferably be added as Calcium nitrate. But also as gypsum where needed.

Remember that any chemicals you add to the water will increase the EC. Some waters are therefore unbalanced and cannot be used for irrigation.

Except for balancing the water, scheduling with poor quality water always requires a more frequent cycle to keep a low osmotic pressure and also requires some leaching (± 20%) to push toxic ions like sodium and chlorine out of the profile.

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