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Managing citrus orchards with less water

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Introduction

In situations of reduced water availability, it can sometimes be more profitable to provide optimum water to part of an orchard and produce good marketable fruit, rather than watering the whole orchard and producing small unmarketable fruit. Managing your citrus orchard with a reduced water allocation requires planning. The following information outlines a number of management options and strategies that can be used in developing a plan of action.

Citrus water use

Mature sprinkler irrigated citrus trees grown in Sunraysia require around 1000 mm (10Ml/ha) of water annually. Figure 1 depicts average water use by mature citrus trees based on long-term data collected at Dareton in south western NSW. This information can be used as a guide for determining water needs and planning for the coming season. An Excel water budget spreadsheet for Dareton and Griffith is available from the Australian Citrus Growers “Resources” web page www.australiancitrusgrowers.com

Water and citrus growth

Under ideal growing conditions citrus trees require water all year round. Normally the peak demand for water is during the warmer months from October to March. Using the information from Figure 1 on the following page, typically 54% of the annual water use of citrus trees occurs between the months of November and February and this rises to 74% if we include the months of October and March. Water use normally falls during late autumn and winter with the onset of cooler temperatures and the slowing of tree growth.

Generally citrus trees adapt to insufficient water by reducing overall water use and fruit growth. Water comprises 85-90% of the fruit mass by weight, so harvesting the fruit can reduce tree water demand. Rootstocks also vary in their tolerance to water stress and salinity levels. Rough lemon, *Carrizo citrange,* and *Swingle citrumelo* have good drought tolerance, *Cleopatra mandarin* and *Troyer citrange* have moderate tolerance and *P.trifoliata* and Sweet orange have poor tolerance. Drought tolerance is related to rooting depth.

Soil water also affects soil aeration, temperature, salinity and the growth and health of tree roots. When soil water is depleted over an extended period root growth slows and feeder roots become thicker. Soil temperature also affects water absorption and tree transpiration ceases when root temperatures reach about 34°C. Most of the active rootzone of trees is in the upper 30-40cm of the soil and can vary between rootstocks.

Water stress can affect citrus at all development stages and stress can occur before any visual symptoms appear. Water availability strongly influences flowering and fruit set and can affect fruit drop, fruit size, yield, internal fruit quality characteristics and canopy development.

Water stress in spring (September-October) during flowering, fruit set and early cell division will have a big impact on reducing fruit numbers, fruit size and

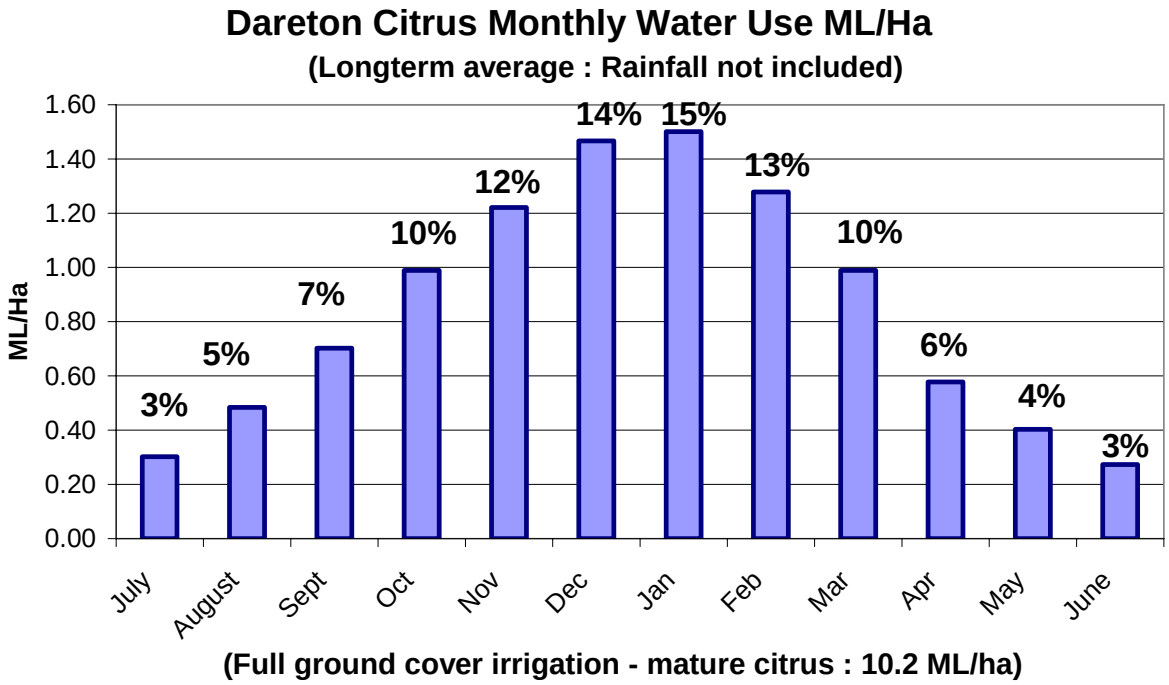

***Figure 1**: Long-term average water use of mature citrus trees with full ground cover, sprinkler irrigation and monthly percentage values at Dareton.*

overall yield. Water stress during late spring and summer (November-February) at the time of late cell division and cell expansion, will have a big impact on fruit size. Water stress closer to harvest can influence internal fruit quality characteristics such as acidity, % juice, TSS and fruit maturity. Water stress can also restrict vegetative growth and reduce canopy development, which is especially important in young trees and for next seasons flowering sites.

Citrus growth stages

- Flower bud induction and initiation
  mid May – July
- Flowering
  mid September – October
- Stage 1 Fruit Growth (cell division)
  November – December
- Stage 2 Fruit Growth (cell expansion)
  Jan – April
- Fruit maturity
  May onwards

Flower bud induction and initiation mid May – July.

During this stage trees utilise about 10% of annual water requirements. Moderate water stress at this time can increase flowering. In fact in some regions (Northern Territory) water stress is a technique used to induce flowering in citrus. However drought periods of more than 30 days are usually required to induce a significant number of flower buds.

Flowering & Fruit set mid September – October.

During this stage trees utilise about 13% of annual water requirements. Water stress during this period can reduce fruit set, cause excessive fruitlet drop, reduce yield and suppress the spring flush.

Stage 1 Fruit Growth (cell division) November – December.

Throughout this period trees utilise about 26% of annual water requirements. During this stage cells are dividing and up to 60% of final fruit size is determined. Small fruit size at the end of this period tends to be small at harvest. Water stress during this stage can cause excessive fruitlet drop and reduce fruit size. Fruitlet drop is usually more severe when water stress is coupled with high temperatures (>35° C). Trees carrying mature fruit at this time, such as Valencias, seem to be able to buffer this effect to some extent, so fruitlet drop is usually more severe in navels. The summer leaf flush may also be suppressed which can affect next seasons flowering sites.

Stage 2 Fruit Growth (cell expansion) January – April.

During this period trees utilise about 40% of annual water requirements. The first few months of this stage (mid-December to February) is the critical

time when fruit cells are expanding (cells can increase 1000 times) and final fruit size is determined. Therefore water stress in the early part of this stage should be keep to a minimum. An early sign of stress is that fruit stop growing, so it is important to measure fruit size regularly. From January onwards measure fruit size weekly at the same time each day (7-9am). If water is supplied at the first sign of a fruit growth decrease then fruit size may not be reduced.

The best window for extending irrigation intervals is during late summer and autumn. Minor water stress during the latter part of this stage can be tolerated without a major affect on fruit size. However prolonged water stress will reduce fruit size, and is more pronounced when the crop load is heavy. Prolonged water stress can also influence internal fruit quality characteristics, increasing the acidity and Total Soluble Solids (TSS) of fruit, while slightly decreasing percent juice. Mid-summer and autumn leaf flush will be suppressed, which can affect next seasons flowering sites.

Fruit maturity
May onwards.

During this stage trees utilise about 10% of annual water requirements. Moderate water stress will have a minimal impact on fruit size but it may bring forward fruit maturity slightly, reduce the shelf life of fruit and increase the incidence of stem end rind breakdown. The best strategy for reducing water use at this time is to slightly extend the timing of irrigation intervals.

Impacts of water stress on growth

The following information is a guide to the possible impacts of various levels of water reduction on the health and productivity of a citrus tree. Reducing water application rates can lead to increased soil salinity levels. Soil salinity should be checked regularly using soil salinity tests. The salinity of irrigation water can also increase in times of drought, so water salinity should also be tested. Irrigating with saline water will increase the severity of stress on trees. Contact your local Horticulturist or Irrigation officer for more information about salinity management.

10-20% reduction in water application

In some situations a 10%-20% reduction in water application can be tolerated with minimal impact on fruit size and yield. Reductions of this capacity may be achieved by improving irrigation efficiency and scheduling and eliminating water losses due to deep drainage.

20 to 40% reduction in water application

Fruit size will decline and some crop reduction may occur. The vigour of leaf flush may be reduced. The following season's productivity may be affected depending upon the severity and timing of water stress.

40 to 75% reduction in water application

Significant crop reduction, decline in fruit size and decline in leaf flush will occur. Depending on the severity of water reduction, fruit may be too small for traditional fresh fruit marketing. The trees may take a season or two to fully recover to optimum production. Recovery will depend upon the severity of the water reduction and how the current season's leaf flush has been affected.

More than 75% reduction in water application

Total crop loss would be expected and the trees will be unthrifty with significant twig dieback and leaf drop. It may take a couple of seasons for the trees to fully recover.

Water saving practices

Basic strategies to implement in times of water shortage

- **Do a water budget**. Estimate the monthly water requirements for your orchard. Using average water use figures (Figure 1) and your own irrigation records, you can predict monthly water requirements for each block. Combined with information on the long-term plans and value of individual blocks this information can then be used to help prioritise irrigation applications. See page 5 for more information on developing a water budget.
- **Install irrigation scheduling devices.** It is critical to have some type of soil moisture monitoring device installed in order to more accurately check soil water levels. This will allow you to schedule irrigation applications more precisely and extend out irrigation intervals more confidently. If you do not currently have any devices, then tensiometers are relatively cheap, easy to install and use. More expensive sophisticated scheduling tools will allow you to be far more accurate and effective with your irrigation applications. However it generally takes a longer time to learn how to use and understand the information generated from this equipment.
- **Check, manage and maintain the irrigation system.** Check your irrigation system and fix any leaks. Test the efficiency of your irrigation system. Check the accuracy of water meters by cross-referencing readouts with application

rates. If irrigation uniformity is below 75% contact an irrigation consultant for advice on how improvements can be made. The effect an inefficient system has on an orchard will be exasperated during times of drought.

- **Stop leaching losses.** Ensure water is not applied and lost below the root zone by carefully monitoring soil moisture levels and irrigation depth.
- **Mulch the wetted strip.** Applying mulch helps reduce soil evaporation. In large mature orchards this may be uneconomical, however it can be a useful option for young trees where large amounts of the soil surface is exposed. Overseas information has shown that plastic mulches can be economically viable for young trees. Ensure that the drip line is underneath the mulch. In plantings with sprinkler irrigation mulches may sometimes act as a barrier to effective water penetration.
- **Only irrigate the wetted strip.** This is most applicable to irrigators with low-level sprinklers, and involves changing over to a sprinkler head that only throws water along the tree line. For young trees, sprinkler types are also available which only distribute water in a very small area around the tree.
- **Full cover weed control.** Removing weeds and eliminating sods will reduce competition for water. Sods are best sprayed with herbicide and allowed to form a layer of mulch, protecting the soil and reducing evaporation. For drip irrigation systems it is best to slash the sod and throw the cuttings back over the wetted strip to form a mulch.
- **Irrigate at night.** Under tree sprinkler irrigating at night can make water savings of 20-30% compared to daytime irrigation by reducing evaporation losses. However the water savings with drip irrigation systems is variable depending on the amount of leaf litter and shade over the wetted soil surface.
- **Reduce water runoff.** If water runoff from the soil surface occurs (sprinkler irrigated systems) then break up soil crusts to improve water penetration and soil aeration.
- **Reduce or stop irrigating windbreaks.** This can save water but remember the long-term importance of windbreaks, especially in reducing fruit scarring.
- **Re-use back-flush water**. Back-flush water from drip irrigation gravel filters (i.e. settling tanks) can be reused. Adjust the frequency of back-flushing to suit conditions.
- **Reduce crop load.** Reducing the crop load will help reduce the effects of water stress on fruit size. Trees carrying heavy crop loads will also suffer more stress. Monitor crop levels and fruit size and apply appropriate crop thinning strategies to decrease excessive crop loads. The choice of strategy depends on crop stage and includes winter flower suppression sprays, hedging, chemical fruit thinning and hand thinning (see pages 7- 8 for additional information). The Fruit Size Management Guide Part 1 outlines when and how to implement these crop reduction strategies. It is available on the ACG website: www.australiancitrusgrowers.com

Other strategies:

- **Reduce transpiration.** Kaolin clay based foliar spray products are claimed to reduce water losses through leaves. Demonstration trials have shown increases in the growth of young trees. However the use of these products can increase the incidence of scale insects, particularly red scale.
- **Buy/trade water.** Buying in or trading water, if available, can be a viable option. Consider the long-term value of the trees and crops compared to the cost of water.

Longer term strategies:

- **Install valves for each patch.** Install valves to separate patches that have different water requirements. This will allow you to more accurately match crop water needs with irrigation applications. Water use differs with tree age and variety.
- **Install more sophisticated scheduling equipment.** More sophisticated scheduling equipment (e.g. neutron probes, capacitance probes) will allow you to be far more accurate in your irrigation applications and in gauging rainfall effectiveness. As well, leaching losses can be completely avoided while still ensuring that irrigations are fully effective. This equipment is more expensive and requires some time to learn how to use and understand the information generated.
- **Convert to efficient irrigation systems.** Drip irrigation is the most efficient irrigation system with savings of between 40-60% over furrow and overhead sprinkler systems and up to 30% on micro-sprinkler systems. Figure 2 on the following page shows the differences in monthly water application rates to oranges using drip irrigation and a low-level micro-sprinkler system.

A new permanent drip system requires substantial investment and needs to be professionally designed. Consider the long-term financial viability of taking this step. If there is a high probability that water restrictions will continue in the future, consider installing drip irrigation over the next winter period.

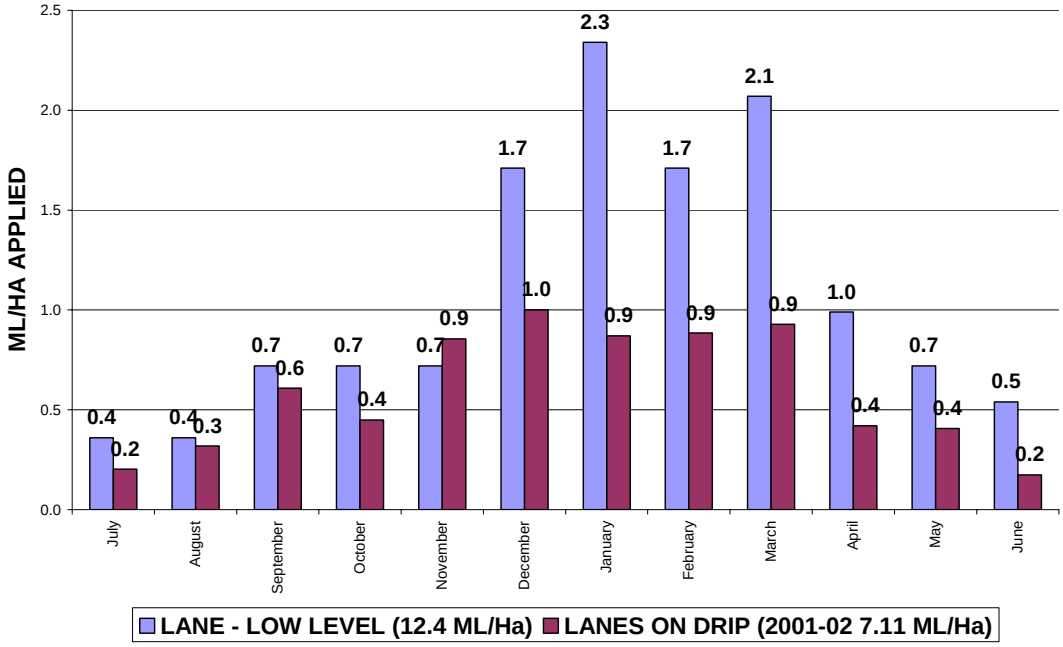

Figure 2: *Monthly irrigation applications to oranges using drip irrigation and low-level micro-sprinklers.*

Most drip irrigation systems are preferably installed in winter because the irrigation system needs to be shut down during conversion. Some growers have successfully converted to drip irrigation during summer, however this carries a high risk if the new system is not quickly operational. A delay in irrigation over an extended period in summer can cause serious tree stress and crop loss. The trees will also need to be adequately irrigated to help them grow roots into the wetted soil drip line, which may initially require increased irrigation levels. The time for the roots to re-establish under the drip line can also cause tree stress. Trees irrigated by drip irrigation can also withstand higher water salinity levels. Experience on the Darling showed citrus with drip irrigation was able to tolerate a water EC of 2000 units. Contact your local irrigation officer to check if subsidies for conversion to drip irrigation are available in your region.

Strategies for managing citrus with less water

The following options can be used to develop a program that best suits your own situation (water supply, irrigation system, climate, soil type, variety mix and tree age, etc). Small fruit normally provide poor returns. In times of predicted water shortages, often the most viable option is to maintain your high value blocks in order to produce good sized fruit, at the expense of less profitable blocks. Before severely water stressing trees, removing, skeletonising or hedging blocks, discuss your plans with your packer/agent/processor, as these actions can have long-term implications. The first step is to develop a water plan or budget for your farm. An example of a water budget is contained on page 9 of this document.

Develop a Water Budget for your farm

A water budget is a plan of your orchard which identifies the present and proposed irrigation allocation for each block and any additional management strategies. These decisions need to be based on a number of factors, including:

- economic viability of the block;
- current and long term plans for the block/orchard;
- tree age, variety, crop load (on/off year) and growth stage;
- packer, processor or agent priorities – current and future;
- resources available;
- current financial situation;
- future water availability predictions.

The following steps can be used as a guide to developing your water budget:

1. Determine the typical monthly water allocation for each block based on historical water use.
2. Decide what additional water saving strategies or management practices will be undertaken.
3. Adjust monthly irrigation allocations to suit your plan.
4. Put the plan into action.

5. Regularly monitor tree blocks and readjust as necessary.

Managing a citrus orchard with 10-20% less water

Implement as many of the basic water saving practices as you can. The amount of water savings you can make will depend partly on the efficiency of your current irrigation management system.

Managing a citrus orchard with more than a 20% reduction in water

Implement as many of the basic water saving practices as you can, however other tree and crop management strategies will be needed to produce a marketable crop. It is important to take action early, and not leave it until you run out of water.

Additional tree management strategies:

Young tree management (0-6 years)

Significant water savings can be made on young trees if water is applied efficiently. (Figure 3) Young trees have a smaller canopy and root zone than mature trees and can use up to 50% less water than mature trees. Monitor soil moisture and implement basic water saving practices, focusing on:

- Reduce leaching losses below the rootzone.
- Build a small basin around newly planted trees to trap water.
- Spreading mulches around the tree to reduce evaporation from the soil surface.
- If inline drippers are used, special clips can be used to block off drippers between trees where the roots have not yet established.
- Install sprinkler heads that have a small throw pattern.
- Schedule irrigations.

Mature tree management (>6 years)

Canopy Reduction

Tree water use is directly related to canopy size, so reducing the canopy reduces water use. Figure 3 illustrates the impact of canopy size on monthly irrigation applications to navel orange trees. The amount of tree canopy you remove for each block should be based on tree age, crop load, stage of growth, long-term block viability and how much water needs to be saved. Providing trees are given sufficient levels of water and nutrients they should recover to form a vigorous canopy that produces good quality fruit. In some circumstances, resources (labour and machinery) may not be available to undertake canopy reduction, so alternatively old or unproductive blocks could be abandoned in preparation for replanting when water supplies resume.

Under restricted water conditions, trees that have had their canopy reduced will recover more quickly than trees without any canopy reduction. Remember to adjust fertiliser applications to suit the tree canopy size and vegetative growth. A heavily pruned tree will require less fertiliser. Gradually increase the amount of fertiliser applied

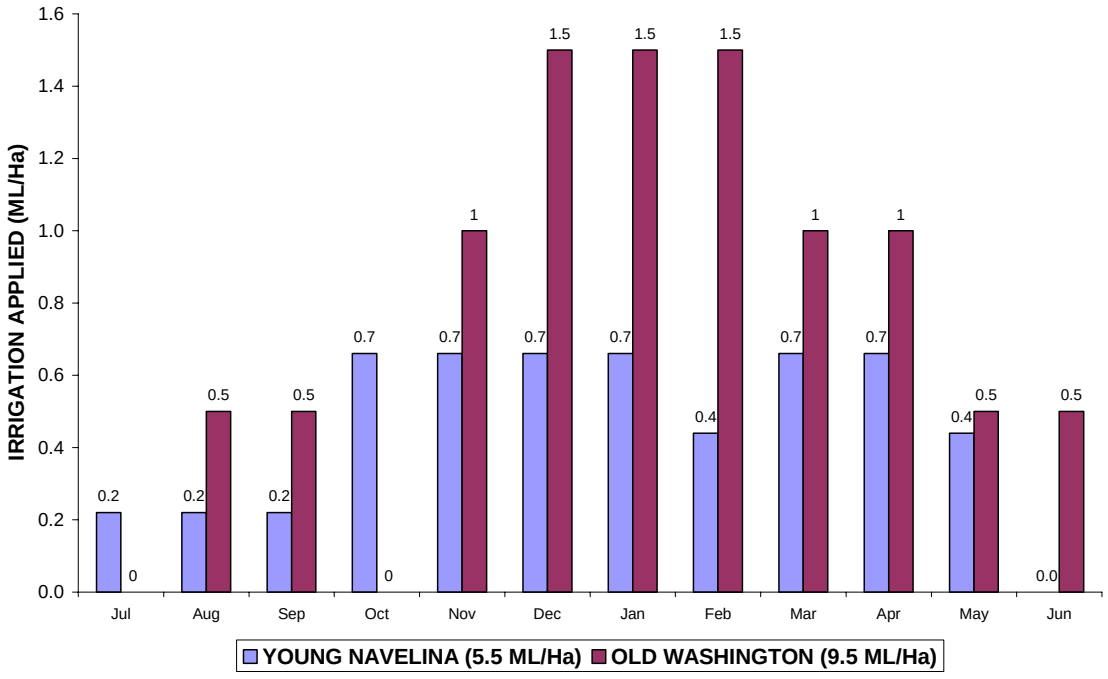

Figure 3: *Monthly irrigation applications to young and old navel orange trees.*

as the tree canopy re-grows. The best time to prune citrus is generally after harvest but can also be undertaken at other times throughout the year.

Skeletonising

Skeletonising is the most severe form of canopy reduction, involving the removal of nearly all tree branches and foliage. This type of pruning is normally used to rejuvenate old trees. Trees that have been skeletonised will use a lot less water, but can take between 2-3 years to come back into full production.

The exposed limbs will need to be painted with white wash (1 part plastic paint: 1 part water). The white wash can be applied quickly and efficiently by spray painting. As the trees grow the regrowth needs to be managed to select out the best positioned shoots to regrow the tree.

Hedging

The best time to hedge trees is in late winter/early spring to reduce the risk of sunburn to the newly exposed limbs. A light hedging will not significantly impact on next season's production, however a medium or heavy hedging can result in trees being out of production for 1-2 seasons.

One option is to hedge only one side of the tree to reduce the impact on yield. Heavily hedging trees in late spring/summer may require exposed limbs to be painted with white wash to protect limbs from sunburn. Sunburn can occur within a day in hot temperatures (i.e. above 35ºC) and the risk increases significantly as temperatures rise further.

Heavily hedged trees may not require white washing if the hedging is conducted in late winter/early spring because the tree has adequate time for its bark to acclimatise to high light conditions and an adequate cover of leaves has grown to shade limbs before hot conditions occur

***Photo 1**: Mechanical hedging can be used to reduce the tree canopy.*

. The western side of the tree is more susceptible to sunburn because it is exposed to the afternoon sun.

Pruning for regrafting

Cutting back trees for grafting will also reduce water use. The exposed limbs will need to be painted with white wash. The 'nurse' limbs can be removed when the grafts are well established and actively growing.

***Photos 2 & 3**: Trees pruned and painted with white wash, ready for regrafting.*

Reducing Crop Load

Flower Suppression

Flower suppression can be undertaken in predicted heavy crop years ("on years"), using a gibberellic acid compound (registered trade name Ralex®) at the time of flower initiation in June – July. (For more specific regional timings contact Sumitomo Chemical Australia or your local horticultural advisor). Ralex® is registered for use in mandarins and there is a permit for oranges (Permit number-PER 8269 expires September 2007). Refer to the Product label and Permit for directions on use and timing. Water stress can also induce a strong

flowering in the following season which will require crop thinning if high numbers of fruitlets set and are retained on the tree.

Pruning at flowering

Pruning can be undertaken before or during flowering with an emphasis on removing weak/dead branches, crossover limbs and water shoots. Hedging can also be used during flowering to remove excess flowers, however it is non-selective, so care should be taken on how much of the canopy is removed.

Chemical thinning at Stage 1 Fruit Growth – December

Chemical thinning using Ethephon (registered trade name Ethrel®) can be used when crop loads are heavy and fruitlets are 10-15mm in size. Chemical thinning has shown to be cost effective in navel and Valencia oranges and Imperial and Murcott mandarins. However the amount of fruit removed can vary depending on fruit load and application timing. Temperature and soil moisture levels are critical to success. Refer to the Product label and the Fruit Size Management Guide Part 1 for more information.

Hand/mechanical thinning of fruit January – harvest

After the natural fruit drop has finished in December, a heavy crop load can be further reduced by hand thinning or light hedging. Hand thinning allows you to be selective and remove small, blemished or clustered fruit. Light hedging will remove fruit on the outsides of the canopy, but is not selective and caution is required.

NSW experience with drought and water reductions – Bourke district

Citrus growers using drip irrigation in the Bourke region of northwest New South Wales (NSW) have experienced drought coupled with severe water restrictions since 2003. This region normally experiences warmer climatic conditions than southern citrus growing districts and generally uses higher water rates. The long-term impact of combined water and salt stress, on citrus trees is not known in Australia.

Some specific examples of their experience and observations include:

- Fifteen year old mandarin trees which had the eastern side of the tree removed were kept alive with 2.2 megalitres (ML) of water per hectare applied from July 2002 to April 2003 (Photo 4).
- A reasonable crop of Leng navels was harvested from a block watered with 5.5 ML of water per hectare (Photo 5).
- A block of three year old navel orange trees receiving 1.5 ML per hectare of 1500 - 2000 EC irrigation water were severely stressed during the summer of 2003. As a consequence, trees and the adjacent Casuarina windbreak suffered heavy defoliation due to the combined effects of water and salt stress. However, the trees recovered well after autumn irrigation and rainfall (Photo 6).

***Photo 4**: Fifteen-year-old Imperial mandarin trees showing new regrowth on the eastern side of trees, which were previously removed.*

***Photo 5**: The block of Leng navel trees maintained with 5.5mL of water.*

***Photo 6**: The young block of navels in June 2003, that recovered from low water and salt stress in summer 2002/03 (Dec –Feb) and re-leafed with autumn irrigation and rainfall.*

Keep informed about water reductions

Keep in contact with your local water authority on the latest information on water allocations, water flows and the water levels in storage. Obtain information on next seasons water allocation scenarios to enable you to make better long term decisions. Some of this information can be sourced from state and local water authority web sites. Look at long term weather forecast information to help schedule irrigations.

Other assistance

Contact you local Horticulturist, Industry Development Officer (IDO) or Irrigation Officer for assistance in developing a water budget or to discuss options for managing water shortages. The affects of drought cause considerable pressure on you and your family. There are a range of professional counselling services available to provide advice on any issues you may have.

If you are experiencing financial difficulties, contact your local rural financial counsellor (www.rfcs.gov.au) and/or the Centrelink Drought assistance Hotline 132316.

NSW growers can also contact their local NSW DPI drought assistance officer. Interest rate subsidises and income support payments are available. Make sure you talk to your local rural financial counsellor for first hand information. You may not realise that you are eligible for financial assistance. Rural financial counsellors can help you with cash flow budgets and other options to get through difficult periods.

Example water budget/plan

Table 1 is an example of a water budget for a sprinkler irrigated citrus orchard. The farm has 27 ha of orchard and 3ha of vacant land in preparation for replanting. The 30 ha farm has an allocation of 390ML. The orchard's water allocation has been cut by 50% and therefore the farm has 195ML available for the full season. The grower has used 95ML up to the beginning of December and has 100ML remaining.

Estimate the typical annual water use for each block and the amount needed for the coming period (eg December to harvest). In this example it is estimated that in a normal year about 35% of the total water used is applied from July to November and the remaining 65% from December to harvest. Next decide on the proposed allocation for each block as well as other management strategies to be implemented. In this example all the remaining water has been allocated, however you may leave some in surplus to allow for higher than expected water use (i.e. extended hot and/or dry periods).

Block	Variety & age	Area (Ha)	Typical annual water use (ML)	Typical water allocation December to harvest (ML)	Proposed water allocation December to Harvest (ML)	Management strategies
River side	Washington 20 yr.	4	42	27.3	24	Monitor soil moisture and eliminate deep drainage.
Bottom	Ellendales 30yr	1	10.5	6.8	0	Abandon, prepare for replanting.
House	Valencia 40yr	3.5	38	24.7	2	Skeletonise and white wash.
Grapefruit	Grapefruit 50 yr	2	21	13.7	0	Abandon, prepare for replanting.
Imps	Imperials 25 yr	3.5	42	27.3	24	Water saving practices. Monitor soil moisture and eliminate deep drainage.
Washy road	Washington 40 yr	8	88	57.2	28	Heavily hedge eastern side of tree & white wash.
Lanes	Lanes 20yr	3	30	19.5	16	Monitor soil moisture and eliminate deep drainage.
Lanes	Lanes 2yr	2	20	13	6	Install manual valve to separate young Lanes from mature Lanes.
	TOTAL	27	291.5	189.5	100	

Table 1: Example of a water budget for a citrus orchard.

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