Does direct drilling reduce seedling growth?

Where to from here to increase productivity in conservation cropping systems?

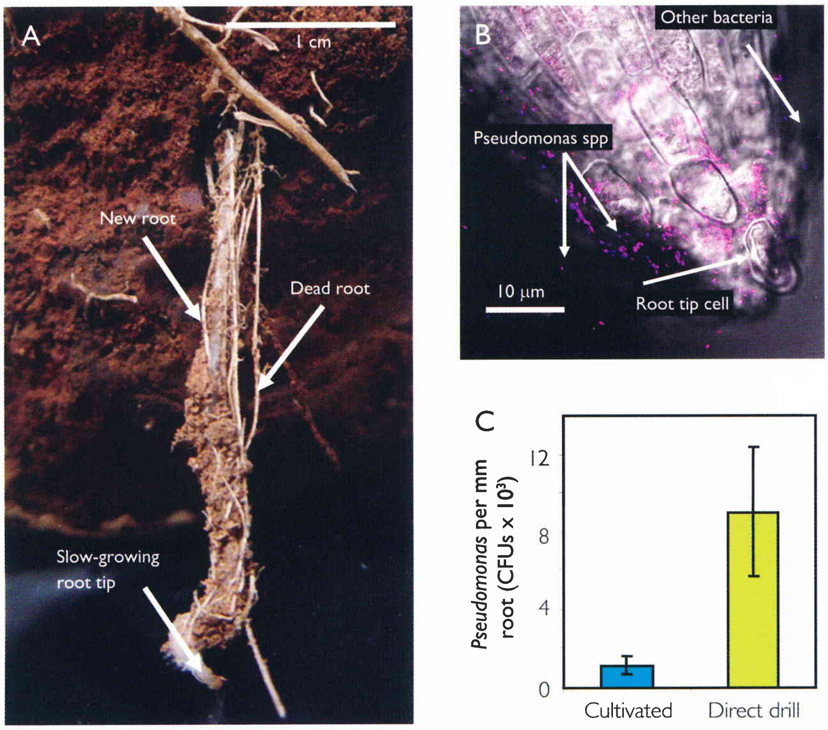
Michelle Watt and John Kirkegaard, CSIRO Plant Industry
Email: Michelle.Watt@csiro.au

Key messages

- Inhibitory bacteria can build-up on slow-growing roots in no-till soil and reduce seedling vigour.
- Early sowing and deep sowing points increase root growth and minimize these effects.
- Varieties with faster root growth and beneficial exudates may suit no-till systems.

Background

Poor early seedling vigour in direct-drill crops has been observed throughout the world and was also present at the Harden long-term experimental site where it often persisted to reduce grain yield. The mechanism was uncertain but the consequence was that crop yield did not respond to the seemingly "better" soil conditions developed under conservation cropping. We pursued evidence provided by Steven Simpfendorfer that inhibitory soil bacteria building up on the roots in no-till soil may be involved. Detailed studies of the roots and rhizosphere organisms under field conditions solved the puzzle and provided explanations and opportunities to increase productivity under conservation cropping systems.

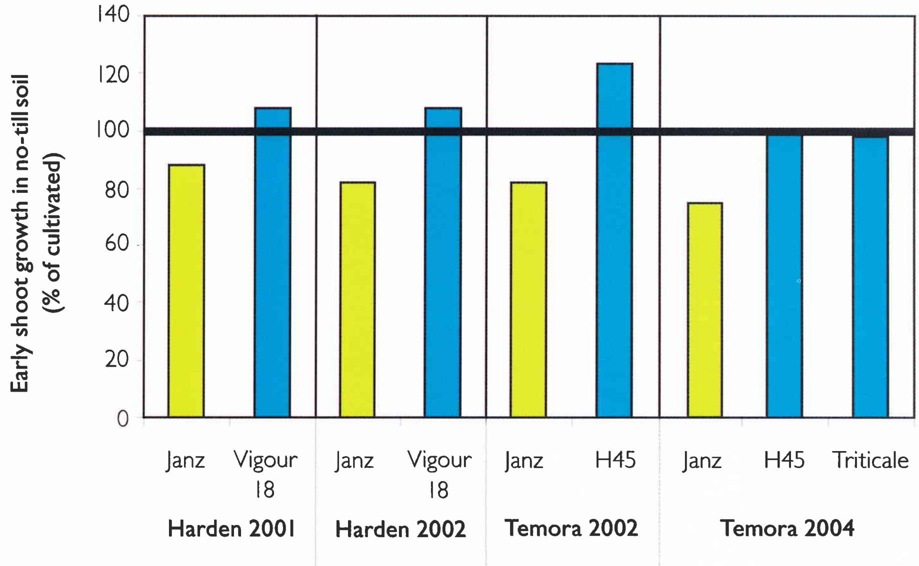


> Figure 1. A wheat root emerging from a pore in no-till soil, with many dead roots stuck to it. The growing tip is distorted and growing slowly in hard soil. B. Wheat root tip (cv. Janz) with bacteria, including *Pseudomonas*, feeding off chemicals released from tip cells. Bacteria are coloured with genetic labels. C. Graph shows that slow-growing direct-drilled roots have higher numbers of *Pseudomonas* bacteria.

Roots and rhizospheres in direct-drill soil

We compared the soil biology in an undisturbed, no-till system with that in a cultivated system. Fumigation or loosening the soil overcame the problem of slow seedling growth – indicating the constraint was an interaction between physical and biological aspects of the soil. Further investigations ruled out the major disease organisms but showed that Pseudomonas bacteria were reducing vigour (Simpfendorfer et al., 2002). New microscopy techniques revealed that many roots in no-till soil were constrained in cracks and biopores, which distorted and slowed their growth, and exposed them to prolonged accumulation of Pseudomonas (but not other bacteria) from the rhizosphere. The reduction in shoot growth of direct drilled crops was caused by growth-inhibiting substances from Pseudomonas (Fig. 1).

These investigations explain a number of observations made at the Harden long-term site and by growers in the region. Using deep points to loosen soil, or sowing earlier into warmer soils reduce the impact of direct-drilling on crop vigour– in both cases the roots are growing faster and presumably avoid the build-up of bacteria. The results also demonstrate that increases in overall biological activity in the bulk soil do not necessarily mean more beneficial soil organisms in the rhizosphere and improved crop growth, and it is important to look at changes in the rhizosphere. Finally the work suggested that wheat varieties with inherently faster root growth should be less affected by direct-drill soil.



> Figure 2. Genotypes with inherently fast root growth (blue bars) grow well in no-till soil.

Varieties with faster roots for no-till

We screened a large number of wheat and cereal genotypes for fast root growth in the laboratory, and then tested them in no-till and cultivated soil at two sites in southeast NSW over 3 seasons (Fig. 2). We found those with inherently fast growth in the laboratory also had more vigorous root and shoot growth in no-till soil in the field, and did not show the reduced shoot vigour seen in cultivars with slow root growth, such as Janz. We are now selecting for genotypes with fast-growing roots.

Practical implications

Identifying soil biological constraints to better crop growth under conservation cropping systems paves the way to develop further innovations to improve productivity in no-till systems. We are investigating the root exudates from wheat varieties shown to perform well in no-till, intensive cereal systems.

New autosteer guidance systems offer exciting opportunities for growers to reliably manage plants in relation to soil organisms by sowing either between or on the roots of the previous crop. Since the roots are colonized by many organisms, there are many opportunities to manage existing and/or applied (inoculant) soil organisms in the rhizosphere with new varieties, and autosteer.

Further reading

Simpfendorfer, S., Kirkegaard, J.A., Heenan, D.P. and Wong, P.T.W. (2002) Reduced early growth of direct drilled wheat in southern New South Wales - role of root inhibitory pseudomonads. *Australian Journal of Agricultural Research* 53: 323-331.

Watt, M., McCully, M.E. and Kirkegaard, J.A. (2003) Soil strength and rate of root elongation alter the accumulation of Pseudomonas spp. and other bacteria in the rhizosphere of wheat. *Functional Plant Biology* 30: 482-491.

Watt, M., Kirkegaard, J.A. and Rebetzke, G.J. (2005) A wheat genotype developed for rapid leaf growth copes well with the physical and biological constraints of unploughed soil. *Functional Plant Biology* 32: 695-706.

Watt, M., Kirkegaard, J.A. and Passioura, J.P. (2006) Rhizosphere biology and crop productivity. *Australian Journal of Soil Research* 44: 299-317.