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Assessment of waterlogged sites

By D. J. McFarlane, Research Officer, Soil Conservation Branch

Soil is said to be waterlogged if any part of the plant root zone is saturated with water. In severe cases soil is saturated to the surface and waterlogging is obvious. Waterlogging is distinguished from flooding in which surface runoff brings down water from higher up in a catchment. However, flooding may result in waterlogged sites.

Problems of waterlogging

Waterlogged land can cause farmers problems at various times of the year.

On some paddocks, because of bogging, farmers may not be able to sow a crop, though direct drilling may lessen this problem. The crop may then not germinate properly. They may have to sow the crop earlier than usual to avoid waterlogging during germination, or delay seeding, which results in decreased yields because of a shortened growing period. Areas of poor or uneven seed germination may have to be re-sown.

Boggy soils during seeding can damage machinery, and the erosion rills and wheel ruts left in the soil surface can cause header damage at harvest. Soil structure can also be destroyed, particularly when heavy-textured soils are worked when they are too wet.
Waterlogging can cause severe runoff and soil erosion problems because the saturated soil cannot absorb any more incoming rainfall. In waterlogged paddocks weed control may be poor because of inadequate ground-based spraying, or there may be a need for costly aerial spraying. With some herbicides, weeds must be actively growing for the chemical to be effective. Where the chemical is absorbed through the roots, weed control is less effective under waterlogged conditions.

Other problems associated with waterlogging include a possible nitrogen deficiency in the growing crop because of the biological breakdown of nitrate in the soil, shallow-rooted crops, and the likelihood of early ripening and pinched grain if there is a dry end to the season. Crops in mildly saline areas may be lost because plants usually tolerate mild salinity or mild waterlogging, but rapidly fail if both occur together.

Farmers with persistently waterlogged paddocks must expect overall decreased yields or be forced to plant lower-priced crops more tolerant of waterlogging, such as oats.

**Waterlogging and yield**

Waterlogging can significantly reduce crop yields during wet years.

Negus (1983), in a comparison of 1974 wheat crop data with the averages for 1962 to 1980, estimated that more than $14 million was lost in Western Australia's Kondinin Shire during the wet year 1974 as a result of a 27 per cent decrease in the area sown and a 13 per cent decrease in crop yield. In the Narrogin Shire there was a 16 per cent decrease in the area sown and a 25 per cent reduction in yield in 1974.

Some of these yield losses in 1974 would have been caused by fungal diseases and nitrogen leaching from the plant root zone. The estimates of decreased area sown and crop yield are conservative as there would have been some waterlogging during the years with which 1974 was compared.

**Waterlogging influences**

The main influences on waterlogging are rainfall, soil type and topographical position.

**Rainfall**

Reeves (1984) has shown that in areas in Western Australia with average annual rainfall exceeding about 500 millimetres, wheat yields decrease with additional rainfall. In areas with average annual rainfall of less than about 400 mm, wheat yields increase with more rainfall.

Rainfall information can be used to estimate how frequently waterlogging will be a problem. Figure 1 shows the probability of areas with different average annual rainfalls receiving at least 400 and 500 mm in any one year. Thus, for an area with an average annual rainfall of 400 mm, there is a 50 per cent probability (one year in two) of receiving at least 400 mm in any one year, but less than a 20 per cent probability (one year in five) of receiving 500 mm or more. However, an area with an average annual rainfall of 600 mm has a 97 per cent probability of receiving at least 400 mm and an 82 per cent probability of receiving at least 500 mm. If crop yield losses can be expected after more than 500 mm of rain in this area, such losses can be expected in four years out of every five.

The use of annual rainfall data may not be the best way of assessing waterlogging risks since it is not necessary to have more than 500 mm of rain a year to experience waterlogging. Some soil types or areas may become waterlogged during years of average or even below average rainfall. However, it is possible to predict the frequency of waterlogging of any particular site from a few years' observations, if it is assumed that the two wettest months of the year are the most critical for waterlogging problems.

Figure 2 shows the probability of receiving between 100 and 250 mm of rainfall during the two wettest months of the year, given the average rainfall during these two months. For example, in an area where 150 mm can be expected on average during the wettest months of June and July, there is about a one year in five chance (20 per cent probability) of receiving 200 mm.

If an area does not waterlog when 150 mm is received during June and July, but does waterlog with 200 mm, it may be assumed that 175 mm is a critical amount. This has a one year in three chance (33 per cent probability) of occurring in that area.

Before a decision can be made on whether to drain an area, the frequency of waterlogging and of cropping and the costs and benefits of drainage, should be known. If there is a 30 per cent probability of waterlogging and an area is cropped every second year, there is a 15 per cent probability (one year in seven) of waterlogging during a cropping year (that is, 0.3 x 0.5 = 0.15). If the area is cropped every third year, the probability decreases to 10 per cent or one year in ten (0.3 x 0.33 = 0.10). The costs and benefits of different drainage methods are discussed in "Drainage to control waterlogging" on page 122.

**Soil types**

The most important soil properties which influence the likelihood of waterlogging are the soil's ability to store water and its ability to allow water to drain away.

Heavy textured (clay) soils store more water than light textured (sandy) soils, but they drain slowly and generally waterlog after prolonged or...
intense rainfall which does not run off. Clay soils occupy about 11 per cent of the State’s agricultural area.

Light textured soils drain rapidly. They only waterlog if they are underlain by a clay sub-soil or a shallow watertable which prevents drainage and limits the amount of water that can be stored in the soil profile. These sand over clay or duplex soils comprise about 37 per cent of the agricultural area. Sandy topsoils encourage infiltration and inhibit evaporation in comparison to clay topsoils, so that duplex soils have several features which predispose them to waterlogging.

Hillel and Talpaz (1977) have estimated the water storage efficiency of different soil profiles (Table 1). The storage efficiency is the percentage of rainfall that does not run off, drain below the root zone or evaporate from the soil surface. Table 1 shows that sand over clay soils have the highest storage efficiency for the soil types considered and for a particular set of rainfall conditions (144 mm in two storms over a 10-day period). Soils with a high storage efficiency are more susceptible to waterlogging.

When rain infiltrates into a duplex soil faster than soil water seeps through the clay sub-soil, a saturated layer forms where the sand meets the clay. If the duplex soil occurs on a hill slope, this groundwater will flow downslope within the soil profile, gradually soaking through the clay sub-soil. This lateral flow has been called throughflow, interflow or shallow seepage flow. Waterlogging can occur where the topsoil becomes thin or less permeable, or has an insufficient slope to move the groundwater.

Waterlogging is also common if the groundwater becomes concentrated on concave hill slopes.

**Topography**

Rainfall distribution over a low hilly landscape is usually relatively uniform. However, runoff during and after rain, and seepage flow in the soil between rainfall events, results in water accumulating in low-lying areas. If heavy textured soils occur in these areas, slow drainage prolongs the waterlogging problem.

Duplex soils are found over much of the agricultural area. Their susceptibility to waterlogging means that saturated soils occur in areas other than in valley floors.

A knowledge of soil type and topography, therefore, helps farmers make decisions about the best types of drainage for an area and the likelihood of a drainage system working. For instance, it is often easier to drain duplex soils on a hill slope than heavy textured soils in valleys. If low infiltration rates are a problem, surface waters must be drained or infiltration rates increased by the use of gypsum or minimum tillage. Drainage of sub-surface waters will be necessary when a shallow watertable causes waterlogging.

**Sources of water**

The water in waterlogged areas comes from various sources:

- On flat land the water may come mainly from rain infiltrating where it falls (that is, local water).
- In soils located downslope of water-shedding areas (for example, rock outcrops, roadways, non-wetting soils) or in flood plains, the water may come from runoff from much further up the catchment.
- In areas with duplex soils, the water may come from shallow seepage from further up the hillslope.
- Saline seepage from deeper groundwater systems which are under pressure may contribute to a waterlogged area.

**Information needed**

When a waterlogged site is assessed for drainage, the following information is needed:

- What is the probability of waterlogging in any one year or at a critical time, such as at germination?
- What is the cropping frequency?
- What, therefore, is the probability of waterlogging during a cropping year?
- What is the soil type and topography and how does this influence the likelihood that drains will work?
- Is the source of the water rain infiltrating where it falls, runoff, shallow or deep seepage?
- Are the benefits of drainage likely to be greater than the costs or would it be best to only use the site for pasture?
- What is the best drainage system for the site?