AWRI Australian Wine Research Institute

Fact Sheet
VITICULTURE

Managing waterlogged vineyards

Introduction

Waterlogging of vineyards occurs when the root zone around the grapevine becomes saturated and the air between the soil particles is replaced by water. Grapevine roots require oxygen for respiration and a lack of oxygen over an extended period can result in root death and eventually vine death. The absence of oxygen in the soil and around the roots triggers a cascade of physical, biological and chemical processes, the results of which can also have a negative effect on vine performance.

Causes of waterlogging

Waterlogging can result from heavy localised rains, flood waters slowly flowing across the landscape, the rising of a water table, or a combination of all three. Whatever the cause, the duration and timing of the waterlogging are important to consider. The persistence of waterlogging is influenced by local topography and the drainage properties of the soil. Hard, compacted soils and soils with shallow impermeable layers are particularly prone to waterlogging. Compaction is generally more of an issue in soils with a high clay content, especially sodic soils with high sodium:calcium ratios.

Effect of waterlogging on soil

One of the most important physical changes in waterlogged soils is the restriction of gas diffusion in and out of the soil, leading to depletion of soil oxygen levels and accumulation of carbon dioxide. This increases the reduction potential of the soil and changes the chemical equilibrium of many elements. This can cause transient toxicities of some soil nutrients (e.g. iron and manganese) that are normally safe when soil is freely drained.

The anaerobic conditions also increase denitrification, a process where soil bacteria convert plant-available soil nitrate into nitrogen gases that are lost from the soil. Denitrification removes valuable nitrogen from the soil and releases this nitrogen as the greenhouse gas nitrous oxide and the pollutant nitric oxide into the atmosphere. Along with denitrification, nitrogen is also lost from waterlogged soils through leaching and also due to a reduction of nitrogen fixation by the nodules of leguminous cover crops. Potassium and boron are also prone to leaching in waterlogged soils.

Under anaerobic conditions, the breakdown of soil organic matter may also produce methane, a greenhouse gas, and ethylene, a gas that affects plant growth and development. Ethylene can disrupt flowering, reduce shoot growth, initiate fruit ripening, trigger leaf and flower senescence and abscission and cause leaf chlorosis (yellowing).

Waterlogging can also cause changes in soil pH, which can then affect the availability of some nutrients. In acid soils, anaerobic conditions can cause the loss of hydrogen ions from the system, resulting in a rise in soil pH, while in alkaline soils, the build-up of carbon dioxide tends to drop the soil pH. Generally, soils tend towards neutrality upon waterlogging. Phosphorus and molybdenum can increase in availability under neutral conditions while zinc tends to become less available.

Waterlogging is also known to exacerbate the impact of salinity. Salts in the subsoil are moved into surface soils and the rootzone area by flooding and rising water tables, becoming highly concentrated and causing damage to vine roots as the soil dries.

Finally, heavy rain and flooding can cause some soils to become compacted and form a surface crust. This is especially true for sodic soils and those with a high clay content. Waterlogged, non-dispersive soils can also become compacted when trafficked by machinery or livestock.

Effect of waterlogging on vines

Symptoms of waterlogging stress include wilting, chlorosis and marginal necrosis of leaves, reduced/inhibited shoot growth, dieback of new root tips and reduced regeneration of new active feeder roots. In grapevines, the periods of active root growth, between flowering and veraison and after harvest, are very sensitive to waterlogging. If waterlogging occurs and recedes before budburst, no significant difference in vine growth occurs. However, if waterlogging persists, root and shoot growth will be affected.

When plants are growing actively, root tips begin to die within a few days of waterlogging. The restricted root system that then develops limits the uptake of nutrients, particularly nitrogen, and water. The uptake of other nutrients such as phosphorous and calcium can also be inhibited. Root damage from waterlogging also affects the ability of vines to keep sodium and chloride out of the roots so the vines end up accumulating more salt than normal.

Short periods of waterlogging, where water disappears in one or two days, usually have little impact on vine health. However, when waterlogging persists for a longer period, issues may arise. Pot experiments have shown vines will tolerate 3 to 7 days of soil waterlogging before showing signs of reduced growth, while longer periods of intermittent waterlogging (3 days of waterlogging every 14 days for 18 weeks) significantly reduced total vine growth.

The reduced accumulation of nutrients by vines under waterlogged conditions may have an impact on yield in the current season, as well as in the following season. If waterlogging persists up to the time of flowering, flowering and fruit set can be disrupted – anthers become irregular, filaments fail to elongate normally, ovaries appear enlarged, pollen germination is low, and growth of pollen tubes is weak.

In situations where waterlogging has been caused by flooding, the movement of flood water across a vineyard can cause additional issues such as increased weed seed distribution, damage to vineyard infrastructure, the flattening of vines, the accumulation of debris, disturbance of compost and mulch, and the erosion of topsoil from run-off. Flood waters can also deposit a fine clay layer or crust on top of the soil, which may prevent oxygen and water penetration.

Factors affecting grapevine susceptibility to waterlogging

Rootstock

While grapevines are relatively more tolerant of waterlogged conditions than many fruit trees, some grape rootstocks are quite susceptible to waterlogging and associated root rots such as *Phytophthora* spp., *Armillaria* spp., *Pythium* spp. and *Cylindrocarpon* spp. (Table 1).

Table 1. *Susceptibility of different rootstocks to waterlogging and root rots (Hoskins et al. 2003, Dimsey et al. 2011)*

101-14	Schwarzmann	3309	3306	Riparia Gloire	Richter 99	Ungrafted
Very prone to root diseases, particularly *Cylindrocarpon* spp., on clay or in waterlogged soils.	Most tolerant to waterlogging and moderately tolerant to fungal root rots.	Poor tolerance to waterlogging but susceptible to Phytophthora and other root rots	Moderately tolerant to waterlogging but susceptible to Phytophthora and other root rots.	Moderately tolerant to waterlogging and not particularly susceptible to fungal root rots.	Poor tolerance to waterlogging.	Most tolerant to waterlogging.

Grapevine cultivar

Grapevine cultivar also has an influence on tolerance to waterlogging. In a study comparing the susceptibility of seven grapevine cultivars (all grafted onto 110-Richter) to eight days of flooding, significant differences were reported. All cultivars experienced a reduction in water uptake and an increase in water stress in response to waterlogging. Photosynthetic rate and stomatal conductance were reduced in all cultivars after three days of flooding, but they recovered as soon as the flood was withdrawn. Shoot elongation was reduced compared to the control in Cabernet Sauvignon, Sauvignon Blanc and Tempranillo, while Alicante Bouschet was only minimally affected by short-term flooding.

Monitoring

The full impact of waterlogging will not be apparent for some time after the initial event, so ongoing monitoring is important to manage vine health and identify issues. Waterlogging may continue even after surface water has dissipated, particularly in clay soils and soils with a shallow impermeable layer below the surface soil. Digging a hole or installing a test well can help monitor the water table depth and hence the degree of waterlogging. Areas remaining waterlogged for several weeks need to be identified for remedial action in the future (e.g. by installing drainage). Obvious symptoms of root rots may take up to a year to develop in older vines.

Vines should also be monitored closely for the presence of root rots, including *Phytophthora* spp., *Armillaria* spp., *Pythium* spp. and *Cylindrocarpon* spp. Vines suffering from sudden vine decline and death may be suffering from root rots. Digging up the vines to inspect the roots may help to diagnose the issue, but diagnosis through a plant pathology laboratory, such as SARDI (Adelaide) or Crop Health Services/AgriBio (Melbourne), may be necessary to identity the causal pathogen/s. Vines infected with root rots should be completely removed from the vineyard as soon as possible, making sure all root material is removed.

Remediation

To minimise the impact of waterlogging on vineyards, water should be encouraged to drain away, or be pumped from the vineyard as soon as possible. Where possible, a spoon drain dug in the centre of the traffic line will help promote surface drainage. Where flooding is landlocked, a sump can be dug to assist pumping. A permanent sward in the vineyard will assist with the drying process.

It is important not to drive on the vineyard while the soil is very wet to avoid soil compaction. Low flotation tyres are available which can be fitted to tractors and spray units to reduce the risk of compaction. Where vine roots have been damaged by waterlogging and root rot, irrigation should be scheduled carefully to allow for the reduced root uptake and avoid water stress in the vines once the water has drained away. Adding nitrogen soon after waterlogging recedes will ensure nitrogen is available to the crop at the time it needs it. Additional potassium and boron applications may be needed to replace the nutrients leached from the soil.

An organic mulch (e.g. straw), spread undervine will reduce crusting and improve water penetration, aeration and drainage of the soil profile. Manure and organic mulches applied undervine can encourage beneficial fungi to thrive which may be antagonistic to root rots. Sowing a cover crop or permanent sward will assist in replacing organic matter and improving soil structure and aeration. Cereals and grasses with fibrous root systems, such as cereal rye, triticale, annual rye grass, perennial rye grass and tall fescue, improve soil structure, soil organic carbon levels and water infiltration rates and reduce soil erosion.

Vines should be monitored closely for increased presence of fungal diseases. Many diseases, especially *Botrytis* and downy mildew, are more active in wet, humid conditions. Prolonged waterlogging may also cause issues with trafficability, making it difficult to conduct vineyard operations such as canopy spraying, trimming and leaf plucking, further exacerbating the risk of disease. Effective spray programs, particularly around flowering, are important to minimise crop loss to disease pressure. Cultural management techniques such as crop thinning, leaf plucking, and trimming can help to minimise the risk of disease. Helicopters have been used by some growers to apply canopy sprays when trafficability is severely reduced; however, this is an expensive option that is unlikely to be widely available.

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