Variety choice key to successive wheat yields

When combined with minimum tillage, intensive wheat rotations can provide significant financial and environmental benefits but some growers have experienced yield losses in second and subsequent wheat crops. This article details how the discovery of the yield constraint in sequential wheat crops will lead to more reliable grain yields.

by **David Roget,**
CSIRO LAND AND WATER

Wheat varieties leave unique biological 'signatures' in the soil surrounding their roots, which can then impact on the yield of successive wheat crops.

Varieties which suffer yield declines when grown sequentially consistently contain higher numbers of harmful bacteria on their roots. These rhizobacteria are fast-growing and can transfer from old roots to new roots.

If the harmful bacteria develop in one year because a particular variety of wheat suits their needs, they will continue to thrive as long as that variety keeps being planted.

Fortunately, some varieties appear to resist or tolerate these bacteria so do not suffer significant yield decline when grown sequentially. This means there is scope to breed resistance into susceptible wheat varieties and to rotate susceptible varieties with more resistant ones.

Intensive wheat rotations

During the past 5–10 years farmers have used cereals more intensively in crop rotations across southern Australia, increasing financial returns and providing the additional benefits of reducing soil erosion, and lifting soil microbial activity.

Increased carbon inputs into the soil lift soil microbial activity and result in improved nutrient turnover and increased suppression of fungal root diseases.

At a glance

- Second and subsequent wheat crops can yield 5–20 per cent less than wheat following non-cereals, even in areas where disease and crop nutrition are not limiting.
- CSIRO researchers have discovered the yield constraint is caused by a build-up of harmful bacteria on the roots of sequential wheat crops.
- Fortunately, some wheat varieties appear to resist or tolerate the bacteria, providing scope to breed resistance into susceptible varieties.

CSIRO Land and Water

Varieties which suffer yield declines when grown sequentially consistently contain higher numbers of harmful bacteria on their roots. These rhizobacteria are fast growing and can transfer from old roots to new roots. As some varieties appear to resist or tolerate the harmful bacteria there is scope to breed resistance into susceptible wheat varieties and to rotate susceptible varieties with more resistant ones. Inset shows a wheat root under the light microscope, root is pink, remaining soil material is yellow and the bacteria are blue.

Wheat on wheat rotations have, in the past, been subject to high disease risks.

But the improvement in disease suppression and the advent of improved decision support tools for managing major cereal diseases have enabled farmers to grow two or three wheat crops in succession, without significant disease problems.

Yield losses

CSIRO researchers analysed grain yields from 26 different paddocks on a farm at Avon, South Australia. The analysis revealed second and subsequent wheat crops yielded 5–20 per cent less than wheat following non-cereals, even in areas where disease and crop nutrition were not limiting.

The yield decline varied significantly between different wheat varieties.

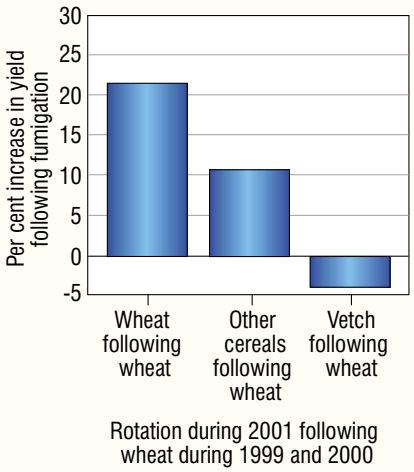
For example, the wheat varieties Krichauff and Trident showed only a 5% yield decline compared with Yitpi or Frame, which declined in yield by 15–20%.

Krichauff and Trident were consistent performers as sequential wheat crops at different sites over three years of the project.

Yield constraint is biological

To determine the cause of the yield decline in sequential wheat crops, researchers compared the yield of wheat crops in sterilised soil with the yield of wheat in paddocks with a history of sequential wheat.

FIGURE 1 Grain yield increased*



* In fumigated soil.

Percentage increase in crop yields following soil fumigation for wheat, other cereals or vetch at Avon, South Australia. Fumigation removed the biological constraint to yield in sequential wheat crops.

Source: CSIRO Land and Water.

Wheat yields in the sterilised soil increased by about 20% compared with yields in the sequential wheat soil, suggesting the constraint to yield was biological in nature (see Figure 1).

When wheat roots from the paddocks with a history of sequential wheat were added to sterile soil, growth of subsequent wheat seedlings was reduced significantly — confirming the biological nature of the yield constraint.

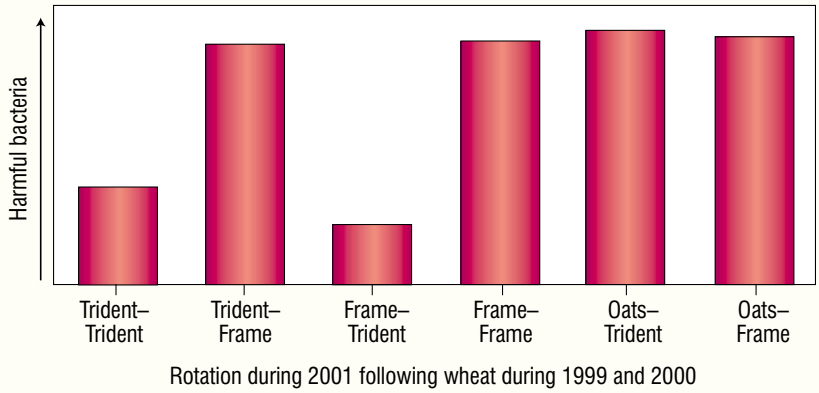
Rhizosphere bacteria

The microbial population within the root rhizosphere (close to the root's surface) has been linked strongly to the performance of agricultural crops.

When researchers isolated the bacteria within the rhizosphere of the sequential wheat crops they discovered higher populations of copiotrophic (fast growing) bacteria on the roots of poor performing wheat varieties (see Figure 2).

Different wheat varieties have varying bacterial populations because they have different rates of root exudation of carbon products such as sugars and proteins.

FIGURE 2 Yield penalty in sequential wheat crops is biological



Populations of copiotrophic (fast growing) bacteria in the rhizosphere of wheat varieties grown after either wheat or other cereals at Avon, South Australia. High populations of fast-growing bacteria were found in the rhizospheres of poor performing wheat varieties (for example, Frame) compared with the best performing wheat varieties (for example, Trident).

Source: CSIRO Land and Water.

Different carbon products encourage the presence of different bacteria and researchers suspect certain populations of bacteria are detrimental to growth.

For more information contact David Roget by email on david.roget@csiro.au, phone (08) 8303 8528 or fax (08) 8303 8560.

CSIRO

No-tillage lifts production and reduces erosion

Farm information

Farmer
Allen Buckley

Location
Waikerie, South Australia

Property size
5000ha

Enterprises
Mixed cropping, livestock

Annual rainfall
250mm

Soil type
Sandy loams

Soil pH
8–9 (calcium chloride)

Growing wheat intensively using no-tillage has enabled Allen Buckley, Waikerie, South Australia, to double his production base, while reducing erosion and herbicide costs.

Allen has grown wheat intensively for the past 10 years in an effort to protect his most valuable resource base — his sandy loam cropping soils.

Mastering no-tillage has allowed Allen to maintain constant groundcover on his 5000-hectare property, removing the erosion problems common when he practised a fallow phase and used conventional cultivation.

From a fallow–wheat–pasture rotation Allen has moved to an intensive cropping rotation based on three years of wheat followed by two years of barley–triticale; two years of cereal rye or oaten hay (and peas or canola if stubble cover and seasonal break permit); one year of Clearfield wheat and then a return to an intensive wheat phase.

Cereal rye is used to combat any emerging disease problems from the intensive wheat rotation. Allen said the rye 'balanced the soil' and provided the best disease resistance of all his crops.

Clearfield wheat is used as the first variety in the wheat cycle as it eliminates volunteer cereals and grass weeds and ensures a clean wheat sample in the first year.

Allen has discovered some varieties yield better than others when grown intensively. For his area, Kirchauff outyields all other varieties but unfortunately is no longer favoured by milling companies as it produces a yellow flour colour.

Allen said there was a need to develop new varieties with the yield potential of Kirchauff under intensive cropping.

When Allen first converted to no-tillage and intensive cropping, weed control was a challenge with onion weed being a particular problem. But in the past five years, no-tillage, herbicides and competition from continuous cropping have brought onion weed under control.

Carolyn MacDonald

Allen Buckley, Waikerie, South Australia, said no-tillage and intensive wheat cropping had doubled his production base while reducing erosion and herbicide costs.

Allen does not use tramlines when sowing his crops but instead follows the same path each year while sowing the entire paddock.

In Allen's opinion, tramlines on his soils could lead to erosion problems and he prefers to keep the entire paddock covered in crop.

Allen deep rips and deep-bands fertiliser to about 130 millimetres (five inches) each year during crop sowing.

Weeds are sprayed as soon as they appear following the opening rainfalls. A second knockdown chemical is then applied immediately before sowing but only in areas with a weed problem.

CSIRO