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Causes of waterlogging

Jim Cox

Don McFarlane

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By **Jim Cox**[1] and **Don McFarlane**[2]

[1] Research Officer, Water Authority of Western Australia, Perth

[2] Research Officer, Division of Resource Management, Department of Agriculture, Albany

Waterlogging is highly variable, both between years and within paddocks. This results in uncertainty as to whether a paddock should be cropped in a particular year, and whether different management should be used on waterlogged areas within a paddock

A study has determined what are the most important causes of waterlogged soils.

The most susceptible sites have a combination of low permeability subsoils and thin topsoils (also with a low permeability). They are on low slopes and downslope of an area that sheds water. Such sites waterlog even in years of low rainfall.

Profiles of waterlogged soils often have a mottled appearance which can be seen at any time of the year.

Waterlogging (brown areas) is affected by several factors which vary throughout the landscape.

Why waterlogging is so variable

Waterlogging is caused by a combination of excess rainfall (for the site), poor external drainage (runoff), poor internal drainage (water movement in the soil profile) and the inability of the soil to store much water.

We studied the relative importance of these causes at Narrogin and Mt Barker to determine how to predict and manage waterlogging. The results are summarised under three sections: rainfall, soil type and landforms.

Rainfall

Narrogin

The 1985 growing season (May to October) rainfall of 356 mm was less than the average seasonal rainfall of 397 mm. The average waterlogging intensity measured in 107 shallow wells was about 300 cm.days which is equivalent to a water level at the soil surface for 10 days. (See 'How we measured waterlogging intensity' on page 59.) About half of the wells had little or no water within 30 cm of the surface, while three had more than 1,000 cm.days of waterlogging (equivalent to 33 days with the water level at the soil surface).

Growing season rainfall in 1986 was only 267 mm (130 mm below average). Sixty per cent of the wells had little or no waterlogging. However, even in this dry year four wells had more than 700 cm.days of waterlogging (equivalent to 23 days with the water level at the soil surface).

This is a common feature of waterlogging; susceptible areas are waterlogged even in dry years. These areas lower the overall yield of paddocks whenever they are cropped and therefore need separate management, either drainage or they should be left uncropped.

How we measured waterlogging intensity

Duplex soils (sandy topsoil over a clayey subsoil) are the most common soil type in the agricultural areas. Water perches on the clay subsoil in these soils and saturates the root zone of plants from below.

When measuring waterlogging intensity we need to know how close to the soil surface these perched water levels rise, and how long the water levels stay close to the surface. We also need to know at what time of the year soils waterlog relative to the growth stage of the crop.

In this study we measured waterlogging intensity by summing the daily values (in centimetres) of groundwater levels within 30 cm of the soil surface (Figure 1). Therefore, three days with the water level 20 cm from the surface (10 cm above the 30 cm threshold) has a waterlogging intensity of 30 cm.days (3 days x 10 cm). This is equivalent to one day with the water level at the soil surface (1 day x 30 cm). This method of measuring waterlogging intensity is called the SEW_{30} index (sum of excess water above 30 cm).

Perched water levels in the soil fluctuate rapidly in response to rainfall (Figure 1). Once soil profiles are wet, small amounts of rain cause the levels to rise markedly. These fluctuations in water level influence crop growth.

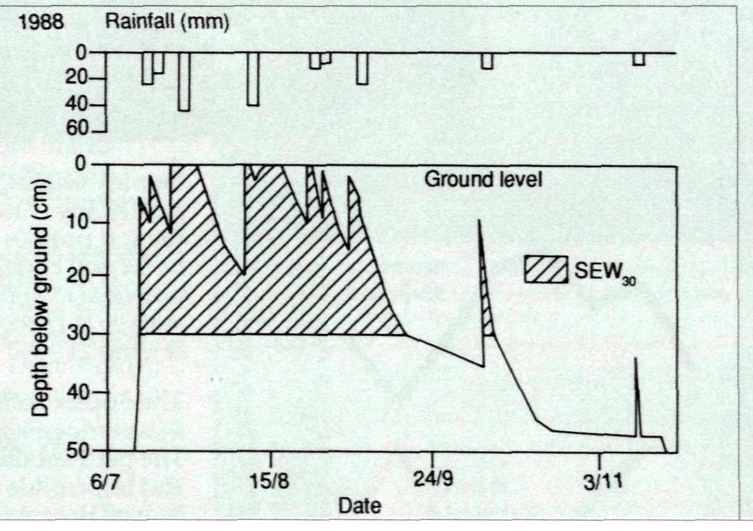


Figure 1. Perched water levels in the soil fluctuate rapidly in response to rainfall. The shaded area is the SEW_{30} index which is a measure of waterlogging intensity.

Mt Barker

Average growing season (May to October) rainfall at Mt Barker is higher (470 mm) than at Narrogin (397 mm). The seasonal rainfall in 1984 was 532 mm which resulted in widespread waterlogging as recorded by 55 shallow wells. The average waterlogging intensity was 1074 cm.days (equivalent to 36 days with the water level at the soil surface).

Some wells recorded more than 2,500 cm.days of waterlogging (equivalent to more than 80 days with the water level at the soil surface).

In 1986, the seasonal rainfall was slightly below average (442 mm) but the average waterlogging intensity was still high (665 cm.days). This is equivalent to 22 days with the water level at the soil surface.

The proportion of wells with hardly any waterlogging changed little between 1984 and 1986, indicating that some areas are not prone to waterlogging, even in wet years. Some areas appear to be so prone to waterlogging that they cannot be drained effectively, while others will not become waterlogged even in very wet years.

The likelihood of waterlogging can be assessed from rainfall data if the previous history of waterlogging at a site is known. A method is outlined in McFarlane (1985).

Soil type

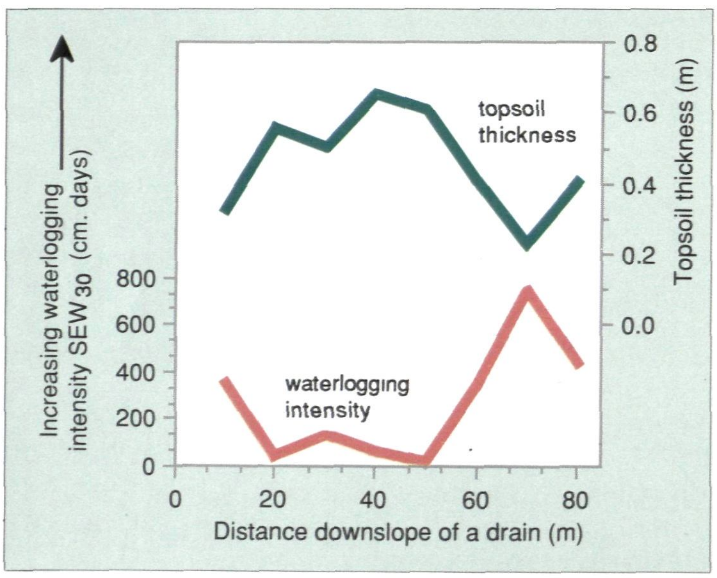
The two types of soil most susceptible to waterlogging are duplex and heavy textured (clayey) soils, particularly when these soils occur on low slopes.

The sandy surface of duplex soils enhances water infiltration while the clay subsoil can inhibit drainage within the profile. Sandy topsoils store less water and lose less water by evaporation than do clayey soils.

Clayey soils are waterlogged when the water ponds on the surface and saturates the soil profile from the top downwards, whereas duplex soils saturate from the clay subsoil upwards.

Duplex soils are very susceptible to waterlogging. The soil saturates from the clay subsoil up to the surface.

Figure 2. As the thickness of the topsoil decreases, waterlogging intensity (as measured by the SEW_{30} index), increases.



Duplex soils at Narrogin and Mt Barker store hardly any water. After the break of the season, the soil profiles were saturated to within 30 cm of the soil surface once rainfall exceeded potential evaporation by only 50 mm. Water storage is highest in soils with a thick topsoil (Figure 2).

The duplex soils which were most susceptible to waterlogging had less permeable subsoils. The permeability was found to be very variable and impossible to predict. Some subsoils may be well drained where old root channels open up the clay subsoil (Figure 3).

Waterlogging was also more common in duplex soils with less permeable topsoils which result in slow downslope drainage (on top of the subsoil).

Landforms

The article 'The extent and cost of waterlogging' on page 44 of this Journal showed that floodplain areas were most susceptible to waterlogging, followed by sloping landforms with duplex soils. This section looks more closely at which landforms in individual paddocks are most susceptible to waterlogging.

Slope

At Mt Barker waterlogging was extreme in areas with little slope. Areas with a slope of 5 per cent had no waterlogging in years with between 350 and 485 mm of rainfall. In contrast, areas with only 0.8 per cent slope had about 2,000 cm.days of waterlogging in a high rainfall year. This is equivalent to 67 days with the water level at the soil surface.

A mottled soil indicates seasonal waterlogging. This photo was taken in the Katanning area.

High slopes increase the amount of rain that runs off, particularly when the soil is saturated to the surface and rain cannot infiltrate. High slopes also increase the amount of lateral seepage in the soil. However, the topsoils need to be fairly permeable for this to be important.

Length and shape of the slope

Immediately after heavy rain many duplex soils will be saturated because of their low storage capacity.

As the perched water moves downslope, a drying front develops in areas where there is no inflow from above (for example, at the top of slopes and downslope of drains).

The front may take weeks to reach the bottom of slopes, in which time more rain may have resaturated the soil profile. Areas towards the bottom of long slopes are therefore highly prone to waterlogging because of the prolonged inflow of seepage water from upslope.

The shape of the slope is important. Concave ('amphitheatre-shaped') slopes concentrate seepage waters and result in the most severe waterlogging. Waterlogging is also common where slopes decrease abruptly. Drains can prevent waterlogging in both cases.

How we can recognize sites liable to waterlogging

There are a number of indicators of waterlogging:

- The presence of weeds such as toadrush, *Phalaris* species and dock that tolerate waterlogging, and a predominance of grasses over broad-leaf plants.
- The absence of waterlogging sensitive species such as clovers, apart from the yanninicum subspecies (Yarloop group) and white and strawberry clovers.
- The presence of red, yellow or blue-grey mottles (areas with different colours) in the soil profile. Some mottles are the result of waterlogging in a past climate.
- Combinations of the soil and landscape features identified above: shallow, low permeability topsoil; low permeability subsoils; below water shedding areas or long slopes; low slopes; concave slopes.

Acknowledgements

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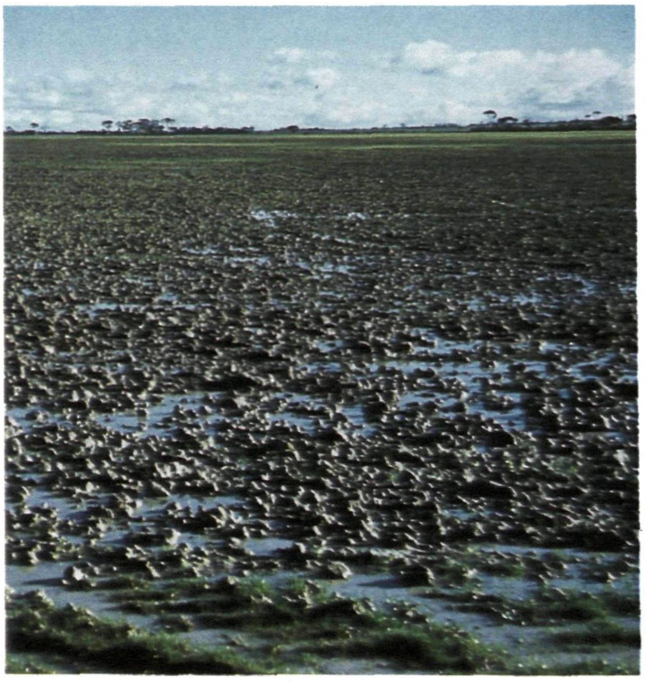

Clayey soils are also highly susceptible to waterlogging. The soil saturates from the top down in contrast to duplex soils which saturate from the clay subsoil upwards.

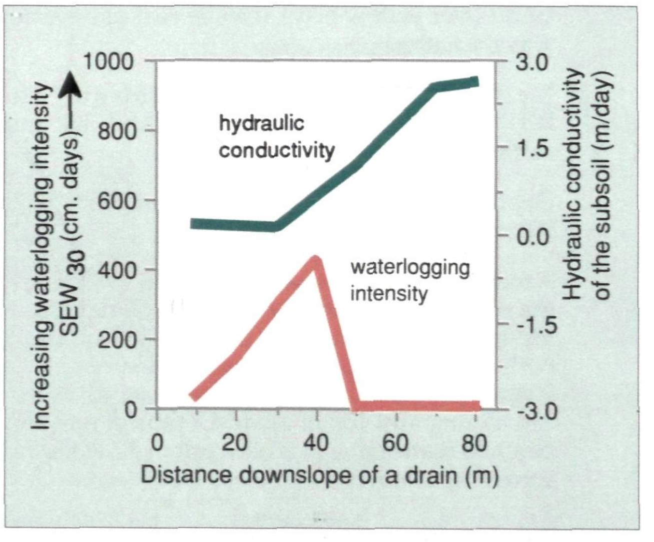

Figure 3. The change in waterlogging intensity (SEW_{30} index) below a drain. For the first 40 m below the drain waterlogging increases. After 40 m there is no waterlogging because the subsoil is highly permeable (as measured by its hydraulic conductivity).

Further reading

McFarlane, D.J. (1985). Assessment of waterlogged sites. *J. Agric. W. Aust.* 26(4): 119-121.