Waterlogging occurs whenever the soil is so wet that there is insufficient oxygen in the pore space for plant roots to be able to adequately respire. Other gases detrimental to root growth, such as carbon dioxide and ethylene, also accumulate in the root zone and affect the plants.

Plants differ in their demand for oxygen. There is no universal level of soil oxygen that can identify waterlogged conditions for all plants. In addition, a plant’s demand for oxygen in its root zone will vary with its stage of growth.

Symptoms and causes
Lack of oxygen in the root zone of plants causes their root tissues to decompose. Usually this occurs from the tips of roots, and this causes roots to appear as if they have been pruned. The consequence is that the plant’s growth and development is stalled. If the anaerobic circumstances continue for a considerable time the plant eventually dies.

Most often, waterlogged conditions do not last long enough for the plant to die. Once a waterlogging event has passed, plants recommence respiring. As long as soil conditions are moist, the older roots close to the surface allow the plant to survive. However, further waterlogging-induced root pruning and/or dry conditions may weaken the plant to the extent that it will be very poorly productive and may eventually die.

Many farmers do not realise that a site is waterlogged until water appears on the soil surface (figure 1). However, by this stage, plant roots may already be damaged and yield potential severely affected.

Waterlogging occurs when the soil profile or the root zone of a plant becomes saturated. In rain-fed situations, this happens when more rain falls than the soil can absorb or the atmosphere can evaporate.

Western Australia’s ‘Mediterranean’ climate of cool and wet winters and hot dry summers produces more rain than the atmosphere can evaporate every winter. The amount of ‘excess’ rain is particularly large in the higher rainfall areas of the south-west.

Cost of waterlogging and inundation
Most data on the cost of waterlogging and inundation are from the Upper Great Southern (see McFarlane et al., 1992), although the problems are widespread. Cereal crop yields decrease by about 150 kg/ha for every 10 mm of rainfall in excess of the decile 5 rainfall during August in the Upper Great Southern. In the same study it was calculated that over a 10 year period in eight shires from that region, excess rainfall costs farmers about 14% in lost wheat production each year.

Waterlogging and inundation slow pasture growth in winter and delay the spring flush. Pasture growth in winter is at least five times more valuable than extra production in late spring. Waterlogged legumes grow more slowly than waterlogged grasses, so waterlogged pastures become grassy and weedy.

In wet years, waterlogging reduces the area that can be cropped. When paddocks are waterlogged shortly after seeding, germination and emergence are often reduced; and crops may have to be re-sown when the soil is firm enough to support machinery.

Waterlogged and inundated areas contribute recharge to

Key points

- Waterlogging occurs when roots cannot respire due to excess water in the soil profile.
- Water does not have to appear on the surface for waterlogging to be a potential problem.
- Improving drainage from the inundated paddock can decrease the period at which the crop roots are subjected to anaerobic conditions.
- While raised beds (see Raised Beds fact sheet) are the most intensive management strategy, they are also the most effective at improving drainage.

Figure 1: Waterlogging in a crop grown on a duplex soil in early winter, 1997, along the Esperance South Coast.
saline aquifers, are very susceptible to water erosion and are prone to soil structure decline if cultivated or stocked when too wet.

**Identifying problem areas**

The best way to identify problem areas is to dig holes about 40 cm deep in winter and see if water flows into them (figure 2). If it does, the soil is waterlogged. Digging holes for fence posts often reveals waterlogging.

Some farmers put slotted PVC pipe into augered holes. They can then monitor the water levels in their paddocks. Symptoms in the crop of waterlogging include:

- Yellowing of crops and pastures.
- Presence of weeds such as toad rush, cotula, dock and Yorkshire fog grass.

![Figure 2: Waterlogged duplex soil—sandy loam topsoil overlying a sandy clay subsoil at 30 cm. Seepage is entering the hole above the clay base.](image)

**Effects on plant growth**

Low levels of oxygen in the root zone trigger the adverse effects of waterlogging on plant growth. Waterlogging of the seedbed mostly affects germinating seeds and young seedlings. Established plants are most affected when they are growing rapidly. Therefore, if a soil becomes waterlogged in July, final yields may not be greatly reduced; soils are cold, the demand for oxygen is low and plant growth is slow at this time of year. Prolonged waterlogging during the warmer spring period could be more detrimental, however the probability for this to occur is much lower than waterlogging in July.

When plants are growing actively, root tips begin to die within a few days of waterlogging. The shallow root systems that then develop limit the uptake of nutrients (particularly nitrogen) and water, particularly when the soil profile starts to dry in spring. As a result plants may ripen early and grains may not fill properly.

Nitrogen is lost from waterlogged soils by leaching and denitrification (degassing). These losses, together with the lowered ability of plants to absorb nutrients from waterlogged soil, cause the older leaves to yellow. Waterlogging also directly reduces nitrogen fixation by the nodules of legume crops and pastures.

**Solving waterlogging**

Drainage can be improved on many sites and is the first thing to consider once a waterlogging problem has been identified. Options might vary from shallow surface drains (i.e. Spoon- and 'W'-drains) to more intensive drainage using wide-spaced furrows, to the intensive drainage form of raised beds (see Raised Bed Cropping fact sheet). The efficiency of surface drainage increases in that order as does the degree of management. Consult your local adviser for further advice.

**Further reading and references**

Belford R and McFarlane D (1993) Managing waterlogging and inundation in crops. Department of Agriculture and Food, Western Australia. Farmnote 80/93 (online)


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