Lift soil microbe activity to reduce disease

Diseases such as rhizoctonia root rot and take-all have a significant impact on crop production across southern Australia with rhizoctonia alone costing an estimated $77 million each year in lost production. This article details how to manage cropping soils to stimulate a natural level of disease suppression.

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Managing soil nitrogen levels during summer and autumn can reduce disease levels in subsequent crops.

CSIRO research at Avon, South Australia, shows intensive cropping, stubble retention, limited grazing, minimum cultivation and above-average yields lift disease suppression levels over time in cropping soils.

The trick is to balance nitrogen and carbon inputs to alter the composition and lift the activity of the soil microbial population.

More microbes means there are more predators to keep disease-causing microbes in check.

In addition, there is more competition for resources, so the disease microbes cannot gain a competitive advantage and so numbers remain lower.

Beth Field

CSIRO research shows intensive cropping systems can, over time, develop significant disease suppression activity provided carbon and nitrogen inputs are well managed. Limited or no cultivation, stubble retention and above-average yields all combine to lift soil microbial activity and depress disease-causing microbes.

Thwarting pathogens

How well soils suppress fungal diseases is a function of the population, activity and composition of the soil microbial community.

All soils have an inherent level of suppressive activity but this level can be modified significantly by management practices used within a farming system.

At CSIRO's research site at Avon, disease suppression increased from low to high during 5–10 years following a change in management practices to full stubble retention, limited grazing and higher nutrient inputs to meet crop demand.

The increase in suppression provided complete control of the soil-borne diseases rhizoctonia and take-all.

Soils with high levels of disease suppression also have been identified on commercial farms across SA and Victoria.

The management factors consistently associated with soils with improved disease suppression include intensive cropping, stubble retention, limited grazing, limited or no cultivation and above-average yields (high water-use efficiency).

These management practices increase biologically available carbon inputs and change the composition and activity of the soil microbial community over time.

In consequence, there is more competition for soil resources which, along with predation and inhibition of pathogens, leads to increased disease suppression.

Soil mineral nitrogen

In the short term (1–3 years), the effectiveness of the disease suppressive activity already developed in the soil can be influenced by the availability of mineral nitrogen, particularly during summer and early autumn.

As the amount of available nitrate nitrogen in the topsoil increases during this non-crop period, the disease suppression available in the following crop season decreases. The underlying suppressive activity is probably not lost but it is not expressed effectively in the presence of high mineral nitrogen levels.

Any factors that result in the accumulation of high available nitrogen levels for long periods will tend to curb the effectiveness of the future suppressive activity of the soil. Some of these factors include legume pastures, green manures and crops left unharvested (sprayed to control resistant weeds).

Conditions which stimulate a high net rate of nitrogen mineralisation during the non-crop season can also lead to reduced disease suppression.

High net rates of nitrogen mineralisation can occur when moisture conditions and temperature are suitable and when there are insufficient microbes to take up the excess nitrogen.

Removing carbon inputs regularly by burning stubble can reduce carbon to nitrogen ratios and reduce microbial growth.

In addition, conditions that do not favour leaching of mineral nitrogen from the topsoil during the early part of non-crop periods can cause excessive nitrogen mineralisation and reduced disease suppression.

Carbon inputs critical

Intensive cropping can encourage disease suppression by enabling nitrogen to be exported from the system and by creating a

At a glance

- Disease outbreaks can be minimised by increasing the inherent disease-suppressive activity of cropping soils.
- Lifting soil carbon turnover (via stubble retention) and minimising the accumulation of soil nitrogen enables a more diverse and larger soil microbial population to develop.
- More soil microbes means there are more beneficial microbes to attack disease-causing microbes.
- Intensive cropping, minimum tillage and limited grazing minimise soil nitrogen accumulation.

strong nitrogen sink through a supply of biologically available carbon.

Carbon supply can be increased via the production and retention of residues to maintain high levels of microbial carbon turnover. This does not necessarily equate to a low fertility system but one in which the timing of nitrogen availability is better synchronised with crop requirements.

In such systems, early season nitrogen availability depends heavily on fertiliser nitrogen but crop nitrogen requirements later in the season will be supplied by net nitrogen mineralisation through microbial turnover.

Disease suppression in practice

CSIRO researchers developed a high level of disease suppression under a productive cropping system with complete stubble retention from the late 1970s through to the late 1980s. This suppression was very stable and provided complete control of take-all and rhizoctonia through the 1990s.

During the late 1990s herbicide-resistant grass weeds at the Avon site had become such an issue that the plots were sprayed out at flowering to limit seed set.

The practice was carried out for three successive years. Following the first year of spraying a very low level of rhizoctonia was observed on the crop roots.

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Retaining stubble in intensive cropping systems lifts carbon turnover rates leading to a more diverse and larger soil microbial population.

After the second year of spraying, small patches of rhizoctonia damage were observed.

But after the third year of spraying, the following crop (2003) was severely affected by both rhizoctonia and take-all.

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By exporting nitrogen from cropping systems via above-average yields, net nitrogen mineralisation can be kept low.

During 2003, the level of mineral nitrogen in the topsoil at sowing had reached 70 kilograms per hectare.

Crops were harvested during 2003 and subsequently soil mineral nitrogen levels declined during summer–autumn.

During 2004, crop disease levels declined substantially but were still detectable. It is likely that full suppressive activity will be restored following re-establishment of carbon and nitrogen turnover processes to prevent the accumulation of high levels of mineral nitrogen during the non-crop periods.

Dry spells and disease suppression

Occurrence of rhizoctonia damage was unexpectedly high in many southern areas during 2004. Generally, rhizoctonia incidence increases following drought (reduced microbial competition) and decreases following high rainfall seasons (increased microbial competition).

The favourable season of 2003 saw a higher incidence of rhizoctonia than was expected due largely to a very dry period between January and sowing which reduced competitive microbial activity and severely limited available nitrogen in intensive cropping systems.

Adequate yields or at least adequate biomass production during 2003 removed nearly all available nitrogen by harvest.

The dry summer–autumn conditions during 2004 then provided little opportunity for breakdown of the large stubble loads.

Consequently, there was limited or no net mineralisation of nitrogen.

Disease outbreaks of rhizoctonia (pictured) can be minimised by maintaining high soil carbon turnover and low net nitrogen mineralisation.

In addition, during 2004 crops were sown in marginal moisture conditions. In intensive cropping systems, stubble incorporation during sowing added to the nitrogen drawdown due to microbial immobilisation.

Under these conditions, even the fertiliser nitrogen added (at what normally would be regarded as adequate levels) often would have been immobilised quickly with net mineralisation (nitrogen availability) occurring only three or four weeks after sowing. This resulted in extremely nitrogen-deficient and slow-growing plants.

Setbacks

While the low nitrogen status of the topsoil ordinarily would increase disease suppression activity, the retarded growth and poor seasonal conditions combined to make crops vulnerable to disease.

Interestingly, these same conditions did not result in high disease levels in soils with inherently high disease suppression activity such as the CSIRO trial site at Avon.

But in paddocks where suppression levels were low to moderate, the poor seasonal conditions and crop growth outweighed any suppressive activity generated by the low soil nitrogen levels.

Rhizoctonia is an opportunistic disease and is favoured by slow-growing plants and soils with low disease suppression.

During 2004 many crops were sown during June into cold soils that were nitrogen deficient. These same conditions favoured the development of yellow leaf spot in wheat on wheat rotations, which further delayed development and made the crops even more vulnerable to rhizoctonia.

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