The South-west of Western Australia experiences a Mediterranean climate that generally does not lend itself to fungal disease problems. However, wet winters combined with deep laterite derived soils over structured clay subsoil leads to deep rooting, vigorous vines. The springs are often wet leading to leaf Botrytis and a high carry over of inoculum.

Weather patterns during March and April in some seasons see large masses of warm moist air associated with tropical cyclones off the Western Australian coast moving south, which combine with cold frontal air from the Great Southern Ocean. The combination of these weather systems can produce significant rainfall events late in the ripening period with disastrous consequences for grape growers. Short periods of heavy rainfall and associated cloudy conditions produce rapid and heavy bunch rot infections, leading to significant crop loss.

As growers in this area we have had to develop solutions that satisfactorily control bunch rot. To achieve this we have found that integrated strategies that include canopy management, site selection, chemical control and pest control are the most effective. The following describes the techniques we have employed and why.

Site selection
The drainage of soils is very important to most South-west vineyards although it can sometimes be difficult to select a completely free draining site. Soils across the South-west vary considerably over short distances. Thus when choosing a site drainage is always looked at critically. Often drainage is required to achieve soils that are not waterlogged and hence vines that develop slower in the block and make disease control more difficult.

Typically, slotted pipe drainage is installed in wet areas although in particularly wet areas, tyre drains have been used. The drains are used to remove excess water and further drying of the soil is achieved using cover crops.

Cover crops
Typically we use cover crops to reduce the free water available in the profile post budburst. The benefits are varied in the vineyard. The control that cover crops can exert over vigour is necessary in the successful control of bunch rot.

Across the South-west of Western Australia, perennial ryegrass pastures are common. These pastures are particularly well suited for use within vineyards as they are deep rooted and provide large amounts of leaf area early in the season. A high leaf area leads to high water use and therefore rapid drying of the soils post budburst. The rapid drying of the soils reduces the vigour of shoot growth. Smaller berries are also achieved, producing bunches that have an open structure. This leads to lower levels of bunch rot and ultimately better fruit quality.

Canopy management
Canopy architecture can be used to reduce bunch rots and is thus very important in our management strategies. Open canopy architectures can be achieved by reducing early season vigour, through the removal of soil moisture soon after bud burst and careful nutrition management. An open canopy allows the circulation of air around the bunches, aiding the removal of moisture that can lead to bunch rot.

Correct canopy management has been shown to be a key method of controlling Botrytis (Wolf and Zoecklin 1994). This is an area on which most emphasis is placed after chemical control, particularly as vineyards attempt to reduce chemical inputs. Smart and Robinson (1991) found an open canopy makes Botrytis control easier compared to a dense canopy. Clusters wet by rain or dew dry out more quickly, especially due to increased wind speed in open canopies compared to dense canopies. Since Botrytis has developed resistance to some chemicals it is important to reduce dependence on sprays by maintaining an open canopy. This is backed up by Emmett et al. (1994) who found that less Botrytis bunch rot developed when vine management produced small, loose, well-dispersed bunches and an open canopy.

Canopy management begins with choosing appropriate trellising systems for both vigour and economic efficiency. Smart-Dyson is used in those areas that have mid range vigour, while mid height Sylvvoz is used in areas that have greater vigour. These canopy architectures work well to produce exposed fruit when the system is used with careful trimming. Trimming is undertaken as close to fruit set as possible, to ensure the correct age of leaf during ripening. Poni and Intrieri (1995) found that trimming at this stage produced

We have used the perennial herb chicory to remove soil moisture in wetter areas. It has a deep root system providing competition to the vines. Research by Naylor et al. (1995) showed the increased competition places the vines under moisture stress, thus producing smaller berries. Bunches with smaller berries suffer less bunch rot, due to a reduction in berry rub. It has been shown that damage to the berry surface is a prerequisite for infection. There are many opportunities for damage to occur in the field, for example friction between berries and feeding by insects. A high spore numbers the chance of a spore encountering a damaged area would be increased (Warren et al. 2000). In bunches with bigger berries, very exposed fruit often has higher levels of bunch rot due to the bunches trapping more water from rainfall, and this leads to skin breakdown in the berries. Bunches that are less exposed often have less water trapped in them as the leaves surrounding bunches shed the rain away from the fruit. Paradoxically, better fruit exposure increases the bunch rot potential if berry size is too big.
leaves that are functioning at their peak during ripening. This helps the rapid accumulation of sugars during ripening.

Leaf removal is a widely used method of canopy manipulation. Leaf removal carried out during trimming is efficient and produces exposed fruit although for higher vigour varieties a specific leaf removal pass may still be required. Typically we undertake leaf removal as early as possible to ensure bunches are exposed for the greatest time possible during the growing season. The removal of leaves at an early stage also allows better spray coverage.

In our opinion there are no machines on the market at present that allow efficient leaf removal, whilst producing acceptably low levels of berry damage. Damaged berries provide infection points for bunch rots. Thus the minimisation and preferably complete prevention of damage must be a high priority for designers of such machines. Forced air is a vital element in any new design of leaf removal machinery to allow the removal of flower trash. Emmett et al. (1994) state that dead infected flower parts that become enclosed within the bunch are often a further source of infection.

Nutrition

Soils in the South-west are very old and nutritionally poor. Thus growers have had to apply appropriate fertilisers to ensure good vine growth. However, care is needed to avoid high nitrate levels that in turn lead to thin skinned, large berries. Phosphorus is very low across the South-west and correction of this problem to grow good fruit set is important. Better fruit set within bunches aids in keeping berry size to a minimum. Potassium is low in soils throughout the area and applications can help the ripening process by aiding in sugar accumulation.

Pruning

Pruning is integral for developing the appropriate canopy structure and reducing bunch rot inoculum sources. Spur pruning to decrease berry size is used widely and is achieved by the use of a barrel pruner followed by hand cleanups. Emphasis is placed on the removal of excess wood and old bunch stalks. The vines are pruned to achieve 40 buds upon the cordon. When extra buds are required, this is achieved by pulling down canes prior to pruning when mid-height Sylvoz is being used, or through downward pointing spurs for Smart-Dyson or Ballerina systems. The aim here is always to achieve target yields that are quick to ripen.

Fast ripening

It is important to set the target level of fruit at slightly more than required as a method of risk management. However, in many vineyards in the South-west of Western Australia, this frequently is not achieved and often growers overcrop. To prevent overcropping, fruit should be bunch-thinned at the end of the fruit set period. Leaving excess fruit after this stage, in an attempt to maintain small berries, creates difficulties with irrigation management and wastes vine resources that could be better utilised to promote rapid ripening of the fruit. Care needs to be exercised to ensure yield estimates are correct and that berry size is closely managed with irrigation.

Inoculum

A fire pruning, undervine areas are swept to ensure all bunch stalks are removed and mulched. This reduces the inoculum potential, which can have significant effects on the carry over of disease (Nair and Balasubramaniam 1995). We use a weed-free strip of 0.7 m under the vine, which is narrower than most vineyards in the South-west of WA. This allows a greater proportion of the vineyard floor to be covered with catch crops thus increasing water use. A fire budburst, as frost is not a risk, the cover crops are left to grow as high as comfortable for vineyard operations (typically 0.5 m high). The greater leaf area of high cover crops allows greater water use.

Despite excess water may have been a problem early in the season, later in the season the lack of water available to the vines becomes a problem. Thus once shoot growth has ceased and adequate stress applied to control berry size, it is important to ensure adequate moisture is available and the balance between fruit and leaf area is correct. Often South-west growers apply levels of water stress later in the season that does not allow the rapid accumulation of sugars in fruit. This is especially true in younger vineyards.

To avoid the wet weather late in the ripening period, which can lead to bunch rots, fruit ripening must occur quickly. In our vineyards, it is our experience that supplying water by deeper irrigation prior to veraison provides a bank of soil moisture, ensuring no stress occurs during veraison. This gives the fruit a 'flying start' to ripening and ensures rapid accumulation of sugars despite the weather.

Pest management

Integrated pest management is also very important in the successful control of bunch rots. Wingless grasshoppers (Phalacridium vitatum), helleloths (Heliochorema punctiga), South African garden weevil (Phyllophaga callosus), and birds, particularly the silvereye (Zosterops lateralis), all damage berries and provide open infection sites for bunch rots. Pest control, including the method of control throughout the growing season, becomes vital. The use of synthetic pyrethroids to control weevils, grasshoppers and helleloths has produced secondary pest outbreaks of long-tailed mealybug (Pseudococcus longispinus), two spotted mites (Tetranychus urticae) and rust mites (Calepitrimerus vitis), all of which either directly lead to bunch rots or slow fruit ripening thus increasing the risk of such rots. The bird pest mating, whilst only reducing bird damage, restricts the ability of growers to apply chemical controls to bunch rot. It also intercepts valuable sunlight that helps photosynthesis and the drying of canopies after rain events.

An integrated solution is required to manage these pests. The use of insecticides was making bunch rots worse as it increased levels of secondary pests. These pests often appear too late for chemical control as the chemicals used have long winery withholding periods. Thus the use of poultry such as chickens and guinea fowl is becoming more accepted as growers attempt to find non-chemical methods of control. The poultry graze the vineyards removing enough vine pests to put damage below acceptable thresholds. This eliminates the need for chemicals that may lead to secondary pest outbreaks. This is also aided by the integration of a careful choice of cover crop as certain plant species, such as ryegrass, have been shown to promote the reproduction of pests such as garden weevil (Learmonth, pers. com.).

Chemical control

Chemical control of bunch rots in the South-west is integral to the production of quality fruit. Chlorothalonil is used early to control leaf Botrytis and shoot collapse. The weather at flowering in the South-west is often cool, leading to an extended flowering period. Thus growers often need to apply chemicals repeatedly during flowering to ensure protection of inflorescences. Chlorothalonil is often sprayed at early flowering to give protection to the inflorescences.
Benzimidazoles are used at mid-flowering and if conditions are particularly wet, and Scala® is used at 80% capfall. Prior to bunch closure a dicarboximide spray is applied. This may be applied again if there are late season outbreaks of bunch rot. Potassium metabisulphate or sodium metabisulphate is applied after late season rains to dry up split berries and prevent bunch rot establishing.

We have found multi-head spray equipment (where the heads are directed at the fruit zone) to be very effective when combined with water rates of up to 1000 L/ha. This ensures adequate coverage. As control of bunch rots is vital during the flowering period, the use of predictive computer models to give an indication of the likely severity of disease pressure later in the season can also be important. Automated weather stations can provide insights into leaf wetness at flowering and other factors that may influence the likelihood of infection. This information can then be used to guide spray decisions later in the season.

Research from many sources suggests that a high level of protection from bunch rot can be achieved with applications of appropriate chemicals. However, growers across the South-west of Western Australia are reporting that chemical application is causing an increase in bunch rot problems. This is particularly the case with the use of dicarboximides close to harvest.

Last season, in one Great Southern vineyard, vines within a block were divided into two sections. One section was inoculated with Botrytis to produce a dessert wine after which no fungicides were applied for the control of bunch rots. The other half was given a normal fungicide program and had extra sprays applied to provide protection against the expected Botrytis in the vines nearby. However, bunch rots were more severe in the non-sprayed vines compared to the inoculated vines. Thus the vines inoculated with Botrytis were harvested for dry wine and the sprayed vines became the dessert wine. New Zealand growers report similar experiences.

This suggests that control of Botrytis is being achieved, and it is other fungi such as Penicillium spp., and Alternaria that are causing the bunch rot problems. Or is disease being promoted by the application of chemicals in some other manner? These questions are becoming more commonplace with growers in the South-west of Western Australia.

The South-west of Western Australia regularly experiences problems with bunch rot due to rainfall late in the ripening period. The successful management of bunch rot requires integrated approaches to all aspects of vineyard management. Pest, nutrition, irrigation and canopy management in conjunction with chemical application all play an important role in the control of bunch rots.

Growers must produce fruit free of bunch rot that is acceptable to winemakers, their customers. Growers must develop integrated management systems to ensure resistance development is slowed, secondary pest problems are not promoted and all at a reasonable price.

References