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Chemical Thinning – a Tool for Managing Biennial Bearing

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Chemical thinning is more judgment and art than science. This is because there are so many factors that influence the result. Furthermore, a lot of these factors are beyond your control or only forecasts at the time chemical thinning decisions are made.

The APAL Future Orchards 2012 website has a number of good articles about chemical thinning and fruit set that delve into these factors in some depth. In particular, I draw your attention to the paper I wrote for the September 2007 orchard walk titled "Chemical Thinning and Application Technology", and Craig Hornblow's "Thinning Strategies: Build a Plan" written for the September 2009 orchard walk. Dr Sally Bound also has a good summary of chemical thinning practices for chemical thinning in Australia titled "Thin to Optimise", also posted in September 2009.

Healthy trees with strong bloom and adequate provision for cross pollination have extremely low risk of over-thinning with aggressive chemical thinning programmes. As a rough guide for every instance of over-thinning from a chemical thinning programme, there will be at least ten instances of under-thinning. So, where fruit set turns out to be inadequate following a chemical thinning programme, more likely than not the poor fruit set will be due to something else.

Certainly, there are documented examples where chemical thinners are responsible. The ones I have come across include:

- Excessive rates of NAA or ethephon due to misinterpretation of the label.
- NAA applied over the bloom period to high vigour young trees with weak flower.
- NAA application following frost damage to foliage.
- Over-spraying with ATS, or when application has been followed by rain within 24 hours of application.
- Ethephon applied very close to Regalis® application.
- Ethephon or BA (Benzyladenine) thinner application followed by exceptionally high temperatures.
- BA thinners applied following a long period of dull cloudy weather which has lowered photosynthate reserves.
- Excessive shading within the canopy – can make Carbaryl an aggressive thinner.

This may seem to be a long list, but in general these situations do not occur very often.

Provided the orchard is healthy, has good strong flowering with adequate cross pollination, and not excessively high in vigour, the risk of chemical thinners over-thinning is rather low. Experience we have

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had, particularly with post-bloom thinners, is that once fruit numbers have been brought down to levels the tree is comfortable with, the response to further chemical thinner application is weak.

Also, if fruitlet numbers have been brought down to close to optimum crop load by the chemical thinning programme, there is little further natural fruit shedding in the December drop. With young, vigorous trees, early fruitlet removal with a chemical thinner often leads to a larger harvested crop than where no chemical thinner was applied.

Figure 1: Excess vigour and strong upright branches is a major factor in the biennial bearing problems and poor cropping performance of these Fuji.

Situations to be wary of

The major reasons for poor fruit crop include:

- Absence of flower due to biennial bearing.
- Poor root health due to water-logged soils.
- Lack of cross pollination.
- Nutrient deficiency, notably nitrogen.
- Netted orchards.

Biennial Bearing

Pome fruit are particularly prone to biennial bearing. Generally, the more stressful the growing conditions, particularly in regard to high summer temperatures, the greater the tendency for biennial problems to occur.

Figure 2: These low vigour Fuji stacked with numerous small, pendant, fruitful branches carry full crops every year.

Loss of crop due to frost, or allowing too much fruit to set in the early years of cropping a new orchard or recently grafted trees is a common biennial bearing trigger.

Biennial bearing often follows early season hail storms which cause severe leaf injury at a critical time for flower initiation and bud development. Low nitrogen status is likely to increase the level of biennial bearing.

High tree vigour tends to increase the biennial bearing risk too.

Among varieties there are large variations in susceptibility to biennial bearing. Royal Gala and Cripps Pink tend to be least likely to suffer biennial bearing problems, while Fuji is very susceptible, as is Braeburn, Envy™, Jazz™, Jonathan, Red Delicious and to some extent Granny Smith. Pears are also fairly susceptible to biennial bearing.

Once established, it is very difficult to break out of biennial

bearing. Our experience with strongly biennial varieties is to avoid the problem by adopting aggressive post blossom thinning programmes commencing in the first year the trees or grafts show significant flowering. Successful programmes have been Carbaryl plus NAA, or BA plus NAA for varieties that do not suffer from pygmy fruit retention problems following post bloom NAA use. Where pygmy fruit is a problem, BA plus Carbaryl is preferred to the NAA combinations.

Because of its erratic behavior, NAA as a blossom thinner on high vigour young trees often leads to over-thinning so NAA is not used widely on young trees or grafts now. ATS, however, applied later in the blossom period has a place in young trees to minimize biennial bearing risk.

Ethephon will enhance return bloom as well as thin fruit, but adversely affects tree vigour, so is not a suitable thinner for orchards where good tree vigour is still necessary for rapid canopy development.

Once strong biennial bearing behavior becomes established thinning programmes alone are usually inadequate to overcome the problem, but are a key part of the programme for breaking out of the problem.

Figure 3: Poor return bloom in a biennial variety where no chemical thinner was applied the previous season.

Figure 4: Strong return bloom in the same blocks as Figure 3 where BA thinning spray was applied the previous season.

Managing your way out of biennial bearing needs an integrated plan that involves pruning, thinning, crop load levels, vigour control and orchard nutrition.

Varieties prone to biennial bearing need higher bud to fruit ratios than regular cropping varieties, preferably 3:1 bud to fruit ratio coupled with aggressive thinning to clear two out of three fruiting sites within about four to six weeks of full bloom in the “on” flower year.

The pruning strategy needs to focus on elimination of branches showing excessive levels of vegetative growth, while retaining weaker pendant fruitful branches. A pruning strategy worth considering for biennial blocks is alternate year pruning with the major pruning carried out in the winter prior to the next “on”

crop. The main focus of this pruning should be to remove branches showing excessive annual shoot growth so that next year, prior to the "off" crop season, little pruning, if any, is required.

Chemical thinning strategies for the on crop flower need to focus on programmes known to enhance return bloom. The most effective for this purpose are:

Blossom period:	ATS, ethephon, or a combination of both.
Post-blossom:	BA plus NAA (for varieties not prone to pygmy fruit). BA plus Carbaryl (for varieties prone to pygmy fruit, eg, Fuji) Carbaryl plus NAA (for varieties not prone to pygmy fruit)

Repeat sprays of Carbaryl plus thiram are another option that is widely used in Australia. Carbaryl is very damaging to important insect pest predators such as *Aphelinus mali* for Woolly Apple Aphid control (WAA) so excessive use, or application over large areas of the orchard will lead to more problems with insect pest control.

In the case of pears, ATS blossom sprays can be effective blossom thinners if they can be applied without inducing russet and in the post-blossom period BA is very effective for varieties that respond to it such as Packhams Triumph.

Figure 5: Slight leaf burn around the margins caused by ATS thinning sprays. This level of damage is acceptable and will not affect tree performance.

Figure 6: Significant foliage damage from overspraying with ATS. This level of injury is unacceptable and can happen if the product has not been properly mixed or the sprayer is poorly calibrated.

"Off" crop chemical thinning programmes need to be conservative because flowering is sparse, in which case it is relatively unresponsive to chemical thinning, or weak and likely to be very easily thinned by chemical thinners. Where blocks are largely "off" in their flowering, resorting to hand thinning may be the safest path to follow, or use of a very selective chemical thinning programme based on ATS applied selectively.

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Where only a small proportion of an orchard block, eg, only 10 to 15% of trees, show “on” crop flower targeting these trees for selective blossom removal by hand with the aim of clearing at least two out of three flowering sites is a useful technique for improving return bloom in the following season. Then once the flowering behavior across the whole block has been synchronized you have a better chance of sorting out the problem with chemical thinning.

With some biennial varieties similar percentages of “on” and “off” crop trees occur together. In this situation the best approach to chemical thinning is to take an aggressive approach aimed at doing the best job you can on the “on” crop trees to try and lift their return bloom performance. The odds are that the “off” crop trees will not have much flower to thin off anyway.

Vigour Management

Bringing tree vigour under control is a key part of managing biennial bearing.

The pruning strategy discussed above is the first step in bringing vigour under control. Usually, pruning for vigour control needs to be supported by other vigour control tools. These include techniques such as root pruning, trunk notching or girdling, RDI (regulated deficit irrigation), or judicious use of growth regulators.

Crop Load

Excess crop load, or lack of crop due to frost or other mishaps, is usually the trigger for biennial bearing patterns to establish.

Avoiding excess crop in “on” crop years is an important part of bringing trees out of their biennial bearing.

Aggressive chemical thinning is the starting point, but in “on” crop situations the chemical thinning programme usually needs to be supported with careful early season hand thinning to set crop loads the trees can manage, preferably within four to six weeks of petal fall.

Fruit set counts and the distribution profiles of the initial fruit set will determine how much the crop load needs to be brought down. This may involve two hand thinning passes, the first one aimed at clearing fruiting sites to improve flower initiation, and a later cosmetic thin. This means you cannot leave thinning your “on” crop Fuji until after Christmas as I have sometimes seen happen in Australia.

Growth Regulators

These can be useful tools for helping manage biennial bearing problems.

However, lack of label claims may limit their availability for application to pome fruits in Australian orchards.

There has been considerable international research work into the role of growth regulators in managing tree vigour and flower initiation in pome fruits.

In the “off” crop year, gibberellins applied over the flower initiation stages of growth have been shown to suppress flower density for the “on” crop bloom. This approach is expensive, and not terribly reliable, so far as I am aware is not widely used in commercial situations.

Ethephon is a return bloom stimulant that is sometimes used to improve “off” crop flowering, usually as a blossom thinner in the “on” crop year. There is also data in the scientific literature to show that sequential application at low rates over the shoot growth period reduces shoot growth and stimulates return bloom.

Recent research in the USA has shown that 5ppm NAA applied sequentially in the cover sprays over a three to four week commencing about six weeks after flowering increases return bloom.

Nutrition

Adequate nitrogen supply is critical for good fruit set. Because of the role excess nitrogen levels play in suppressing fruit colour, nitrogen levels in many Australian orchards appear to be marginal for good fruit set.

Foliar urea applications in the post-harvest and pre-bloom periods are a very effective way of lifting nitrogen tissue levels for the critical fruit set period, and because of the relatively low rates being applied do not have a large influence on nitrogen soil reserves to cause problems with fruit colour later in the season.

Chemical Thinner Application Technique and Timing Critical

During consultancy visits to Australia, it has come to our notice that many Australian growers are having difficulty in obtaining satisfactory thinning response from their chemical thinning programmes.

Poor response is frequently mentioned to be a problem with ATS and often there are similar comments made in regard to BA thinners.

As a general rule, it is more difficult to obtain satisfactory thinning results in dry, low humidity climates than in humid climates. Some of this difference has to do with the state of the cuticle and its permeability to thinning chemistry. For fruit growth in humid climates, cuticles can be very disrupted with many crevices and weak points that allow ready entry into the tissue of the thinning agents. This is also why russet problems are associated with humid climates and seldom occur to fruit grown in dry continental climates.

The example I quoted earlier of NAA behaving very aggressively when applied following frost injury is due to the frost injured tissue soaking up more NAA.

Application conditions also play a role in thinner response, as does water rates, droplet size and sprayer calibration.

To be effective, chemical thinners need to reach the target in adequate amounts for a response. The challenge is to knock off enough fruit out of the upper tree while still retaining sufficient crop in the

lower tree. It is natural for heavy set to occur in the upper tree due to factors such as high light levels, lower juvenility influences due to increasing distance from the root system, and fast drying.

In the lower tree shade, proximity to the sprayer, thinning spray dripping through the tree, and slower drying all favour less fruit set.

Some years back Australian scientists studied the impact of sprayer calibration, droplet size and water volumes on chemical thinner response. When sprays were applied in low humidity, fast drying conditions, it was found that finer droplets in the 100 to 150 micron VMD range often failed to reach the target and for thinning spray application larger droplets in the 300 micron VMD were necessary for satisfactory response.

The efficacy of ATS thinning sprays depends on flower stage, and sufficient ATS contact in solution with the flower to burn out the stigma before pollination has taken place. In humid climates with slow drying conditions at time of application, lower water volumes in fine droplet sprays usually work. Under the rapid drying conditions found in low humidity application conditions, higher water rates applied as larger droplets, but perhaps slightly lower ATS concentrations, are required.

Figure 7: Some growers add hydraulic spray booms to their axial fan air blast sprayers for better targeting of the upper tree when applying thinning sprays such as ATS.

ATS thinning spray applications also needs careful targeting relative to blossom stage. Unless dormancy sprays have compressed blossom there is usually a huge range of flower stage within the tree as well as a gradient in rate of blossom opening from bottom to the upper tree with the lower tree flower opening well ahead of the top.

This means it is necessary to apply ATS thinning sprays only to those sections of the canopy that have reached or are at the optimum stage for application.

Used well, ATS can be a fairly selective thinner. The key to achieving selective thinning with it lies in setting the stronger earlier opening flower, then targeting later opening flower, which gives inferior fruit. A common mistake with ATS applications is to go in too early and loose this early set fruit. When early bloom fruit is knocked out, it is no longer there to suppress the set of weaker later flower fruit, so when blossom periods are lengthy this can result in greater, rather than less fruit set.

A typical ATS thinning spray strategy is to plan several applications, perhaps even three or four, the first aimed at the lower tree only when early petal fall is beginning to show in that part of the canopy, the next spray either over the whole tree, or the middle and upper tree, then a final spray just to target the

upper tree. If there is still significant unopened flower at the time of the later sprays and you already have your crop set, the effectiveness of later sprays can be increased with the addition of ethephon. Because this combination targets a range of stages from pink bud to just open, one combination spray is usually worth about three ATS only sprays.

Weather conditions, particularly temperature, determine the interval between ATS sprays. In warm weather, intervals as close as two to four days may be required, whereas in cold weather intervals between sprays are much longer – often five to seven days.

Poor spray mixing and agitation is another cause of unsatisfactory ATS thinning spray response. ATS is a very dense liquid and readily sinks to the bottom of the spray vat if not properly mixed and well agitated in the tank. If this happens, you do a very smart burn-up job on the first couple of rows, then little effect on the rest of the block.

BA thinning sprays are very sensitive to weather conditions that occur prior to or following application, particularly in regard to temperature during the first few days after application. Dull, cloudy, particularly with warm nights immediately prior to application, lowers carbohydrate reserves and increases thinning response. Following application daytime temperatures need to reach 18°C or greater for at least three days. Should exceptionally high daytime temperatures occur during this period, say >26°C, the thinning response can be very aggressive with an over-thinning risk. The growth stage window for BA thinning sprays is quite wide, from around 7 to 8 mm out to 15 to 16 mm fruitlet diameter, so if weather conditions are unfavourable when fruitlets average 10 to 12 mm in diameter, wait for better weather. When weather is cool, fruitlet development slows down, so this automatically extends your time window for application.

Netted Orchards

Netted orchards alter the orchard environment by increasing humidity, extending drying times, increasing shade levels and lifting tree vigour. All of these factors make trees more responsive to chemical thinners so once an orchard is under netting, chemical thinning strategies need to be adjusted to the new orchard environment.

It is also our observation that pollination is weaker under netting and there can be strong reduction in fruit set with increasing distance away from other varieties. Unless there is intensive provision of pollinators throughout a netted orchard, preferably in each tree row of single variety plantings, fruit set will be strong adjacent to pollinator rows, and weaker further away. Areas close to pollinators will need more aggressive chemical thinning than further away from them.