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Bitter pit control could save export Granny Smiths

By S. E. Hardisty, Horticulture Division

Western Australian exports of Granny Smith apples are threatened by the incidence of bitter pit. Fortunately treatments which can control this storage disorder, have become available.

The Western Australian Granny Smith apple holds its condition well and has therefore been popular with export markets in Europe as well as Asian and Arabian Gulf countries.

However in recent years, buyer confidence has been eroded by lack of uniformity including the development of the storage disorder bitter pit during transport to overseas markets.

Bitter pit on Granny Smiths forms as numerous shallow lesions or pits on the calyx end of the apple. It develops after a period of storage, but is not apparent at the time of picking or when the apples are finally inspected before export.

Problems with bitter pit have become particularly bad in Western Australian Granny Smiths in the last two seasons. In 1977, 12,000 export cartons were rejected because of pit and in 1978, 20,000 cartons were rejected. Instances of 50 per cent bitter pit were reported in 1978 from Europe. The problem is made doubly serious by guarantees by New Zealand and South Africa that their apples are free of pit.

Cause

The cause of bitter pit has been known for many years. Although a tree may be well supplied with the nutrient calcium, the fruit itself may become deficient.

The deficiency in fruit is caused by vigorous leaf growth drawing calcium from the fruit. The loss of calcium is greater in hot, dry, windy weather (as encountered in local apple growing districts) when water movement from the leaves is more rapid. This movement of water drags calcium away from the fruit.

On the same tree, apples near leafy growth may be low in calcium while others contain adequate levels. For example, apples closer to the main framework of the tree contain more calcium. Figure 1 illustrates the difference in calcium levels and pit liability on a single tree. Although larger, the apples on an unpruned lateral lower down on the tree had up to three times more calcium than apples from the vigorous, heavily-pruned tops.

The calcium content of apples was as high as 72 parts per million (ppm) on a fresh weight basis, where few leaves per apple were involved, compared to as low as 26 ppm where more leaves were involved.

In the apples containing less calcium, 87 per cent developed pit, but no apples developed pit with the higher calcium content selected lower down from the same tree. This example emphasises the importance of minimising tree vigour in relation to crop load.

Level of pruning

Heavy pruning encourages vigorous leaf growth and therefore bitter pit is more common as a result. Heavy pruning also reduces overall yields of good quality apples and seriously reduces fruit size adjacent to heavy vegetative growth.

Many growers continue to prune heavily partly because of tradition and partly because heavy pruning causes more upright leafy shoot extensions which lessen the percentage of fruit lost to sunburn injury and limb rub.

However despite the higher culling rate, more good quality fruit is produced by lighter pruning or a system of thinning-out pruning after three years of no pruning.

The further disadvantage of heavy pruning in the case of Granny Smiths is to decrease the size of those apples next to vigorous growth. This does not occur in other varieties such as Golden Delicious.

Young trees not yet in full bearing with an excess of vigour are also more liable to develop susceptible fruit.

Spraying to control pit

The incidence of bitter pit can be reduced by several sprays of calcium nitrate before harvest, but
this method of control is not completely effective. These sprays are inefficient if the foliage is dense, reducing the amount of spray reaching the fruit. Furthermore, if the calcium deficiency in the fruit is severe, spraying during the growing season does not supply enough calcium to overcome the pit problem which develops after harvest.

Failure of calcium nitrate sprays is mainly due to heavy pruning. Where trees have not been pruned heavily, sprays have been effective for bitter pit control in Cleopatras, Golden Delicious, other susceptible varieties, and in some cooler districts, Granny Smiths.

South African workers have shown that effectively applied tree sprays can be expected to reduce pit by 16 per cent. This would have left an unsatisfactory level of pit at 34 per cent in the instance of the reported 50 per cent pit last season. A campaign to ease the severity of pruning has failed particularly in the Donnybrook district. Therefore tree sprays are no longer recommended for the full control of bitter pit on Granny Smiths. The newly developed alternative, an immediate post harvest treatment with a mixture of calcium chloride and Australian DPA (diphenylamine) in water will completely control both bitter pit and superficial scald.

**Research on post harvest treatment**

In most susceptible varieties, bitter pit develops internally as well as externally, but in Granny Smiths, it only develops at a shallow depth under the skin (Fig. 2). Because of this, calcium treatment after harvest is particularly effective as the applied calcium can quickly penetrate susceptible areas. Since the early 1970s it has been known that DPA improves the effect of calcium chloride. However, the formulation of DPA which contains 60 per cent xylene as a solvent damages fruit. Free xylene is liberated when this DPA is added to calcium chloride (Fig. 3). An alternative source of DPA, "Chemley no scald" was obtained from the United States in 1976 and preliminary trials in 1977 cleared this method of control for commercial use after registration for the 1978 season.

Many growers have had a satisfactory season's experience with the United States formulation and this is the only DPA which can be used for this post harvest treatment. A valuable side effect is that it helps retain the green colour of Granny Smiths.

Co-operative work in 1978 with K. Scott of the Department of Agriculture of New South Wales showed that costly pressure and vacuum infiltration techniques for applying calcium after harvest were not needed for the control of pit in Western Australian Granny Smiths. Bitter pit was completely eliminated in apple samples treated by dipping or flooding within 24 hours of picking with a post harvest DPA calcium chloride dip and cold stored for several months. Some apples which had not been treated developed pit in 80 per cent of apples.

Calcium chloride without DPA controlled pit to an average level of 10 per cent in highly susceptible fruit, although in commercial fruit this control should be much better. The results however highlighted the value of the combined DPA and calcium chloride.

The poor results of tree spraying were demonstrated in some of the apples studied in 1978. Residues of an adequate coverage of calcium nitrate sprays to the tree were visible on apples which still developed up to 40 per cent pit when no post harvest treatments were made.
were applied.

Another feature of the 1978 trials was the importance of post harvest handling conditions. Apples held for seven days before cold storage at 5°C had twice the incidence of pit compared to those stored immediately at 0°C. Thus apples in cartons generally develop more pit than those in bulk bins, as cartons are well insulated packages and slower to cool.

Another 1978 trial showed that treatment immediately after picking improved results. Treatment within a few hours of picking followed by rinsing two days later was much better than a two day delay between picking and treatment.

A disappointing result was that after such a delay of two days, the more elaborate vacuum or pressure treatments were relatively ineffective. Treatment with calcium chloride alone must be done immediately after picking, although if necessary the combined calcium chloride/DPA treatment can be delayed a few days.

Results of a delay in rinsing the treatment from the apples were promising. Calcium is absorbed from the skin treatment during the cold storage period, and ideally apples should be undisturbed in the bin after treatment.

Apples treated in the packing shed and immediately moved over the brushes had most of the dip removed with correspondingly poor results. However treatment was effective with a delay of at least four days between treatment and brushing or rinsing in fresh water. In this three days, the calcium is able to penetrate enough to control the shallow form of pit associated with Granny Smiths.

The DPA has its effect before the treatment dries and therefore is not affected by rinsing.

The best method of treatment is to dip the bulk bin in a dipping tank. Apples in container bins or in bins on the standard 1165 mm pallet can be satisfactorily dipped.

However the large field bin commonly used in the orchard creates problems in dipping, and flooding is a satisfactory alternative. A small pump and relatively cheap equipment can be used to drench apples in the bin with the solution which is collected in a tray under the bin for recycling. With the shallow field bin, 150 litres or more of solution is required depending on the rate of recycling.

**Corrosion**

Experience in the 1978 season showed that calcium chloride was corrosive and that apples slightly wet with this chemical could damage grading equipment.

Calcium chloride rusted working parts of some graders, and attacked sizing belts of a rubber-canvas mixture. The carbon black in the rubber had dissolved and apples disfigured by black smudges from affected belts were subsequently rejected from export. Plastic compound-canvas belts were not affected. Rust on the field bin caused by calcium chloride was minimal and of no concern, but pumps with plastic housing and plastic impellor blades are recommended.

**Procedure**

Immediately after harvest apples should be treated with 1500 ppm DPA and 3 per cent calcium chloride solution. This solution is obtained with 0·5 litres of DPA from the United States and 3 kg of commercial flake calcium chloride (72 per cent) per 100 litres of water.

The required quantity of DPA should be vigorously mixed with the water before adding the calcium chloride which must be dissolved in a bucket of water beforehand. No wetting agent is required because the DPA already contains wetters.

For the less effective treatment with calcium chloride alone, 3 kg is used per 100 litres of water with a small quantity of wetting agent according to the manufacturer's recommendation.

The amount of the solution required for dipping depends upon the dimensions of the dipping tank and this should be carefully measured.

A suitable flooding unit for field bins has been designed by the Department of Agriculture. A small electric pump (about 0·4 kw) with a plastic impellor and housing is recommended. A larger than specified outlet hose (37 mm) gives an improved pouring action. The solution should last several days, and deteriorates mainly due to dirty fruit. Treatment of wet apples will still be satisfactory and the resulting slight dilution of the solution will be of little importance.

Normally bulk bins are lined with material such as strawboards to reduce bruising, but if the floor of the bin is lined, drainage of the liquid back to the tank will be impeded. Also apples against the wet strawboard could be liable to slight lentical spotting from being held in contact with the wet strawboard.

**Industry action**

Adequate testing for post harvest treatments can be maintained by separate tests for calcium chloride and for DPA, and export inspectors will be equipped with test kits in the 1979 season.

Fruit growing and shipping organisations fully support compulsory dipping immediately after harvest for all export Granny Smiths. Only for 1979 will the less satisfactory alternative of tree sprays be acceptable.