Department of Primary Industries

primefact

Soil management – drought recovery

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This Primefact outlines the impacts of drought on soil and strategies to help preserve and manage soil when drought breaks. The information in this Primefact complements that contained in the comprehensive document NSW DPI Drought recovery Guide.

Drought recovery checklist

- Check soil nutrient status and add fertiliser if safe to do so
- Consider options to improve hard setting surface soil including soil ameliorants and green manure crops
- Consider herbicide residues to avoid plant back
- Consider growing period left for crop or pasture
- Inoculate legumes with the correct rhizobia strain when resowing pastures or pulses
- Check if weeds are impacting growth of crop or pasture & decide on management
- Seek professional advice for crop or pasture options suitable for your farm

A. What effect does drought have on the soil?

Drought can have dramatic and long-term effects on your soil and can impact future production. However, when drought breaks, drought affected soils can return to their normal state in time if given a little help. During drought:

- life in the soil slows down which slows the cycling of nutrients,
- the stability of soil aggregates can be reduced without the biological by-products produced by soil organisms,
- the surface of soils can become hard set, with bare powdery surface or cracked and hard,
- many soils will have high levels of nitrogen (N) and phosphorus (P) and,
- some herbicides may persist in the soil.

It is important to remember that both during and after drought, the greatest risk to soil is from erosion. Re-establishing ground cover is the number one priority to prevent soil loss and further degradation and to rebuild soil condition and function.

Changes in physical condition of soil

Heavy black, grey and brown clays can develop wide and deep cracks during drought. Generally speaking, their structure is as good as it is ever likely to be. On the other hand, the structure of non-cracking red loam soils generally deteriorates during drought. Topsoils can become very dry and powdery, which makes them highly vulnerable to erosion. Loss of ground cover (due to grazing animals, cultivation or lack of water) leaves soils vulnerable to compaction and wind and water erosion. Erosion due to drought-breaking rain can make up 90% of the total soil loss in a 20–30 year cycle.

Changes in soil biological activity

Drought can have major impacts on both the composition and activity of soil biological communities. The effect of drought also impacts biologically mediated processes in soil, including the cycling of nutrients and stabilisation of soil aggregates. Organic matter at the soil surface is preferentially blown away leaving the soil bare and depleted of an important source of energy for soil organisms.

Under drought conditions soil microbial activity decreases and C, N and P cycling are reduced which in turn can impact plant performance. The increased soil water repellency observed under drought has also been attributed in part to soil microbes.

Bacteria are likely to be affected more than fungi during drought, however there are a range of ways soil organisms cope with drought. Microbes shut down and form resistant spores ready for response when soil moisture increases. Worms will lay eggs at the surface and then burrow deep to hibernate.

When plants are drought stressed, rhizobia in nodules are susceptible to desiccation. When nodules senesce or break-down, rhizobia are released into soil. Rhizobia may survive in soil as free-living bacteria under favourable conditions. However, even in the best conditions the number of rhizobia will decrease over time without the presence of a legume host.

Changes in soil chemistry

Soil nitrogen (N), phosphorus (P) and sulphur (S) may increase during droughts as organic matter continues to mineralise after plant growth has become water-limited and fertiliser may carryover from previous applications. These nutrients are concentrated in the topsoil and if erosion occurs the nutrients and their benefits will be lost. Soil testing is recommended to assess nutrient status.

Fertiliser N applied to previous failed crops may remain in the soil and be available in the current year. Following prolonged heavy rain, much of the soil N is likely to be moved down the soil profile where it may not be readily available to germinating crops and pastures. It is also important to remember that weeds can also use available soil N, reducing the amount

available for subsequent crops. Consider deep (rooting-depth) soil tests to assess available N.

Where potassium (K) levels in soil are historically marginal, plant deficiencies are much more likely to be seen during dry years. Drought has no direct impact on soil pH, although manganese (Mn) availability is likely to increase in some soil types following drought which may be an issue for sensitive plants.

Herbicides

The effect drought has on herbicides in the soil is explained in more detail in the NSW DPI publication 'Herbicide residues after drought', but key points are summarised below.

Drought will exacerbate the issue of herbicide carryover. When conditions are dry, the breakdown of agricultural chemicals and their residues can be significantly slowed. Breakdown of these chemicals is reduced as the rate of chemical and biological decomposition of them is controlled by moisture and temperature (in addition to soil characteristics such as pH and clay content). The reduced decomposition can have a major impact on re-cropping intervals in subsequent crops. The risk is typically exacerbated on sandy soils with low organic matter, as the microbial activity may remain low even after rainfall due to rapid drying of the soil and because the organic matter level needed for microbial metabolism is low.

The residual herbicides of concern include the group B herbicides (including the sulfonylureas and imidazolinones), group C (e.g. atrazine and simazine) and group I (e.g. clopyralid, aminopyralid) products. Some herbicides from other groups (e.g. trifluralin, diflufenican) may also persist for longer periods and cause plant-back issues.

B. How to manage your soil after drought

The principal aim after rain should be to establish either pasture or crop as a groundcover on your bare paddocks as quickly as possible. Pasture, crop stubble and plant litter protect the soil surface from erosive raindrop impact and slows runoff thus increasing infiltration of water into the soil.

It is best practice to inoculate pasture legumes and pulse crops with the appropriate rhizobia when replanting. A detailed guide can be found at https://grdc.com.au/resources-and-publications/all-publications/bookshop/2015/07/inoculating-legumes.

Liming is a good option if your soil pH is low. Raising pH to about 5.5 not only encourages earthworms and other soil organisms but also increases the availability of nutrients in your soil.

Remember when the rains return, any remaining plants will quickly green but it will take longer for soil to really recover.

Soil nutrition

If the drought resulted in crop or pasture failure where sufficient nutrients (N, P S) had been supplied then some of these nutrients may still be may be some residual available. This may mean applications rates following the drought can be reduced but a **soil test will be required to determine this**.

Soil N levels are likely to be higher than usual for two reasons.

1. Much of the N applied before sowing the failed crop will still be available, provided the crop was not grazed, or cut for hay.
2. Mineralisation of N (conversion from organic to plant-available forms) increases markedly once a drought breaks and even during drought periods very small rainfall events are enough to enable mineralisation to occur.

The combination of potential carryover of nutrients from previous failed crops, and mineralisation rate make it very difficult to estimate the N available to plants. The only reliable method for determining N status is to test deep soil N on each paddock.

Avoid sowing crops or pastures susceptible to manganese toxicity such as canola on problem acid soil paddocks without first applying lime and allowing sufficient time for the lime to react.

Soil testing

It is highly recommended to soil test as this is the most reliable way to determine levels of nutrients such as P and N that are available for plant growth in order to calculate fertiliser and lime rates. Too little nutrient reduces plant growth and crop yield and too much wastes your money and may have damaging effects on water quality particularly after drought where the risk of loss by water erosion is greater.

For more detail on sampling procedures see Fertilizer Australia's soil sampling guide 'A guide for fit for purpose soil sampling'. You may also want to consider sampling 0-5 and 5-10 cm increments to understand pH and nutrient (such as P) stratification.

Cropping

Soil phosphorus (P) can be stratified (layered) particularly in no-till farming systems. When the topsoil is dry, this P will not be available to the crop.

A useful strategy, to take advantage of available nutrients, is to sow your most erodible paddocks early. Planting grazing oats will provide good surface cover quickly. Reserve your less erodible paddocks for your main winter crop.

Nitrogen rates need to be matched with the amount of stored soil water and the paddock yield target. Where winter rainfall is more reliable, splitting N between sowing and topdressing in-crop is a sound risk management strategy. Despite high soil N levels, starter fertiliser and some side dressings may still be required - consult your agronomist for more information.

Pastures and stock containment areas

For paddocks in reasonable condition, consider the benefits of retaining pasture rather than entering straight into crop. Pasture will generally build more soil organic matter than crops. Existing pasture in reasonable condition will give more groundcover sooner than sowing a new crop or pasture and has the advantage of an existing root structure which stabilises soil and can access more soil water. The strategy selected should be in line with your property management plan.

Soils in stock containment areas are likely to be in poorer condition than other paddocks on the farm due to soil compaction by livestock. Extra care needs to be taken in rehabilitating these areas. These areas are likely to have elevated nutrient levels due to high loads of livestock manure and urine so soil loss via erosion may be especially damaging to nearby waterways.

Soil structure and erosion

Where the soil has developed cracks, rain will flow into these cracks once the drought breaks. If the rain is flowing mostly into the deep soil a dry layer between the subsoil and the topsoil may result that can have implications for plant growth. A good time to apply gypsum to sodic clay soils is when the soil is cracked. When rain falls it will move the gypsum into the strongly cracked soil to maintain good infiltration after the cracks have closed

Where the drought affected soil has developed a powder like or hard-set surface, water infiltration can be severely limited. In this case, the 'effective rainfall' may be considerably less than the total rainfall as water is lost as runoff and only a shallow surface layer of soil is wet.

After drought breaking rains try to confine machinery traffic to narrow laneways and keep stock off wet soils to maintain good soil structure. Uncontrolled machinery traffic and stock trampling are major factors in causing the structural degradation, and subsequent erosion, of soils.

Pastures

In pasture paddocks, consider your grazing management plan to avoid overgrazing pastures during the recovery phase, and to avoid compaction in susceptible soils. Where pastures have been severely degraded, consult your local consultant on re-sowing or pasture renovation options. When establishing new pastures, avoid deep cultivation due to erosion risk.

Cropping

Cropping paddocks with a history of cultivation will be low in organic matter and prone to soil structural damage, so where possible keep tillage to a minimum. Pasture rotations that include a legume are a good way to rebuild soil organic matter and improve soil structure. Green manure crops in rotation or between rows can be slashed to rebuild soil organic matter.

Weeds

As a consequence of the extra plant nutrients in the soil, weeds are likely to grow rapidly after rain and may need to be controlled, preferably by spraying as this retains some surface ground cover. Weeds recover faster than desirable species after a drought. Observe how the pasture/newly sown crop is growing and decide on a management strategy if weeds show signs of dominating. Remember, if cultivation is used, soils are more susceptible to erosion. For further information see Weeds and drought.

Herbicide residues

If there are herbicide residues remaining this can damage sown crops and pastures.

In the first instance, it is critical to refer to product labels and ensure that rainfall requirements for relevant plant-backs periods have been reached. This goes not just for residual herbicides under extended dry periods, but also some typically non-residual herbicides, e.g. 2,4-D that can persist under short-term dry periods and have rainfall requirements prior to sowing.

Be aware that if the herbicides have leached deeper into the soil it will take time for the roots to pick the herbicide up. It is important to compare treated areas with areas that are known to have no risk of herbicide carryover.

Consult the NSW DPI publications Weed Control in Winter Crops, and Weed Control in Summer Crops for information on re-cropping intervals, plant-back periods and testing for herbicide residues.

C. Long-term soil management

It is important following any drought to review management practices and how these have contributed to or hindered your drought recovery. It is a good time to take the opportunity to commence practices that will ensure greater resilience and improve drought recovery results. The most effective management that will improve recovery after drought is that which follows conservation farming practices and effective management of soil nutrition. These two ingredients are important because they support soil function and vigorous plant growth. This is your best defence against drought - being well prepared.

Some examples of strategies to protect soils from drought:

- Reducing stocking rates before damage to pastures and soil results from animals grazing too close to ground level when fodder is limited. Ensuring fencing is adequate to both to control where and when stock are grazing
- Using minimum tillage or no tillage, and direct drilling wherever possible.
- Following best management practices for strategic tillage. Be aware that any cultivation where ground cover is minimal and drought breaking rains may occur is at significant risk of erosion
- Retaining stubble on the surface for as long as is practicable; if burning is necessary, wait until the main period of high erosion risk has passed.
- Using herbicides, rather than tillage, to control weeds during fallows.
- Using crop/pasture rotations that include well-managed perennial pastures and legumes.
- Using permanent, raised beds for irrigated row cropping
- Confining machinery traffic as much as possible.
- Increasing soil organic matter levels by, for example, stubble retention or incorporation or mulching, and including pastures in crop rotations.
- Applying lime to acid soils and and gypsum sodic clay soils.

Where necessary, in order to reclaim eroded areas or prevent future erosion, contour furrows or soil conservation earthworks should be constructed but must be vegetated quickly. These will reduce and slow run-off, limit the movement of soil and organic matter, and decrease the sedimentation and nutrient contamination of dams and waterways. It is important to consult with a technical expert to ensure these structures are designed and constructed correctly or they may cause more damage (Refer to the NSW Soil Conservation Service).

Fertiliser management

- Match nutrient supply, principally nitrogen and phosphorus, to the needs of the plant, through soil and/or plant tissue testing and improved timing of fertiliser application.

- Incorporate (rather than broadcast) fertiliser wherever possible.
- Do not broadcast fertiliser on bare soil especially when storms are likely. Consider waiting until the time of year when storms are less likely.
- Do not fertilise close to or across dams or waterways.
- Keep records of fertiliser usage and calibrate spreading equipment to reduce the likelihood of overuse.

Further information

On the management of soils during and after drought, view:

1. Soil Network of Knowledge (SNoK) webinar by Graeme Schwenke
2. NSW DPI Drought recovery Guide
3. Pasture sustainability and management in drought - Primefact 325
4. Other NSW DPI print publications on soils, including:
    a. Soil management guides, including Southern irrigation Soilpak
    b. Soil acidity (including liming)
    c. NSW Department of Soil conservation services

On the behaviour of residual chemicals, see : Congreve, M. and Cameron, J. (eds) (2019). Soil behaviour of pre-emergent herbicides in Australian farming systems – a national reference manual for advisers. 2nd Edition. GRDC publication, Australia

Acknowledgements

This Primefact is based in part on information contained in an earlier NSW Agriculture (now NSW DPI) publication, Drought Recovery Guide (Agnote #355) and subsequent revision of this in the Primefact 'Soil management following drought', 2007 by Abigail Jenkins (Primefact #367)

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