Rockmelon Agronomic Guidelines

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Summary of Agronomic Recommendations

The overall principle for accumulating sugar in the fruit is that the plants must be kept healthy and functioning right up to harvest. It is during the last 10-14 days of fruit development, after the fruit have reached full size that is the most significant for sugar accumulation in the fruit.

Nutrition

Nitrogen: Nitrogen is important for photosynthesis which produces the sugar for fruit. It is important there is enough N available for the plants for function well into harvest. Supply most N in the base, but ensure the plants don't run right out by harvest.

Potassium: Important for moving sugars into the fruit. Supply in the base, but also supplement right up to mid fruit development.

Calcium: Important for good firm fruit and to stop leaking of fluid in to the seed cavity of the fruit. Supply early in plant growth, especially around flowering and early fruit development. Late soil or foliar applications (after mid fruit development) are not taken up by the fruit. Adequate Boron also required for calcium utilisation.

Use dry leaf analysis at flowering to monitor crop nutrition.

Irrigation

- It is crucial to avoid water stressing the plants from fruit set right through to the last pick. This means avoid too little or too much water.
- Maximum sugar accumulation depends on efficient photosynthesis to produce the sugar. This means keeping the plants stress-free while sugars are accumulating.
- The plants should be given a moderate water stress from establishment to the start (or just after) of flowering. This stress is to encourage a strong root system and avoid problems with sudden wilt.
- Over watering is as much a problem as under watering when it comes to post-flowering irrigation scheduling, monitor soil moisture closely.

Plant Density and Crop Load

- The current industry standard plant spacing of 0.5m between plants provides the best balance between yield and fruit Brix.
- Removing fruit not expected to be harvested 7-10 days prior to harvest commencement increases sugars with no yield loss.
- Thinning to 1 fruit per plant 4 weeks before harvest also produces sweeter fruit; however some yield loss occurs.

Nutrition

The key point with nutrition is to obtain a pre-plant soil test to collect some basic information about the soil nutrient levels and physical properties.

During crop growth, the plant nutrient status should be monitored using leaf analysis (not sap testing) once at flowering and again at mid fruit development. The results can be used to monitor crop progress and fine-tune the nutrition program and are especially useful while trying to develop a successful nutrition program.

Sap testing may be useful for monitoring plant nitrate and potassium levels.

Plant leaves must be kept healthy and functioning right up to harvest. It is during the last 10 days of fruit development, after the fruit have reached full size that is the most significant for sugar accumulation in the fruit.

The fertilizer rates suggested here are just a guide. They need to be adjusted based on soil and leaf test results and from grower experience.

Basal Fertilizer

	Nutrients			
Timing	Nitrogen (kg/ha)	Phosphorus (kg/ha)	Potassium (kg/ha)	Calcium (kg/ha)
Pre plant	25	85	90	110
At planting	15			
	40	85	90	110

Fertigation

	Nutrients supplied		
Timing	Nitrogen (kg/ha)	Phosphorus (kg/ha)	Potassium (kg/ha)
2 weeks after planting	15		
3 weeks after planting	10		
Fruit golf ball size	5		30
7-10 days later			30
	30		60

Foliar

FOLIAR	Timing	Rate (kg/ha)	Nutrients supplied			
			Nitrogen (kg/ha)	Phosphorus (kg/ha)	Potassium (kg/ha)	Calcium (kg/ha)
Zinc	2 weeks after planting	Recom. Rate	-	-	-	-
Magnesium	2 weeks after planting	Recom. Rate	-	-	-	-
Zinc	3 weeks after planting	Recom. Rate	-	-	-	-
Magnesium	3 weeks after planting	Recom. Rate	-	-	-	-
Sett (Stoller)	3 weeks after planting	5	-	-	-	1
Calcium nitrate	Fruit golf ball size	10	2	-	-	2
Zinc	Fruit golf ball size	Recom. Rate	-	-	-	-
Magnesium	Fruit golf ball size	Recom. Rate	-	-	-	-
Sett (Stoller)	7-10 days after golf ball	5	-	-	-	1
Supa K (Agrichem)	7-10 days after golf ball	10	-	-	3	
Sett (Stoller)	14-20 days after golf ball	5	-	-	-	1
Supa K (Agrichem)	14-20 days after golf ball	10	-	-	3	
NBX	2 weeks before harvest	4	-	-	-	-
Total Foliar			2		6	5

Total NPK

	Nutrients			
	Nitrogen (kg/ha)	Phosphorus (kg/ha)	Potassium (kg/ha)	Calcium (kg/ha)
Base	40	85	90	110
Fertigation	30		60	
Foliar	2		6	5
Total	72	85	156	115

Important Comments Regarding Recommended fertiliser Rates

Nutrient	Rate	Comment
Nitrogen	Apply about 70 kg/ha Apply around 40 kg/ha of Nitrogen in base and the remainder split over 3 fertigations, mainly while the fruit is young. This rate may need to be adjusted depending on the level of residual nitrogen in the soil. In trials, higher N applications have produced good results, however growers are cautioned about using high rates of Nitrogen without trialing on their own farms first.	The main principles with nitrogen are to: Ensure adequate nitrogen for photosynthesis and growth. Photosynthesis is closely related to leaf nitrogen level, so it important to make sure there is enough N available in the plant for the leaves to continue photosynthesising properly right up to the end of harvesting. Vegetative growth is regulated by the fruit load, as well as nitrogen supply, so vine size can controlled provided there is adequate fruit set. High nitrogen does not appear to lead to soft fruit **provided** the nutrient supply is balanced, ie adequate potassium, phosphorus and calcium are crucial, if high rates of N are to be used. High N alone can lead to soft fruit which is prone to breakdown. Avoid late N applications as these are more likely to lead to soft fruit and breakdown. Take care not to apply excessive N in winter which can suddenly become available when soil warms up in spring, and in this case may lead to excessive growth and poor quality fruit.
Phosphorus	Apply at 70 – 100 kg/ha in basal application.	Adequate phosphorus is needed to maintain leaf levels into fruit development stage. Phosphorus plays a role in sugar movement in the plant and therefore fruit Brix. Phosphorus also appears to play a role in maintaining adequate fruit firmness in our studies.
Potassium	150 kg/ha. Apply 60% in the basal and the remainder through trickle in at least two split applications, once when the fruit are golf-ball size, and again 7-10 days later.	Potassium is important in sugar movement from mature leaves to developing fruit. Avoid excessive amounts of potassium, and ensure that adequate calcium is also supplied to the plant. Potassium competes with calcium for uptake by the plant, and high potassium can induce a calcium deficiency which can cause soft fruit and reduce sugar accumulation in the fruit.

Calcium	Aim to apply about 100-120 kg/ha of available calcium pre-plant. Calcium should be applied mainly in a plant available form in the base fertilizer and supplemented with small applications through the trickle pre fruit set and as foliar sprays which directly contact the fruit after fruit set. Consider basal fertilizers which are high in calcium such as single superphosphate. Calcium can be supplemented by applying gypsum to the soil prior to planting. However, very little of the calcium in gypsum is available to plants in the short term. Aim for a soil Ca:Mg ratio of soil about 4:1. Alternatively, calcium can be applied through the trickle irrigation as micro fine gypsum which is more available for uptake by the plants. Foliar sprays from flowering to harvest every 7 days are useful if calcium low.	Calcium is also critical for sugar development and seed development. If seed development is inadequate, then fruit do not develop normally and Brix levels will not reach full potential Calcium is crucial for cell membrane integrity which plays a role in sugar movement to the fruit. Calcium is also involved in the layer which binds fruit cells together. This layer is important in fruit firmness and preventing fruit breakdown after harvest. Calcium is unable to move into the fruit through the stem after early fruit development. This means that calcium must be freely available to the plant from flowering through to mid fruit development. Post mid-fruit development, foliar sprays can be an effective way of applying calcium, but it is more likely that it is the calcium which falls on the fruit that is effective rather than calcium moving from the leaves to the fruit. There is evidence that in the form of an amino acid chelate may be able to move more readily from leaf to fruit. Calcium can also be applied to fruit as a post harvest dip, where the fruit is dipped as soon as possible after harvest (within a couple of hours). Melon Dip (Stoller) was found to delay fruit softening and extend post harvest life.
Micronutrients	Apply as foliar sprays, starting before flowering if any are known to be deficient. Use leaf analysis to monitor micronutrient levels.	Levels need to be kept within normal ranges. Pay particular attention to boron which must be adequate from the start of flowering onwards. This means foliar sprays need to commence before flowering.

Nutrient Target levels in the Youngest Fully Expanded Leaf

Nutrient		Flowering to Fruit Set Stage			Mid Fruit Development			Harvest		
Nitrogen*	%	5.5	...	6.0	3.5	...	4.5	3.0	...	3.5
Phosphorus	%	0.5	...	0.8	0.3	...	0.7	0.3	...	0.7
Potassium	%	4.0	...	6.0	2.5	...	4.0	2.0	...	4.0
Calcium	%	3.5	...	4.0	3.5	...	5.0	4.0	...	5.0
Magnesium	%	0.40	...	1.0	0.30	...	1.0	0.30	...	1.0
Sodium	%	0.0	...	0.40	0.0	...	0.50	0.0	...	0.50
Sulphur	%	0.5	...	1.0	0.5	...	1.0	0.5	...	1.0
Zinc	mg/kg	20	...	60	20	...	60	20	...	60
Iron	mg/kg	40	...	300	40	...	300	40	...	300
Copper	mg/kg	5	...	20	5	...	20	5	...	20
Manganese	mg/kg	20	...	400	20	...	400	20	...	400
Boron	mg/kg	30	...	200	30	...	200	30	...	200

* Nitrogen levels are quite high relative to common practice, in trials conducted over the duration of this project these N levels have been achieved without leading to soft fruit. However, these target levels should be treated with caution and grower experience used when considering N applications.

Irrigation

The first point about irrigation is that trickle irrigation is essential for the reliable production of sweet melons. Flood irrigation does not give adequate control of soil moisture levels.

There are dual objectives when it comes to irrigation practice:

- **Maintaining a healthy root system**
- **Maximising sugar accumulation in the fruit**

Maintaining Root Health

Maintaining a healthy root system through to the end of harvest is a crucial factor in producing sweet fruit.

Vines which collapse at the start of harvest or even before harvest begins do not have healthy root systems. A line of browning leaves down the centre of a row which is often seen as the fruit nears maturity, is not normal and is a sign of an unhealthy root system.

Modern melon varieties are highly susceptible to poor root health because they have been bred for high yield and a large vine to protect the fruit from sunburn. There has been no selection for root size, which has tended to remain just large enough to support the plant.

The roots are operating at the upper limit of their capacity to supply water and nutrients to the plant. Anything which reduces root system efficacy can result in roots not being able to keep up with the demand of the leaf, stem and fruit.

Anything which affects the efficiency of the roots then starts to impact on fruit quality. This is most pronounced as the fruit mature near harvest. Some symptoms of unhealthy roots are:

- Plants wilting in the middle of the day
- Browning of leaves along the centre of the bed
- Plants start to collapse after the first harvest
- Patches of dead leaves and exposed fruit

- In the extreme cases, the result is sudden wilt, where large areas of vines collapse near harvest.

Factors which contribute to unhealthy roots

The following practices lead to a compromised root system. Crops may be able to withstand one or more of these factors and still produce healthy crops, however the more of these factors which are present together, the more difficult it will be for roots to supply water and nutrients and for the crop to produce sweet fruit.

- Excessive watering, especially between planting and first flower
- Transplants
- Plastic mulch
- Trickle irrigation tube on the surface of the soil, especially under plastic
- Previous crops of cucurbits
- Prevalence of root rotting diseases in the soil such as Fusarium

Excessive watering, especially between planting and first flower

While plants are being watered the soil around the drippers is saturated, or at least wetter than is ideal. This does two things:

- The normal function of the roots are impaired – they don't take up water and nutrients as well as possible
- Fungi which kill root hairs are promoted – the wet conditions favour their development

So, every time you water you impair the root system. A healthy root system is white with many fine root hairs. It's the root hairs that mainly take up the water and nutrients, not the larger structural roots. If the roots are brown, or there are few very fine root hairs, the roots are not healthy.

Strategy:

1. Irrigate after planting, and don't irrigate again until first male flower unless the plants become excessively water stressed, or soil moisture monitoring probes indicate stress.

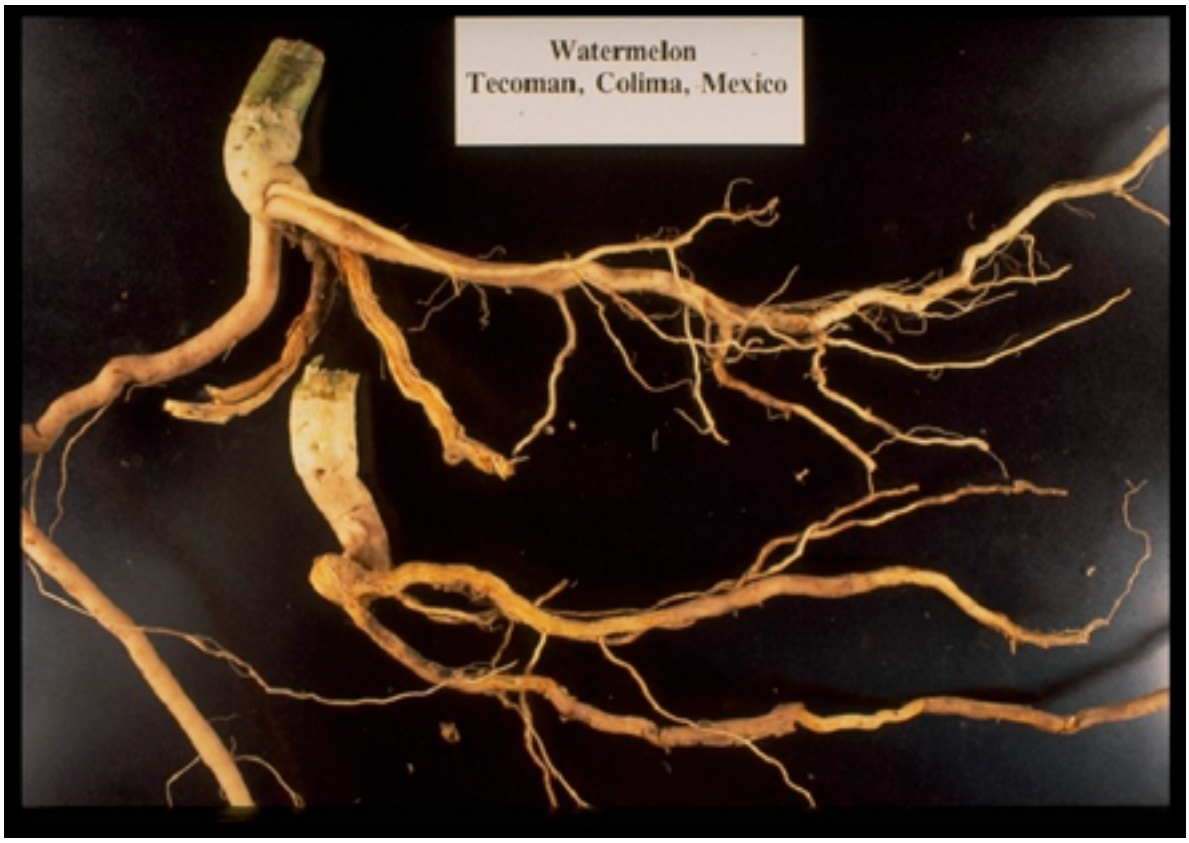
2. After flowering the plants need to be kept free of water stress. This usually means watering every 2-3 days or less frequently. Make use of soil moisture data and use in combination with the appearance of the plants and local conditions to schedule irrigations.

3. When irrigating, irrigate to field capacity, then stop. Avoid partial irrigations. Each irrigation stresses the plants and encourages root killing fungi – keep the number of irrigations to a minimum.

4. Keep irrigating right through until the end of harvest. Our trials have consistently shown that water stressing the plants at any stage after flowering leads to reduced yield and lower Brix in the fruit. It is the last 10-14 days before harvest that are crucial for sugar accumulation (Brix) in the fruit. (See next section on Sugar Accumulation)

Transplants

Seedlings do not develop a normal taproot and have a more fibrous and surface rooting system (see below). If they do develop any sort of taproot, it is typically shallow and runs horizontally. Compare the root systems of some direct seeded and some transplanted plants in the field and you will see this is occurring.



Seedlings: When seedlings are grown in cells, the roots start to circle when they contact the walls of the cell. This is unavoidable despite efforts to minimise this effect by various seedling cell designs. When the seedlings are transplanted into the field, this cycling continues and a thick callus of roots forms near the crown. This mass of thick roots interferes with water and nutrient uptake, and leads to a small fibrous root system.

Direct seeding: While it can be more difficult to get a good establishment, the plants which develop from a seed sown directly into the soil:

- Have a strong taproot which take the roots deeper into the soil
- Have a larger, stronger framework which provide a good structure to support the root hairs which are responsible for water and nutrient uptake.
- Are better able to withstand some root death caused by over watering and fungal attack

Plastic mulch

Plastic mulch traps soil moisture near the soil surface, this encourages plant roots to grow right up to the soil surface. The result is a small, fibrous root system in the upper soil layer.

No mulch, or an organic mulch in combination with buried trickle irrigation tube places the water source below the seed (or seedling) and as the soil dries down between irrigations, the roots are encouraged to follow the moist soil down, contributing to a larger and deeper root system.

The warmer soil and moist conditions just under the plastic do encourage very good vegetative growth and produce a good-looking plant; unfortunately these plants may not be able to supply water and nutrients to melons when the maximum load on the roots comes during the crucial late fruit development stage.

Note Without plastic mulch there is the potential for weeds to compete with the crop and reduce yields and quality. If you choose to grow melons without plastic mulch, it is important to pay particular attention to weed control to ensure there is no competition from weeds.

Trickle irrigation tube on the surface of the soil, especially under plastic

Trickle irrigation tube is commonly laid on the soil surface, just beneath plastic mulch. This keeps the soil moist right up to the soil surface and encourages surface roots, not deep roots.

Placing the trickle tube 10 cm below the soil surface (sandy soil) or about 15-20cm below the soil surface for a clay soil, encourages roots to grow downward toward the water source as the soil dries down.

It is crucial that soil is allowed to drain freely between irrigations; if soil moisture is continuously “topped up” deep roots will not develop to any great extent, increasing the likelihood of vine collapse.

Previous crops of cucurbits and the prevalence of root rotting organisms such as Fusarium.

Growing cucurbits on soil which has previously been used for several crops leads to a build up of disease organisms in the soil which favour cucurbit roots. These can be Fusarium, possibly *Monosporascus cannonballus* or other fungal organisms.

The build up of these organisms places a greater disease pressure on the roots and more fine roots will be attacked and destroyed.

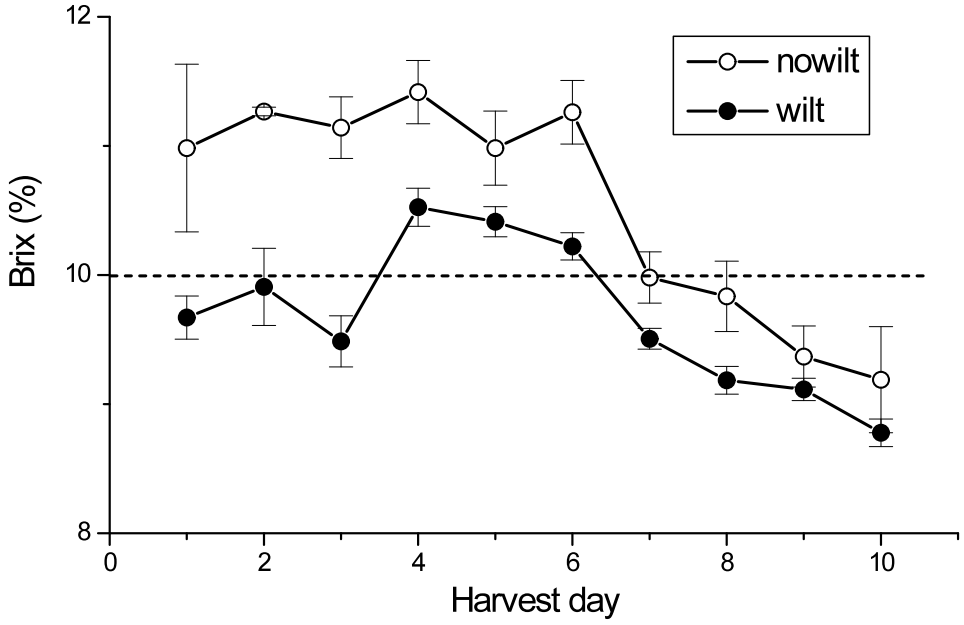
If it is unavoidable to grow melons year after year in the same soil, try to include a rotation with another crop type, or grow a cover crop.

The effect of unhealthy roots and vine decline on melon Brix levels?

The figure below shows the Brix levels over the harvest period of rockmelons from plants which were healthy right through harvest compared to the normal harvest from a trickle irrigated block at Kununurra.

The “wilt” affected plants were not severely affected, and many of these plants still had green leaves attached by the end of harvest.

If the wilt had been more severe, the effect on depressing fruit Brix levels would have been much more pronounced.



Sugar Accumulation

Maximum sugar accumulation depends on efficient photosynthesis to produce the sugar in the first place. In terms of water relations, this means keeping the plants stress-free.

Water stress causes the stomata in the leaves to close to limit water loss by reducing evaporanspiration – water loss through the stomata. This partial or full closure of the stomata does effectively save water, but it also reduces the rate of photosynthesis because it limits the rate at which carbon dioxide (CO_2) can move into the leaves.

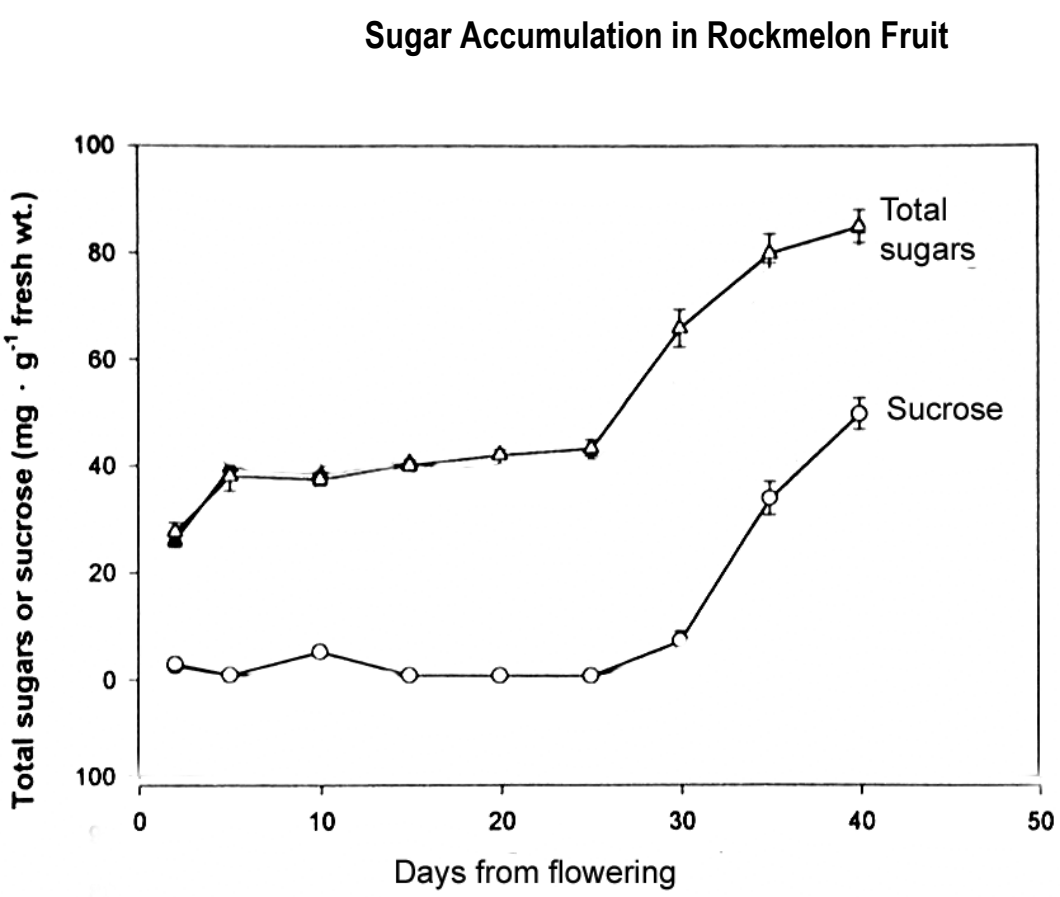
The stomata need to be open for photosynthesis – water stress closes the stomata. The sugars which increase Brix in the fruit come from photosynthesis, so anything which slows photosynthesis reduces sugar accumulation in the fruit and fruit Brix.

Most sugar accumulation occurs in the last 10 – 14 days of fruit development. (see figure below). It is crucial to avoid water stressing the plants at this time. It is important to keep the plants stress-free right up to and through harvest.

There has been some trial data which suggests that a mild stress up to and through harvest gives a further increase in Brix. In these trials however, the control plots were being watered with the rest of the irrigation block, and after examination of the soil water records, we concluded the control plots were being over watered.

It is true to say that over watering is as much a problem as under watering when it comes to producing fruit with high Brix levels

Do not cut off the water before or during harvest. This will reduce fruit Brix.



Irrigation Management – Interpretation of Soil Moisture Data

Summary of Irrigation Strategy

Stage of crop growth	Strategy	Objective
Sowing or transplanting to first male flower	Irrigate to field capacity immediately after planting. Monitor soil moisture and irrigate only when plants become excessively stressed.	**Development of a large root system.** The idea is to dry the soil down the encourage roots to grow in search of moist soil. Buried trickle helps achieve this objective. Subjecting the plants to a mild water stress at this stage will not reduce yield or fruit Brix.
Flowering to harvest	Irrigate when the soil reaches refill point or when the rate of water extraction by plants from the soil begins to slow down. Then, irrigate the soil fully up to field capacity. Do not over-irrigate, and avoid short partial irrigations.	**Keep plants free of water stress during the fruit growth and sugar accumulation phases.** Each irrigation encourages root rotting fungi to kill off roots hairs. Keep the number of irrigations to a minium but do not subject plants to stress.
Harvest period	Maintain normal irrigation as per flowering to harvest. Some trial data suggests a mild stress such as: missing a single irrigation just before harvest, or irrigating half as often during harvest increases sugars but most data suggests maintaining normal irrigation through harvest is best. Do not dry off plants prior to, or during harvest.	**Keep plants free of water stress to enable late maturing fruit to accumulate sugars prior to ripening.** Fruit that will be picked two weeks after the start of harvest has not yet gone through its sugar accumulation phase. This fruit needs to be well supplied with water to aid the accumulation of sugars. This cannot be achieved if the plants are water stressed. **This is a significant change to conventional practice, but is essential for to maintaining sugars during harvest.**

Soil Moisture Sensor Data Interpretation

It is very helpful to have some reliable form of soil moisture measurement to assist in identifying when you should water. The two common systems in operation are the EnviroSCAN system by Sentek and the C-Probe system by Agrilink.

You really need continuous (10 – 30 minute sampling interval) monitoring of your soil moisture and you need to look at this data each day.

You need to identify the full point, and the refill point and use these as a guide as to when and for how long you should be watering. These times will obviously vary as the crop grows and at different times of the year.

Crop appearance should also be taken into account.

If crops are wilting, this could well be due to poor root system health as discussed in the previous section. In this case, the temptation is to give small top-up irrigations to try and get plants past the critical period in the middle of the day. These small top-up irrigations further degrade the roots system and make the problem worse.

Figure 1 – Rockmelons and Honeydew Irrigation Frequency and Duration for Maximum sweetness

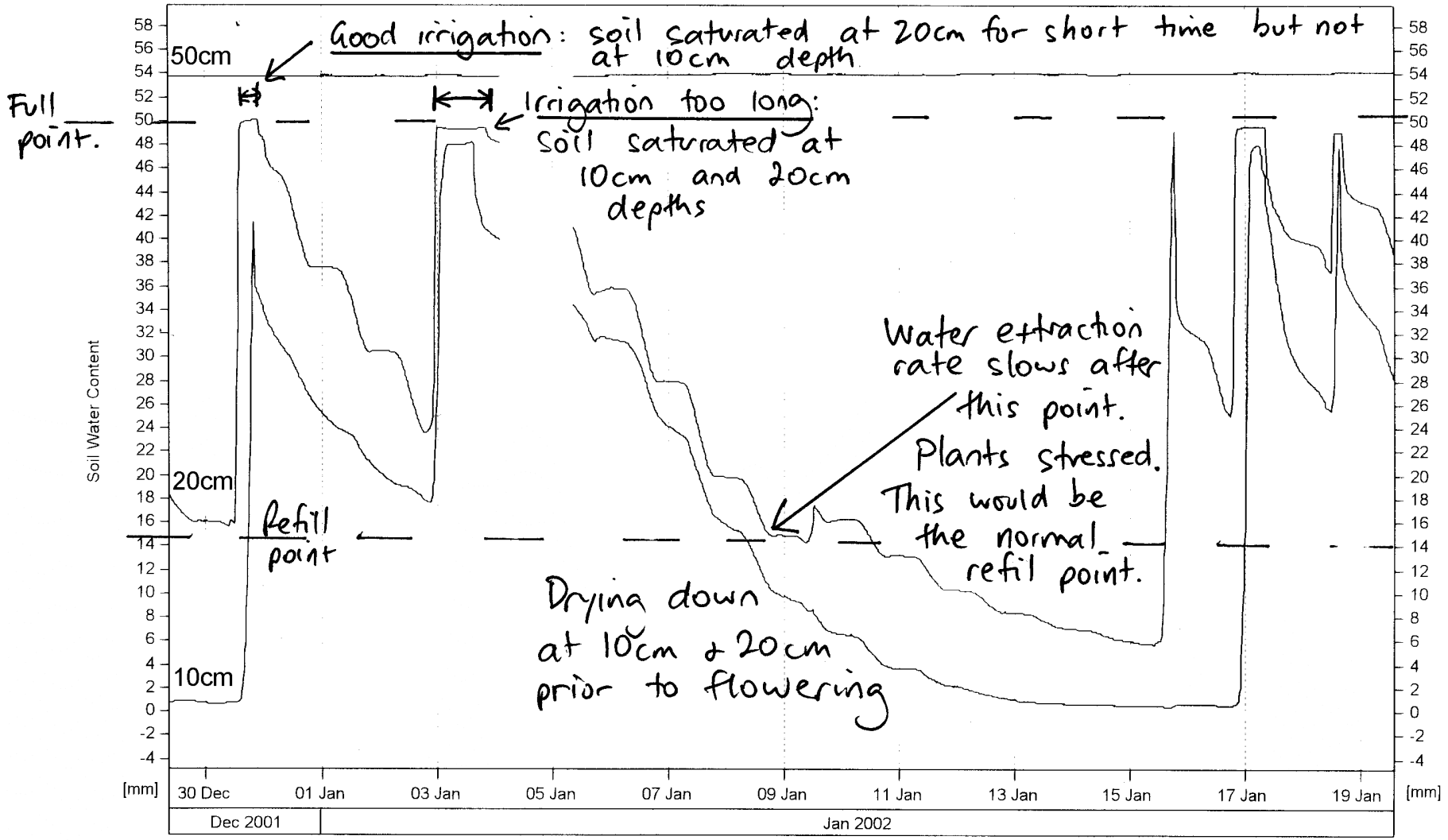


Figure 2 – Correct Irrigation Pattern for Rockmelons and Honeydew for Maximum sweetness

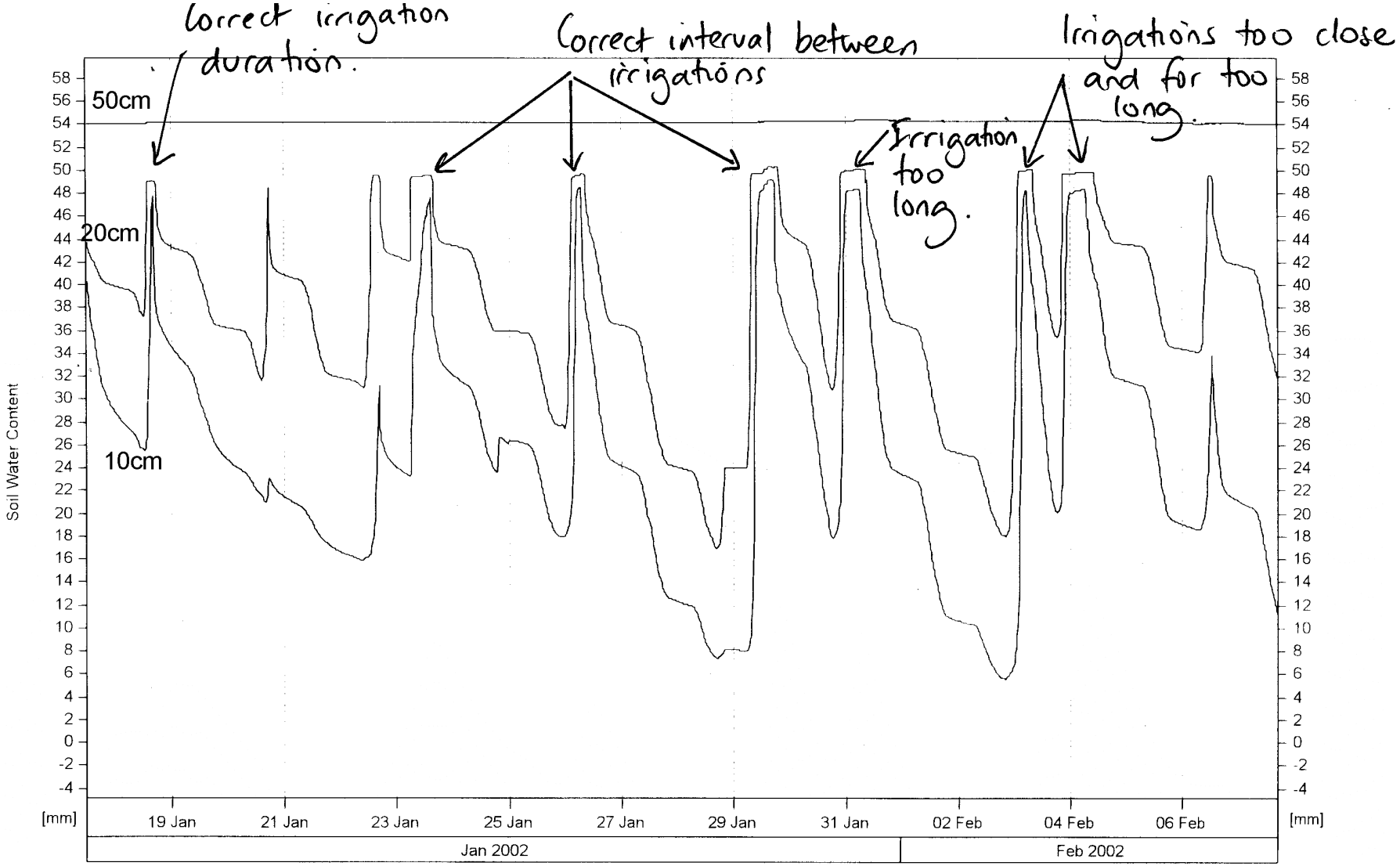
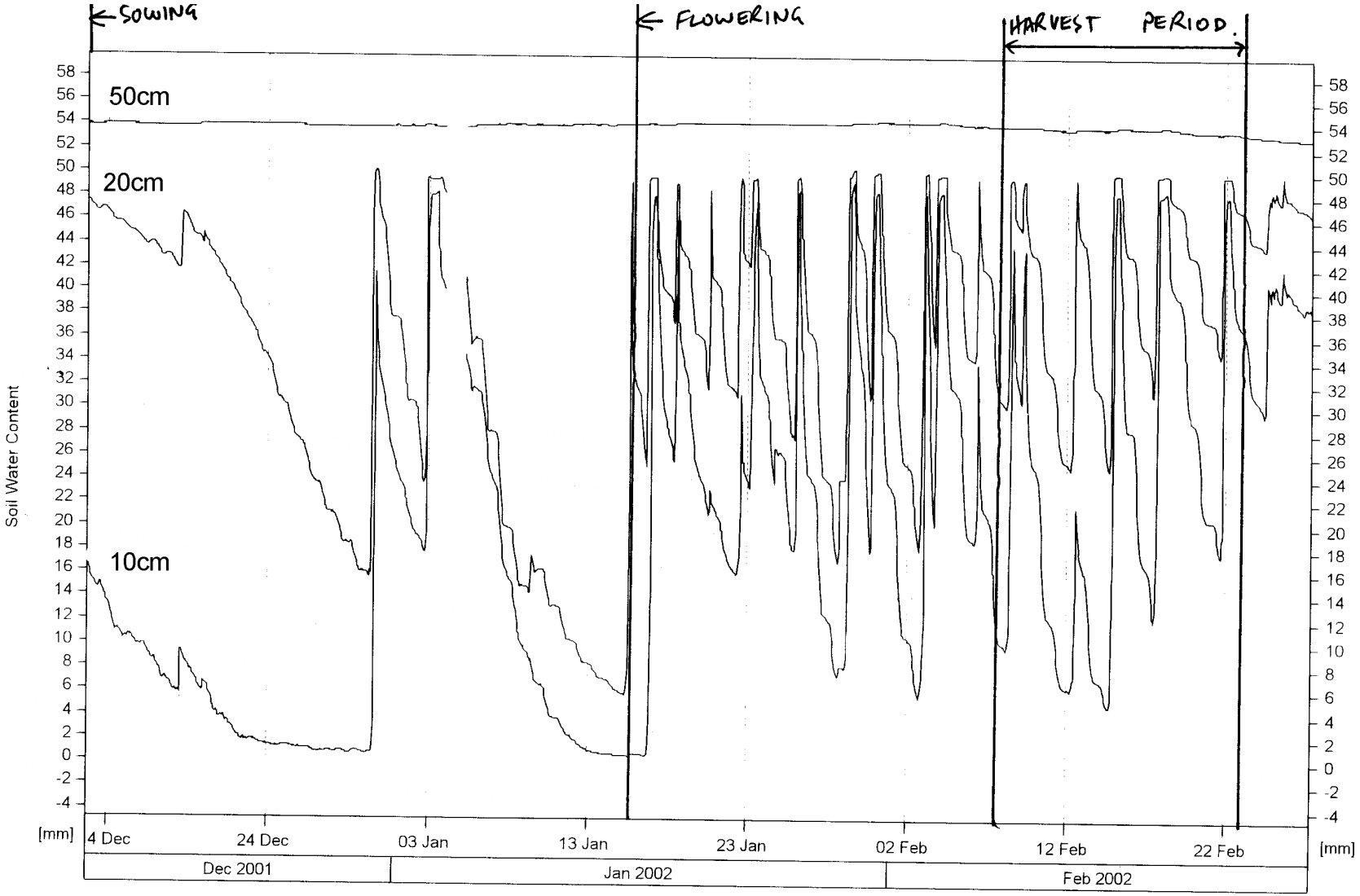


Figure 3 –Crop Irrigation Pattern for Rockmelons and Honeydew for Maximum sweetness



Guidelines for the interpretation of soil moisture data

Set the full point – The full point is where you see the soil moisture level flatten out. If you look at figure 1, you will see that it's about full point is around 50mm of water.

Refill point – The refill point is the level of soil moisture when you should start to irrigate. For melons, if you want to maintain plants stress free, such as during fruit development and over harvest, monitor the moisture level at each depth every day, and when the slope of the line starts to flatten out, this indicates that the plants are starting to have more trouble extracting water – the rate of water uptake slows.

The point at which the line starts to flatten out for the 10cm and 20cm depths, is the refill point. In the case of figure 1, it's about 15mm water.

Note that if you are trying to dry down the soil, and stress the plants, the refill point can be much lower. In the case of figure 1, the soil was dried down to 0mm water at 10 cm and about 6 mm water at 20cm depth. Notice however that even at these dry conditions for the upper soil, the soil moisture at 50cm deep did not change.

You should also monitor the appearance of the plants for the drying down phase – avoid excessive stress where the plants are obviously wilting and badly affected.

How long to irrigate The idea is to irrigate until the soil is fully wet, then stop. When the soil is over irrigated, the soil moisture line flattens out. (Refer to figure 1, and look for the note "Irrigation too long") Note how at 10cm and 20cm depths, the soil moisture line flattens out for about 12 hours – this means the soil was saturated for that long at those depths – that's too long.

Look at the "Good irrigation" note on figure 1, and see the irrigation is shorter, and the soil was not saturated for as long.

Interval Between Irrigations – The soil should be allowed to dry down to the refill point when you are trying to keep the plants stress free. See figure 2 for examples of correct and incorrect intervals between irrigations.

Irrigation Pattern over the Entire Crop Growth – Drying down during the vegetative period, and regular irrigations from flowering onwards through the fruit development and harvest periods.

Plant Density and Crop Load

Plant Density

Decreasing plant density does not produce fruit sweeter than fruit from the standard 0.5 m between plants, even when the crop is thinned. Thinning to 1.5 (on average) or 1 fruit per plant 2 - 3 weeks before harvest at 0.5m spacings does increase sugars slightly, but also reduces yield.

Increasing plant density by reducing plant spacing to 25cm between plants reduces the number of fruit per plant and can result in a 0.5% increase in fruit Brix when the level of pollination is lower than optimal. In general, increasing plant density has a minimal impact on fruit Brix.

It appears that current spacing of 0.5m between plants provides the best balance between yield and fruit Brix.

Crop Load

The sweetest fruit is the crown set fruit. Second set fruit is 1 – 2 % Brix lower than crown fruit.

Fruit thinning is a management option for producing sweeter fruit, however the yield loss must be taken into account before conducting fruit thinning on a commercial scale.

Removing fruit that is unlikely to be harvested about 1 week before the start of harvest may be a useful technique.

Thinning to 1.5 (on average) or 1 fruit per plant at conventional spacings does increase sugars slightly, but also reduces yield significantly.

The following 2 strategies have some merit in increasing fruit Brix:

Technique 1: Remove any fruit that will not be harvested 7-10 days before the start of harvest.

This means sending a picking crew through the crop, and getting them to pull off any small fruit that they can see that will not be mature enough to have been picked by the end of harvest.

In trials this strategy has resulted in fruit with a 0.7% Brix increase in fruit with no loss in yield.

Technique 2: Remove all but 1 fruit per plant (2 fruit per metre of row) about 4 weeks from harvest.

This would mean sending a crew through the block about 4 weeks from harvest and leaving 2 fruit per metre of row (1 fruit per plant). The largest fruit should be left, and the rest removed.

The result will be a highly significant 1.3% Brix increase with about a 20% reduction in fruit number and a 10% increase in fruit size. This results in an overall yield reduction of 10%.

This strategy could be useful when low fruit Brix is normally experienced due to environmental conditions.