NOVEMBER 2011 FUTURE ORCHARDS WALK

Some Key Components of Producing High Quality Fruit

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Steve Spark has correctly identified a major issue preventing some growers going forward is the focusing on cost saving and not investment maximising. This is true when establishing and redesigning new orchards, but can also be a common attitude when running established bearing orchards each season. The focus should always two fold; yield to keep unit costs down and quality to keep unit returns up.

The quality parameters are defined by your customers and its very interesting that the list of Australian chain store and NZ export specifications are so similar. I have selected out three areas where in-season management can have a great affect of quality and which we can discuss at an on-farm level;

1. Nutrition
2. Irrigation
3. Pest and disease control

Quality Parameter	**Determinants**
Colour	Genetics Tree architecture, rootstocks, pruning, Regalis, netting. **Nutrition**
Size	Thinning **Irrigation** **Nutrition**
Maturity - Brix	Light **Nutrition** Retain
Superficial bruises	Picker management Equipment
Healed skin injuries (hail marks, limb rub)	Pruning Netting
Russet	Genetics Weather Choice of sprays
Pest and disease damage	**Hygiene** **Choice of sprays** Spray application

The Major Nutrients.

Nutrient	Symbol	Ability to leach in soil	Mobility within plants
Nitrogen	N	High - especially in sandy soils	Mobile
Phosphorus	P	Low	Mobile
Potassium	K	Medium	Mobile
Sulfur	S	Can be high in sandy soils	Some mobility
Calcium	Ca	Low	Not mobile
Magnesium	Mg	Medium	Mobile

How much fertiliser should be applied ? The minimum is to replace the amount removed by the crop each season. Below is the guideline I use in Stanthorpe apple orchards for different cropping levels. It is based on actual fruit analysis. Fruit grown in different soils and climates may have different mineral contents so it would be worth going thru this exercise for different districts.

Major nutrient removal with fruit from 4 Stanthorpe apple crops (kg/ha).

	Nutrient removal with a yield of 40 t/ha				**Average of crop removal**		
	Orchard 1. Delicious	Orchard 2. Delicious	Orchard 3. GS	Orchard 4. GS	**40 t/ha crop**	**60 t/ha crop**	**80 t/ha crop**
Fertiliser applied	average	more than average	less than average	average			
Crop load	Light	Heavy	Heavy	Average			
Watering	Bit dry	Adequate	Adequate	Dry			
Pruning	Heavy	Lighter	Average	Average			
Nitrogen	26.1	20.8	18.9	18.1	21	31.5	42
Phosphorus	5.5	3.6	3.0	4.8	4.2	6.3	8.4
Potassium	64.0	58.1	47.3	51.9	55	82.5	110
Sulfur	1.58	1.43	1.18	1.21	1.4	2.1	2.8
Calcium	2.4	2.2	2.4	2.4	2.3	3.5	4.6
Magnesium	3.2	2.9	1.8	2.4	2.6	3.9	5.2

Nitrogen is the main nutrient required by all plants for healthy growth. Trees will readily tell you if they are deficient with pale leaves and reduced growth. Orchards with excess nitrogen have dark green leaves, excess shoot growth and will produce lower quality softer fruit.

Stanthorpe fruit removal (60 t)	Washington State estimate	Tasmanian estimate	Incitec estimate (USA)	Commonly applied rates
31.5 kg/ha	39 kg/ha	36 kg/ha	73 kg/ha	50 - 200 kg/ha

The USA figures are often high because of over fertilising there leading to luxury uptake levels.

In these 4 apple orchards only a portion of the nitrogen being applied is walking out of the paddock with the fruit. Where does the rest go ? Some is being unavoidable leached by rain and irrigation, some is growing leaves, roots and wood and some is growing grass and weeds.

Nitrogen is easily leached.

Below is a Stanthorpe example of nitrogen leaching in the sandy Stanthorpe soil. The period November to May experienced very heavy rainfall. These were vegetable paddocks that all received the same annual rate of fertiliser and soil tests were done in June. It's clear how the heavy rainfall on the sandy soil has caused nitrogen to be leached.

Block	Last nitrogen application	Soil nitrogen mg/Kg
Top block	7 months ago	4.2
Gate block	5 months ago	27.0
Bottom block	1 month ago	58.1

How much nitrogen gets leached from your soil with heavy rain ? There is potential to leach nutrients every time you irrigate. This is another reason shorter and more frequent irrigations are better than longer waterings. The policy with nitrogen should be to apply 'a little bit, often'. With the use of fertigation this is relatively easy to do.

Potential leaching is also a reason to be cautions about supplying a lot of nitrogen during the post-harvest period. Trees will take up nitrogen then and it makes the trees stronger for spring, but the risk is that broadcast nitrogen will be leached during the winter. Fertigation is a more appropriate method for post-harvest fertilising.

Every season is different and just as the removal by trees varies with crop load, so does the leaching each year based on the amount of rain and type of rain. Its good to anticipate in-season losses but soil testing in late winter is the only real measure of residual soil fertiliser.

Nitrogen fertilising is the major reason that soil pH's drop over time. The other main reasons are increases in organic matter, cultivation, rainfall and irrigation. Different forms of nitrogen will have different affects on soil pH. Unfortunately the forms that lower pH the least are the dearest! However the need for regular lime and dolomite is greatly reduced and the benefits on tree health will outweigh any savings from cheaper forms of nitrogen.

Fertiliser	**Solubility***	**Affect on soil pH**
Ammonium Sulphate	73	lowers pH a lot
Urea	84	lowers pH
Nitram	158	lowers pH
Potassium Nitrate	21	lowers pH
DAP	63	lowers pH
C.A.N.		neutral or raises pH
Calcium Nitrate	84	neutral or raises pH
Muriate of Potash	31	neutral
Potassium Nitrate	21	lowers pH
Sulfate of Potash	9	neutral

* kg per 100 litres water at 30^0C

Mixed fertilisers often have a component of Ammonium Sulphate and tend to lower soil pH.

Potassium is the most important major element for quality fruit and is often under-applied. Crop removal is always high and a deficiency will cause smaller, paler and poorer tasting fruit.

Stanthorpe fruit removal (60 t)	Washington State estimate	Tasmanian estimate	General Incitec estimate	Commonly applied rates
82.5 kg/ha	71 kg/ha	63 kg/ha	81 kg/ha	40 - 180 kg/ha

Potassium is the major part of the mineral component of fruit. It is less easily leached than nitrogen so we would expect the potassium removed by the crop to more closely approximate the fertiliser applied. However substantial potassium is used to grow wood as well. Some 82.5 and 110 kg/ha is removed by a 60 and 80 tonne crop respectively. These are large amounts that need to be replaced each year and I find that many growers under-do potassium if they base needs on traditional cropping and fertilising.

The highest yields are often on late season varieties, Pink Lady and Sundowner, and there is often a misconception about timing of potassium. Fruit demands increase as the season progresses and many growers have traditionally applied their last fertiliser just have Christmas, which may be too early to stop potassium fertilising. This practice was based on the (sensible) practice of having a low nitrogen supply late season to keep fruit nitrogen/calcium ratios low.

Too often I see a situation where an established, good grower has created a potassium deficiency over 2 or 3 years by supplying less potassium than the crop removes. It takes several years for the soil and tree reserves to be depleted and leaf symptoms only show up at the end of the season when there is peak demand from the fruit and potassium is relocated from leaves to fruit by the tree.

Occasionally I see a situation where a rogue agronomist has recommended a very complex and expensive fertiliser program that involves lots of foliar and fertigated products that is grossly short of potassium. The grower thinks he is doing the right thing because of the cost and frequency of his fertilising but its only when I do a 'fertiliser budget' of the contents of the fertilisers that it becomes obvious why the fruit is small and pale and the leaves have tattered brown edges.

Potassium, magnesium, calcium and sodium are known as the 'cations' in soil chemistry. They are of a similar molecular size and all have positive charges. The uptake of one for the other can be substituted as the plant roots can't discern between them. So its important to have the ratios right in the soil; potassium highest, sodium lowest. It is also good to have more calcium than magnesium by a factor of about 3 - 8.

Calcium takes on particular importance in apple production as its important to prevent bitter-pit and to enable good storage. We want the fruit to have a lot higher calcium content than it thinks is 'normal'. Remember that the apple only needs to grow the fruit to maturity to complete its reproductive cycle. Keeping firm flesh and skin with no bitter-pit for 6 to 9 months is not part of its evolutionary fitness.

Some people are too cautious about having high soil potassium levels as they think it will interfere with calcium uptake. This will be the case if calcium is undersupplied. There are many good forms of soil calcium (calcium nitrate, lime, dolomite, gypsum) and foliar calcium products, and both approaches should be taken.

Some soils have naturally high levels of potassium and only small amounts are ever applied with manures of mixed fertilisers (eg Nitrophoska). This is appropriate; however the trees are removing the potassium from the soil just where the roots mainly are – which is just a subset of the whole soil. After several years the localised supply may be depleted and to be adequately supplied the release of available potassium from the soil (mineralisation) will have to match the removal by trees. In soils with high natural potassium it would be worth doing soil tests from different parts of the orchard floor to see if local variations are developing.

Phosphorus

Very little phosphorus is removed by fruit each year. Phosphorus is not very readily leached from soils but is tied-up or made unavailable in some soils (some red soils). Because most orchard blocks are on older horticultural soils that have been fertilised for many years, soil tests often show high to very high levels of available phosphorus. Often only small amounts of phosphorus are required to replace what is removed by the crop. On mature orchards and in soils that have high levels of P the timing is not critical.

Stanthorpe fruit removal (60 t)	Washington State estimate	Tasmanian estimate	General Incitec estimate	Commonly applied rates
6.3 kg/ha	10 kg/ha	9 kg/ha	8.1 kg/ha	0 - 50 kg/ha

However phosphorus is very important for root growth of young trees and because it does not always easily move down the soil profile it is important to apply it while cultivating the soil of new blocks – and very important in previously uncropped soil.

Boron

Boron is a very important trace element and the right supply can be difficult to get right. Most Australian horticultural soils are naturally deficient. An oversupply is toxic (boron was used as a primitive herbicide) so several years supply cannot be applied in one year. Boron is the most easily leached trace element so a large single application may be lost before trees can access it. Only small quantities are removed with cropping (150 grams/ha with a 60 t/ha crop).

Apple trees are very good scavengers of boron so even though soil levels may be low, leaf levels are often adequate. However if applications are not made for several years trees will run down their reserves and tree health and fruit quality will suffer, this can happen rapidly. Foliar applications are common and many growers also apply boron mixed with their first herbicide application of the year.

Boron is important for pollination, but this need tends to be over-emphasised by companies selling foliar boron sprays. I would rather see foliar boron sprays applied mid season when there are ample leaves to absorb it than pre-bloom when most of the boron ends up on the tree's bark. In well fertilised orchards poor fruit set is much more likely to be because of poor weather or bee activity during bloom than from lack of boron.

Fertiliser Checklist

- Fertilising should be based on a soil test. You should sample where the roots mainly are – which is usually along the tree line. The depth of sampling should be 20 – 30 cm, which is deeper than many reseller agronomists will sample (0 -15cm). Late winter is the best time to sample as it allows time for applied fertilisers to wash in to the soil.
- Mid-season leaf tests can confirm if the program is on track. The main messages will be whether to apply more nitrogen or potassium. Be careful when interpreting as reference standards are based on late season leaf levels. Nitrogen and potassium levels fall during the season and calcium and boron levels rise. Deficiencies can also be diagnosed with leaf tests.
- Leaf tests at the end of the season are a good review of the tree's status and your fertiliser program, but are too late to do anything about it for this year !
- Sap tests are of little use; there are not good standards to interpret them, the nutrient levels vary based on time of day of sampling and irrigation status, they don't test for the full range of elements and they are measuring just a portion of the tree's tissues.
- Just enough nitrogen should be applied to keep the tree healthy, leaves green, and replace what is removed with fruit. Excess nitrogen causes growth and fruit quality problems.
- Potassium should be available in the soil at high levels. High yielding and later harvested varieties are going to need a longer supply and at higher levels.
- Adequate phosphorus is important in establishing young trees. Annual replacement needs are easily met.
- It's hard to get become deficient in the trace elements quickly unless the soil is being planted for the first time, or no fertilisers have been applied for several years. The exception is boron which is easily leached and is very important for all horticultural crops. Too much boron is toxic so a little bit should be applied often.

Irrigation and Growth Rates

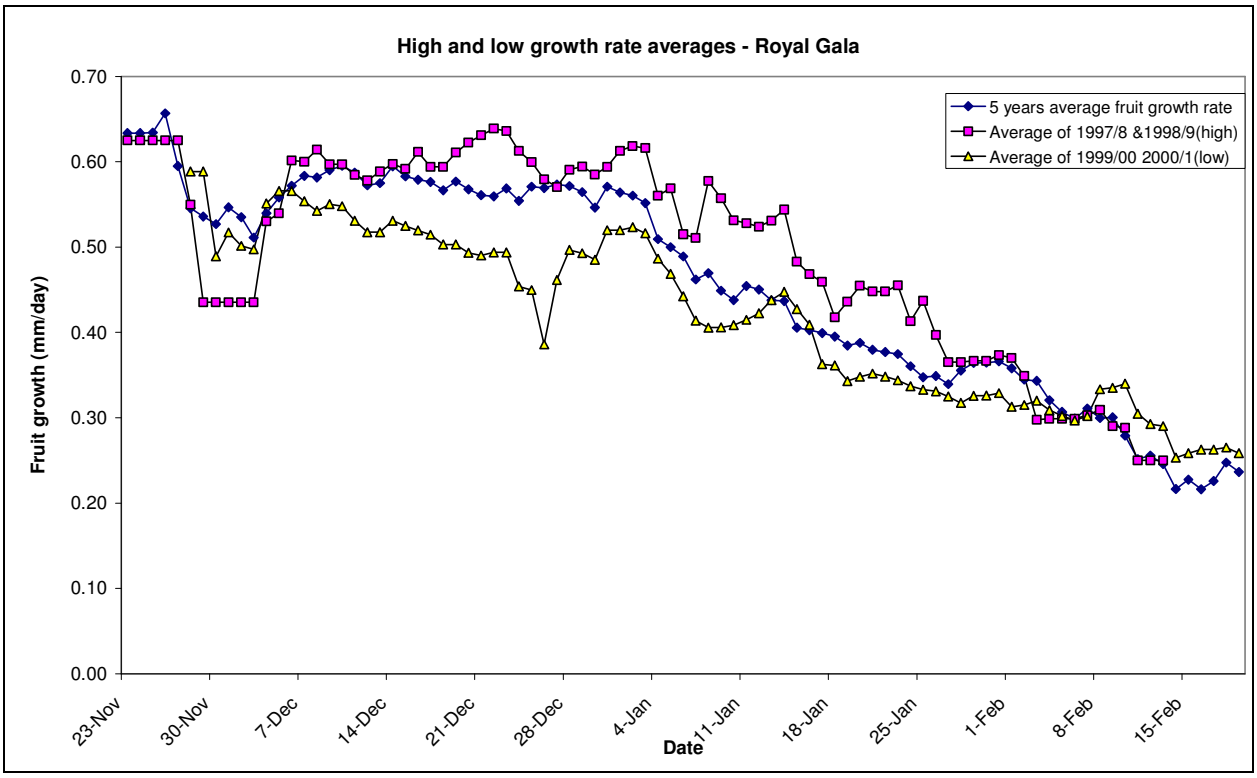
For any give crop load and nutrition situation (hopefully both optimised) the greatest influence on fruit size is water supply.

This makes perfect sense if you think about it; fruit can only grow if sugars and starches move from the leaves to the fruit, sugars and starches can only be manufactured if leaves are photosynthesising, photosynthesis only happens when stomates are open and CO_2 is being exchanged for O_2, stomates will only open if there is adequate moisture vapour within the leaves, and water vapour is only high if trees are taking up water, which can only happen if soil moisture is adequate.

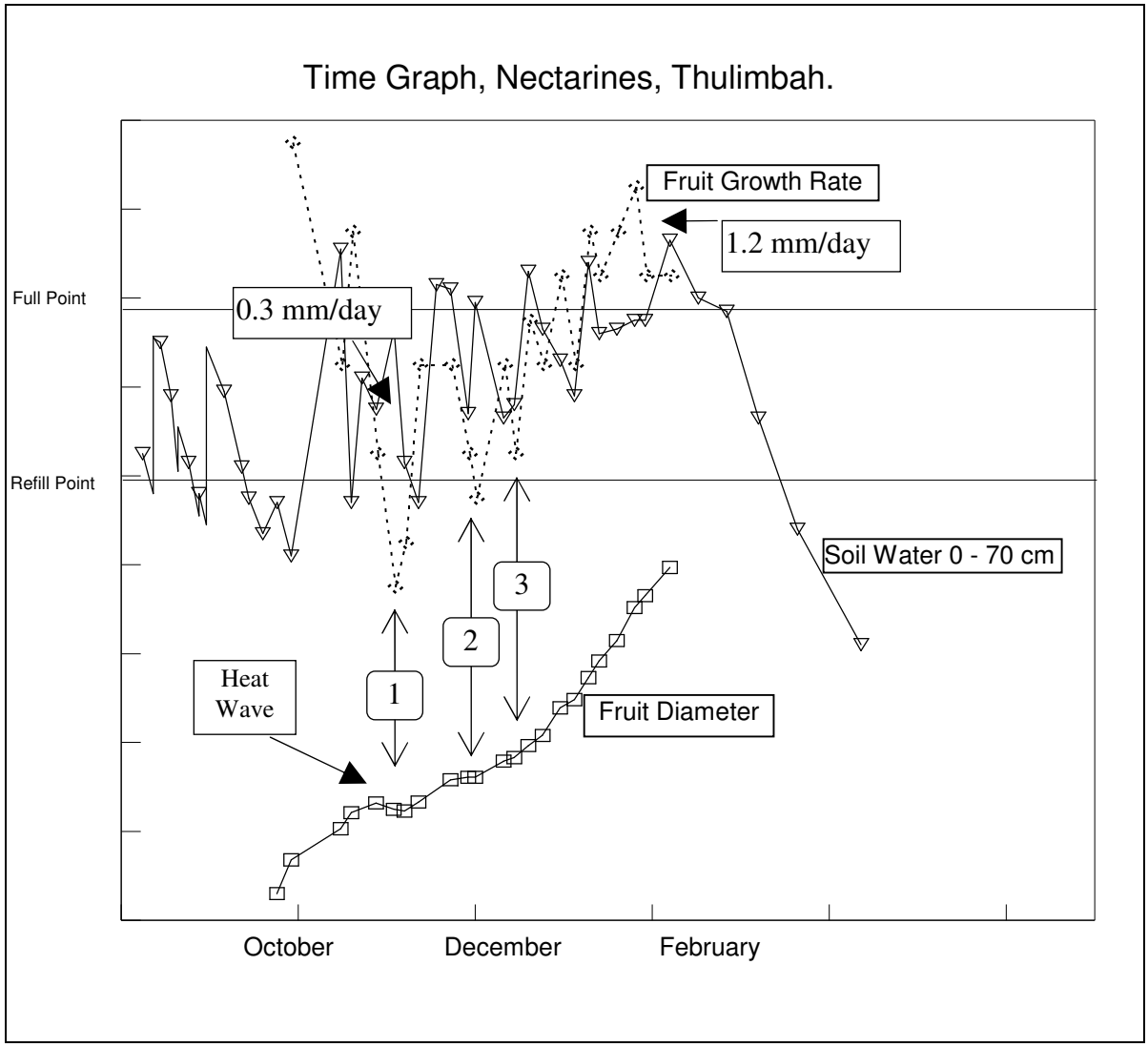
A good sized apple is 75 mm. If a young Delicious fruitlet is 3 mm in diameter after the petals fall on the 18th October and it is harvested on 28th February it has 133 days to grow 72 mm. This is a growth rate of 0.54 mm per day. The actual growth rates vary for different times of the season and vary greatly based on soil moisture. Fruit size can be practically measured using digital calipers. To get meaningful data you need to measure at least 10 apples twice a week. Its better to have five apples in two adjacent trees to smooth any variation between trees.

Apples and stonefruit have different growth patterns. Stonefruit grow rapidly towards the end of their season whilst apples grow most rapidly in the early and middle of their season.

Growth rate is measured in mm/day. A target rate for Galas is 0.5 to 0.6 mm/day before Christmas and 0.4 mm/day during January.



An excellent case study of nectarines at Thulimbah (just north of Stanthorpe) shows how fruit growth rate is directly related to soil moisture, with both measured every 3-4 days.



There were three periods when the fruit growth rate was low.

1 was at the end of November - start of December when the maximum temperature was over 30° C for 7 days, and the trees shut down under heat stress. Note that the soil water was high (because the orchard was being irrigated) but the growth rate was actually negative as fruit shrunk.

2 & 3 were periods when soil water was too low for too long and the fruit growth rate dropped from 0.5 mm/day to 0.1 mm/day. These two periods combined amount to 10 days at a disadvantage of 0.4 mm/day or a total loss of size of 4 mm by harvest.

Note that after periods of slow or no growth there is no catch-up spurt of rapid growth.

Fruit size lost is never regained.

In the orchard at Pozieres (near Stanthorpe) graphed below there were Hi Early Delicious and Royal Gala apple trees in neighbouring rows. The trees were the same age and had been pruned, thinned, fertilised and irrigated similarly.

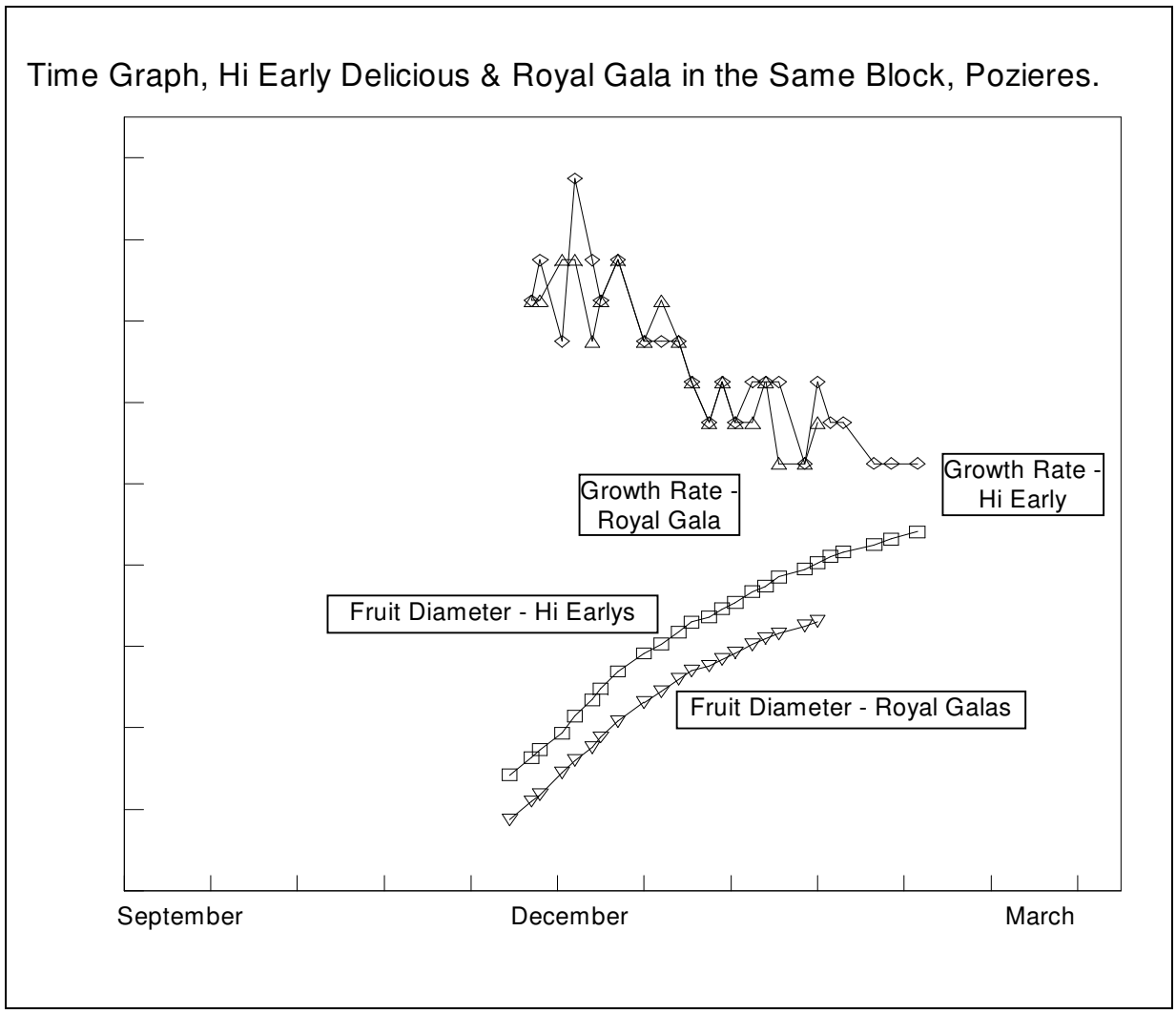
The fruit diameter and fruit growth rate curves show;

⇒ the growth rates for both varieties were high and low during the same weeks.

⇒ they generally fell as the season progressed.

⇒ Hi Early Delicious apples were always larger than the Gala.

⇒ That the Hi Early Delicious apples had higher growth rates than the Galas for some of the time, thus their relative sizes were getting progressively bigger.



Monitoring soil moisture.

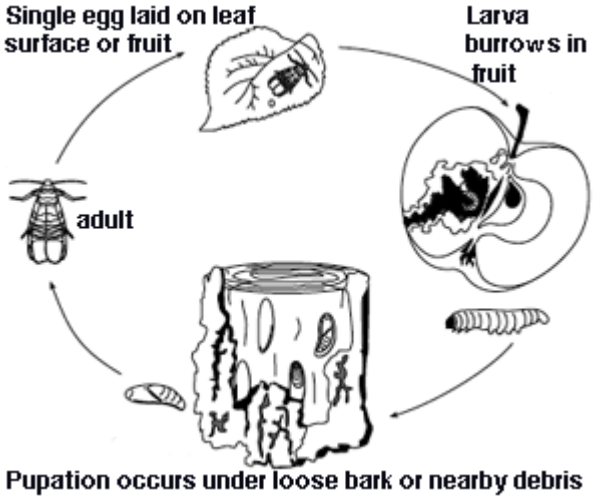
Soil moisture should be monitored continuously and there are two practical and affordable methods of doing so;
Capacitance devices – eg Enviro-Scan, C-probes, measure soil moisture content
Gypsum blocks – G-Bugs, measure soil moisture tension -how hard it is for plants to take water.

Irrigations can be optimised so that water loss thru the root zone is minimised. This means that most of the applied water is used by trees and nutrients are not leached. When soil moisture is monitored irrigation can be correlated with fruit growth.

Pest and disease control take up a large proportion of an orchardists time each season and account for many costs (although a lot less than labour and packaging). To pack high quality fruit the pieces of fruit blemished by pests and disease need to be culled. It's a far better strategy to not have the damage in the first place.

Let's review the key pest and key disease of apples and pears and their control.

Codling Moth is the key insect in apple and pear production. This means that left uncontrolled it can be responsible for total crop loss. The codling moth life cycle is simple and is well adapted to the apple's seasonal development. When the tree is dormant the codling moth are dormant, as the tree wakes up in response to temperature the codling moth emerge and develop in sync.



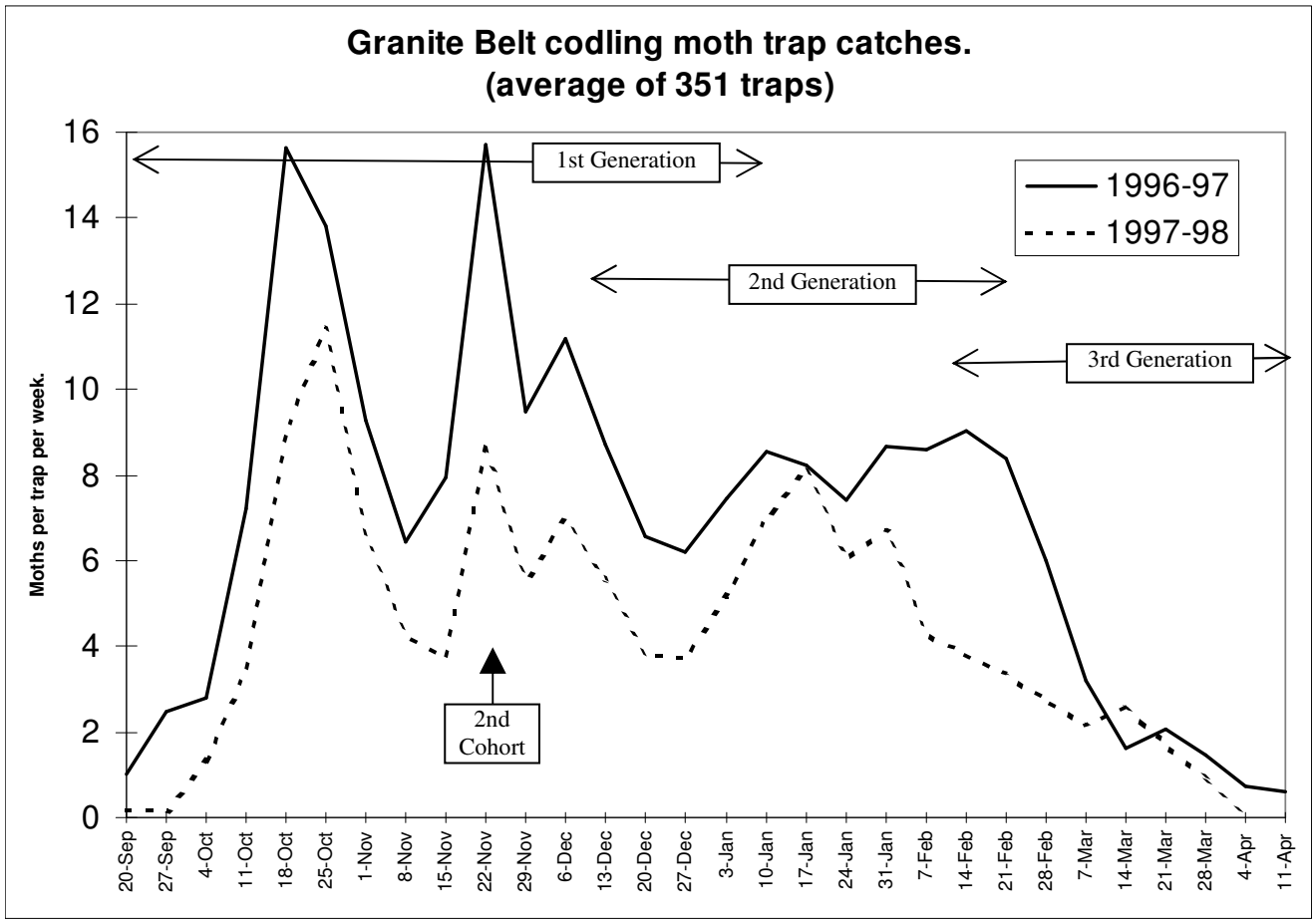
Codling moth are dormant as larvae in silken cocoons until spring and moths emerge and lay eggs that hatch into larvae (grubs) that do the damage to fruit. This larvae-moth-egg-larvae cycle is repeated 3 times a season. In an apple orchard where good commercial control is being achieved with insecticides the first moth flight is usually the greatest and the second and third are usually smaller. This is because insecticides are killing eggs and larvae and the population is decreasing.

The first moth flight from the first population has two peaks. This is because there are often two major emergences in spring. The second group is called the 'second cohort'. Ecologically the population has a better chance of survival if it has these two emergence times.

The second generation overlaps with the first and third generation so there are often a lot of moths in the orchard in mid season from mixed generations. In an orchard where control is not working the second and third moth flights can be higher than the first.

Codling moth monitoring. Because many of these newer controls are not as straightforward as traditional regular cover sprays growers must know the level of codling moth infestation on their orchards and in particular blocks within their orchards. Pheromone baited sticky traps are used to catch male codling moths, and indicate the level and timing of the pest's activity.

When mating disruption is used the drawing power of the pheromone baited lure is over-run by the pheromone emitted by the dispensers (500-1,000/ha). Traps in pheromone treated orchards are baited with a 10X lure and/or a lure with a feeding attractant (kairomone).



Codling moth control options. Regular cover sprays with insecticides were the mainstay of codling moth control for over 50 years. The main chemical used was Gusathion, firstly as a wettable powder and then as a suspension concentrate. However codling moth control went through a period of rapid change in the 1990's when low level resistance was reported to Gusathion, alternative chemicals become available (Insegar, Penncap-M, and Avatar), and mating disruption control was developed (Isomates). Since then additional other good new chemicals were developed and brought to market; Calypso (2002), Samurai (2007), Delegate (2008) and Altacor (2008).

IPM options include a granulosis virus, *Trichogramma* wasps, Bt and pheromone mating disruption. The latter being the only really successful 'soft' option. In Australia the area under mating disruption may approach 50% in some years. In Stanthorpe the area has been up to 70% and is now possibly 55-60%. There are several reputable brands of pheromone dispensers now available and market competition is seeing prices decrease and areas treated may rise again.

How many codling moths are too many ?

Orchard Category	Total no. codling moths caught in a season*
Extremely High	600 +
Very High	301-600
High	176-300
Moderate	101-175
Low	51-100
Very Low	21-50
Extremely Low	0-20

* in a single trap in a non-pheromone treated block

A manageable population. The lower the better!! Low populations will allow growers to reduce sprays or turn to 'softer' controls Insegar, mating disruption or Mimic. To stay in the moderate range an orchard should have no more than 175 moths caught in a year. Experience has shown that a approximately one third of the moths are caught by mid-November (this includes the first cohort of the first moth flight). This is also a practical time to make a decision about whether an orchard has too many moths. Hence if more than 55 - 65 moths are caught by mid-November then the orchard will most likely be above the moderate category. This means that control within the current season will have to be intensive to prevent damage and overall numbers will have to be reduced before 'softer' controls can be used in following seasons.

What are some options for improved control ? Trap catch data can be used to improve pest control.

Situation A. You are not happy with the moth numbers and wish to reduce the moth population and reduce fruit damage.

Option 1. Stick to your present control method but increase the intensity.
Eg, instead of applying 8 insecticide sprays in a season and starting in November you could apply 12 sprays by reducing the intervals between sprays and starting in late October.

Option 2. Stick to your present control method but add another control.
Eg, apply 8 insecticide sprays as well as using mating disruption pheromone dispensers;

Situation B. You are happy with your low moth numbers and want to reduce your chemical use.

Option 1. Change your control program. Eg, change from a program of 8 Pencapp-M and 4 Gusathion sprays to an Isomate program. Alternatively, use a combination of Calypso, Delegate, Samurai and Altacor sprays.

or **Use a combination program**. Eg use Isomates and apply an insecticide for the first generation of moths as a transitional measure.

Option 2. Reduce your program. Eg, reduce the amount of chemical used late in the season if traps are showing consistently low numbers.

Mating Disruption checklist for success

- Block size
- Uniformity of trees
- Initial moth population
- Border situation
- Earliness of application
- Correct rates
- Correct height
- Use MD + insecticides to 'crash' a population
- Border spraying good practice
- Minor pests may flare
- Skip MD every few years?
- MD 'wasteful' on early harvested blocks eg Gala apples?

Extra Considerations

Heliothis. This caterpillar can be active at blossoming and when fruit are very small. Altacor and Avatar are registered for heliothis control. Calypso showed some control in trials. If Delegate is used for western flower thrips control during blossoming then Heliothis damage is usually minimal.

Woolly Apple Aphid. Gusathion and Penncap-M can suppress aphids in the crawler stages in November and December, but they also kill the beneficial wasps in summer and autumn. Altacor, Avatar and Insegar are known to be very safe to the WAA parasitic wasp. Delegate, Samurai and Calypso are moderately safe.

Light Brown Apple Moth. Gusathion, Avatar, Pencap-M, Delegate, Mimic, Lorsban and Insegar control LBAM. This pest sometimes becomes a secondary pest in orchards that have been treated with mating disruption for consecutive years. LBAM has increased as a problem as later maturing varieties have been planted (Pink Lady and Sundowner) as LBAM are more active in the milder autumn temperatures than the heat of mid-summer.

Fuller's Rose Weevil. This is a minor pest that can become a secondary pest in orchards that have been treated with mating disruption for consecutive years. Weevils are easily controlled by 1 or 2 strategic insecticide sprays.

Pest Mites. Broad spectrum insecticides (Penncap-M and Gusathion) can suppress or kill mite predators. Use of softer insecticides or mating disruption will allow predators the best chance to control pest mites.

Queensland Fruit Fly. Mating disruption, Altacor, Avatar, Calypso, Insegar, Penncap-M and Samurai treated blocks in fruit fly districts will require fruit fly treatments in late December - March. The timing and number of sprays depends on the weather and fly pressure. Bait spraying is effective, cheap and reasonably quick. Lorsban or Gusathion cover sprays will also suppress fruit fly and have been used successfully. There is data to show Delegate to suppress QFF and more work is being done to confirm this on larger scale.

Notes:

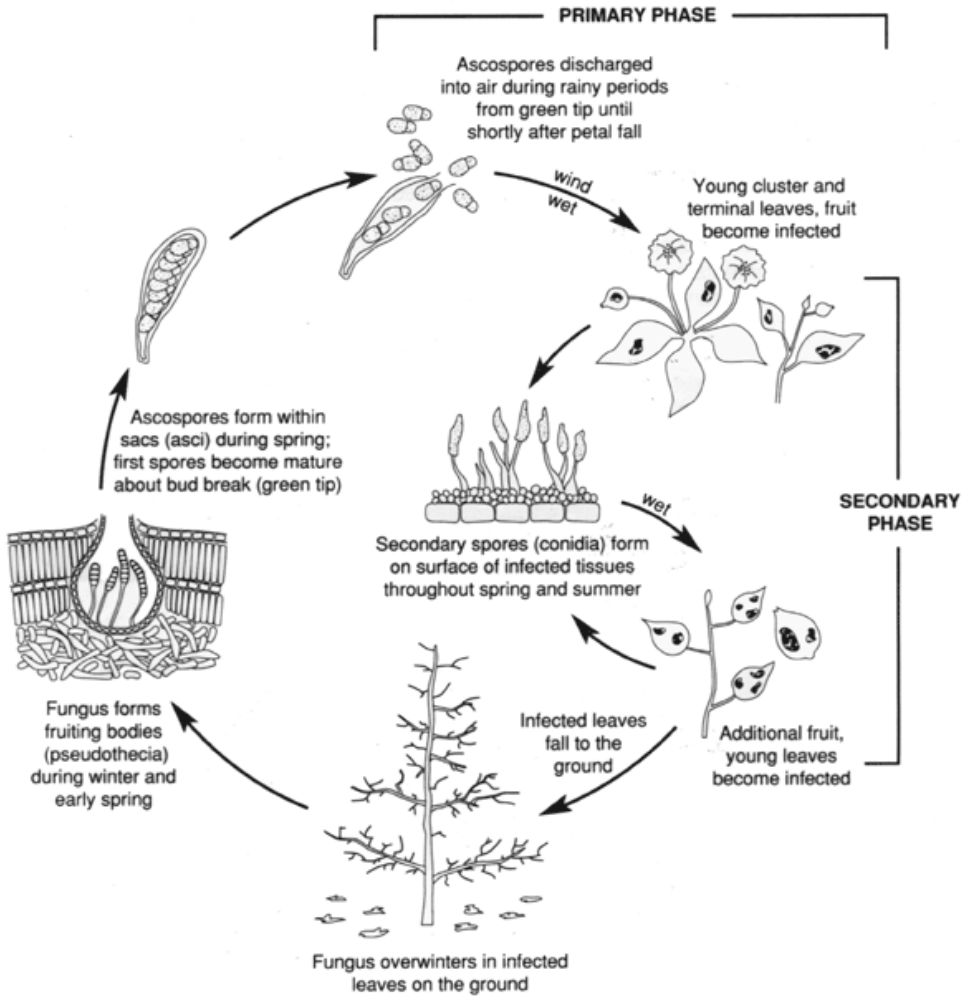
- Insegar is not suited to large trees and spraying should be timed from trap catches. However Insegar will also help control Heliothis and San Jose scale, is not toxic to the woolly aphid predatory wasps or several mite predators.
- If Gusathion and Pencapp-M are replaced by mating disruption the woolly aphid predators and mite predators will be encouraged.
- If using mating disruption or Insegar for the first time some more detailed codling moth trapping will be needed. Also if there is a large carryover of woolly aphid withdrawing Gusathion and Penncap-M may lead to a flare up of woolly aphids because these insecticides do have some suppression activity on woolly aphid crawlers. Be prepared to enlist an extra control for woolly aphid eg Lorsban or Confidor.

Insecticides for codling moth control

	Altacor	Delegate	Samurai	Calypso	Penncap-M	Gusathion	Lorsban	Insegar	Avatar
Group	28	5A	4A	4A	1B	1B	1B	7B	22A
Codling Moth	Yes	Yes	Yes	Yes	Yes	Yes		Yes	Yes
LBAM	Yes	Yes	Suppression		Yes	Yes	Yes	Yes	Yes
Woolly Aphid			Yes	Suppression	Yes				
Mealy Bug			Yes						
Heliothis	Yes	Yes							Yes
Dimpling Bug				Yes			Yes		

Black Spot is the key disease of apples and pears – if untreated it has the potential to infect and downgrade the entire crop.

The black spot disease cycle;



- Overwinters in old dead leaves on orchard floor.
- Winter spores (ascospores) released, when mature, in spring with rainfall that occurs in daylight.
- Spores sit in water film on new leaves and fruit and infection only successful if wet for long enough at threshold temps (Mills period). Black spot warnings issued by DPI based on leaf wetness and temperature.
- Warnings finish around December as the supply of overwintering spores runs out, new green leaves get tougher and there is less new soft leaf growth as fruit growth takes over.
- New black spots are the summer spore (conidiospores) lesions.
- Summer spores can infect leaves and fruit up until leaf fall. The aim is to not get summer infection by controlling winter spores !
- Summer spores don't need daylight to release, they wash onto leaves/fruit and infect after Mills periods.
- Two types of fungicides; protectant and eradicant/curative. There are normal protectants and 'super protectants'
- Eradicants not much forward protection so always mix protectant with a curative. Resistance management.

- Eradicants have different no. days 'kickback'. All presently same group (DMI , C or 3) except Syllit (Y or M7).

Black spot is a very well understood disease and most districts run a black spot warning service to indicate when curative fungicides are needed. The warnings are based on the Mills Table. There is a Day Degree model to predict the maturity of overwintering spores and what proportion will be 'ripe' and ready to be released at each rainfall event. Sometimes this information is incorporated into the warnings.

MILLS TABLE

Average air temp.	Hours of leaf wetness for light infection	Hours of leaf wetness for severe infection	Days between infection and spots appearing
6° C	25	51	?
9 - 10° C	14 - 15	29 - 30	17 days
12 - 13.5° C	11 - 11.5	22 - 24	14 - 15 days
14 - 15.5° C	9.5 - 10	20 - 22	12 - 13 days
16 - 24° C	9	20	8 - 10 days

How to control black spot

1. Hygiene – help overwintering leaves breakdown with urea and mulching.
2. Anticipate rain and apply protectants before the rain.
3. Act on warnings – apply eradicants after infection periods if no protectant cover existed.
4. Think of the Risk Matrix: variety susceptibility / overwintering spore load / intensity of infection period / expected weathering of last applied fungicide and attitude to risk.
5. Need to answer two questions; do I need to spray? what will I use?

There is many fungicides available to control black spot and a wide range of prices exist. The differences in pricing is for a reason – different fungicide do different jobs. Some fungicides will also control other diseases (powdery mildew, Glomerella, Alternaria), some will weather better than others, some have curative action.

Fungicide	Relative cost per Ha	Type of fungicide
Captan	100%	Protectant
Dithane	103%	
Ziram	120%	
Delan	122%	
Syllit	138%	
Polyram	157%	
Chorus	218%	Super-Protectant
Flint	234%	
Stroby	254%	
Pristine	372%	
Systhane	194%	Curative or Kick-Back
Syllit	207%	
Topas	220%	
Vision	295%	

Weathering of fungicides.

There is experimental data with Captan to show that 12mm of rain is enough to reduce spray deposits on apple leaves to 60% of the applied dose and to 20-30% after 25mm. In the absence of rain the spray residue on mature leaves was reduced by 59 - 78 % after 7 days. Also that immature leaves had only 75 % of the deposits that mature leaves had after 7 days due to growth dilution. Hence an immature leaf sprayed before 25 mm+ rain may have only had 10% of the original spray cover left after a week. [natural pesticide loss over 6 days (50 %), the reduction by 25 mm rain (75 %) and losses from leaf expansion (25 %)]. Gentle rain weathers less than heavy rain.

However the greatest reduction in spray deposits is caused by growth dilution, especially in spring when buds are opening, shoots regularly producing new leaves and fruits and leaves are enlarging in size each day.

Older protectants (with the exception of Delan) have a high concentration of active ingredient (998 ppm) compared to the newer protectants (113 ppm) and the eradicants (average 185 ppm). This is one reason why the eradicants do not have very good protectant activity.

The super protectants are described as having the ability to bind to, penetrate into and re-distribute around plant tissue (not systemic but 'mesostemic').

BASF information (2002)

15 mm rainfall every 24 hours for 5 days

- Polyram - protection gone in 1 day
- Delan - protection gone in 2 days
- Stroby - protection gone in > 3 days