

New genetics to improve wheat establishment with deep sowing

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AT A GLANCE

- Current Australian wheat cultivars contain dwarfing genes that reduce coleoptile length by 40 per cent. New dwarfing genes are available that reduce plant height but don't reduce coleoptile length.
- A gene increasing coleoptile length was identified and tagged with DNA markers. Breeding lines and DNA markers for new dwarfing and coleoptile length genes have been delivered to Australian breeders for efficient selection of improved crop establishment.
- Deep-sowing studies show that new dwarfing and coleoptile length promoting genes can increase emergence at sowing depths of up to 120 mm without changing plant height.
- Moisture-seeking points coupled with new genetics should reliably allow seed placement and emergence from sowing depths of 100 mm or greater, and/or with warmer soils.

In Australia's dryland cropping regions, winter crops are typically sown on the first breaking rains. But sometimes these rains are insufficient – and the sub-soil moisture accumulated is too deep – for successful sowing with conventional varieties and planting systems.

The key to good leaf area development for tillering, growth and weed competitiveness is good crop establishment. An ability to establish wheat crops from seed placed 80 mm or deeper in the soil would be useful in situations where the subsoil is moist but the surface dry. Seeding onto moisture at depth extends the opportunities for a greater portion of the cropping program to be sown in the traditional sowing months.



Greg Rebetzke estimates new and improved wheat varieties with longer coleoptile and dwarfing traits, will be commercially available within five or six years.

A separate but concerning issue is the influence of increasingly warmer soil temperatures on reductions in coleoptile length.

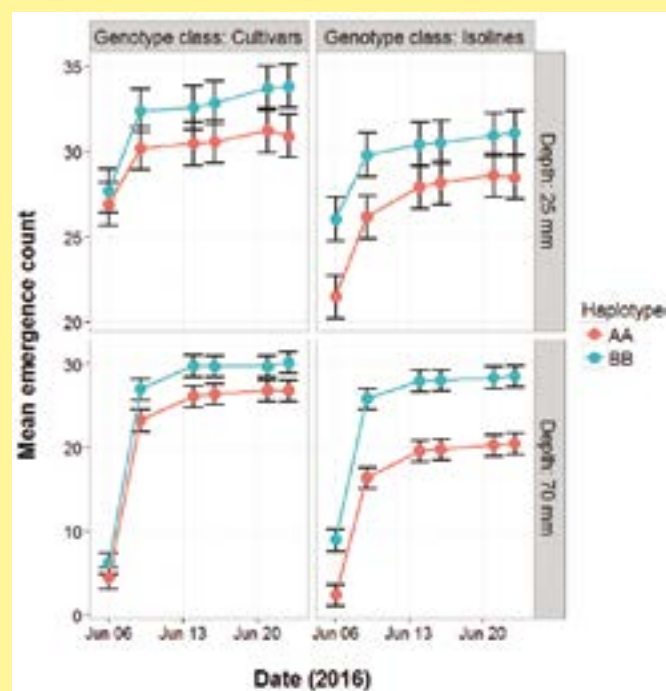
Earlier sowing into warmer soils will reduce coleoptile length by as much as 60 per cent so that a variety such as Mace – with a 75 mm coleoptile at 15°C – will likely have a 40 mm coleoptile at 25°C soil temperature. Some seed dressing and pre-emergent herbicides will reduce this coleoptile length even further affecting establishment.

The 'Green Revolution' Rht-B1b and Rht-D1b dwarfing genes reduced plant heights to reduce lodging and increase grain yields and so are present in most wheat varieties worldwide. Their presence also reduces the length of the coleoptile by as much as 40 per cent. This reduces crop emergence when sown at depths greater than 50 mm, as well as tiller number and leaf size leading to reduced water-use efficiency and weed competitiveness.

New dwarfing genes

A range of alternative dwarfing genes have been identified in overseas wheats with potential to reduce plant height and increase yields while maintaining longer coleoptiles and greater early vigour. Some of these genes (eg. Rht8 and Rht18) have been used commercially overseas but have not been assessed for use here in Australia. We reduced the larger global set of

FIGURE 1: Emergence of wheat cultivars carrying conventional dwarfing genes and tall isolines, Yanco (southern NSW), 2016



Sowing depth treatments were 25 mm and 70 mm. 12 cultivars and 12 isolines were grouped according to the presence of the coleoptile length promoting gene (BB, long coleoptiles) and the lack of the gene (AA short coleoptiles).

alternative dwarfing genes to Rht4, Rht5, Rht8, Rht12, Rht13 and Rht18, and then developed linked DNA-markers to assist with breeding of these genes in a commercial breeding program.

Separately, we then bred these genes using conventional and DNA-based methods into the old, tall wheat variety Halberd for testing and disseminating to Australian wheat breeders.

Genes that promote coleoptile growth

While switching to new dwarfing genes will remove the growth inhibition on early growth, there is a need to promote coleoptile growth, particularly in the presence of conventional dwarfing genes.

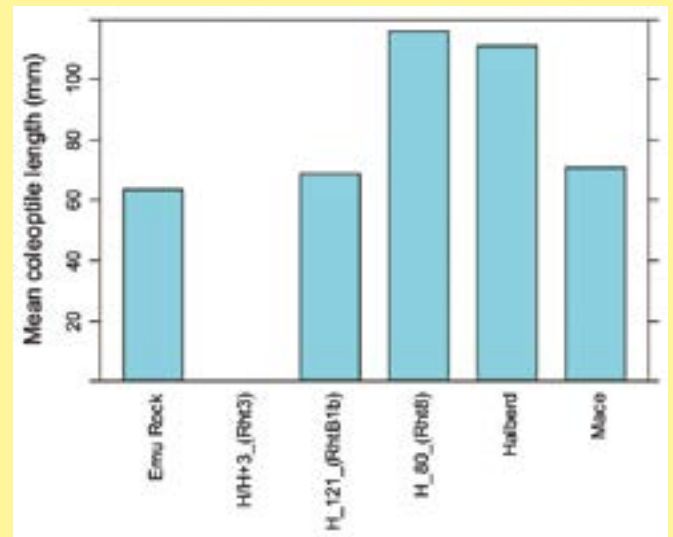
A gene with major effect on coleoptile length was identified in current wheat cultivars. Through a GRDC funded project, we demonstrated that the gene not only increased coleoptile length but also emergence with deep sowing in field trials conducted over three years at Yanco NSW (Figure 1).

The gene was tagged with molecular markers and tested in a wide range of Australian wheat germplasm. We estimated that only 10 per cent of recently released cultivars carry the coleoptile growth promoting gene.

The markers were distributed to Australian breeding companies to assist with the selection and the expected increase of gene frequency in future cultivars. Additional genetic variation for coleoptile length and early growth exists in elite germplasm.

For breeders to take full advantage of this variation, additional genes controlling this trait need to be identified and tagged with

FIGURE 2: Coleoptile lengths of a tall wheat genotype (Halberd) and genotypes with dwarfing genes Rht-B1b (syn. Rht1) and Rht8 in a Halberd background



Emu Rock and Mace are current commercial cultivars with Rht-B1b and Rht-D1b, respectively.



Wheat variety Mace (left) side-by-side with long coleoptile, Mace containing the Rht18 dwarfing gene (right) at Condobolin in 2017.



Wheat variety EGA Gregory (left) side-by-side with long coleoptile, EGA Gregory containing the Rht18 dwarfing gene (right) at Condobolin in 2017.

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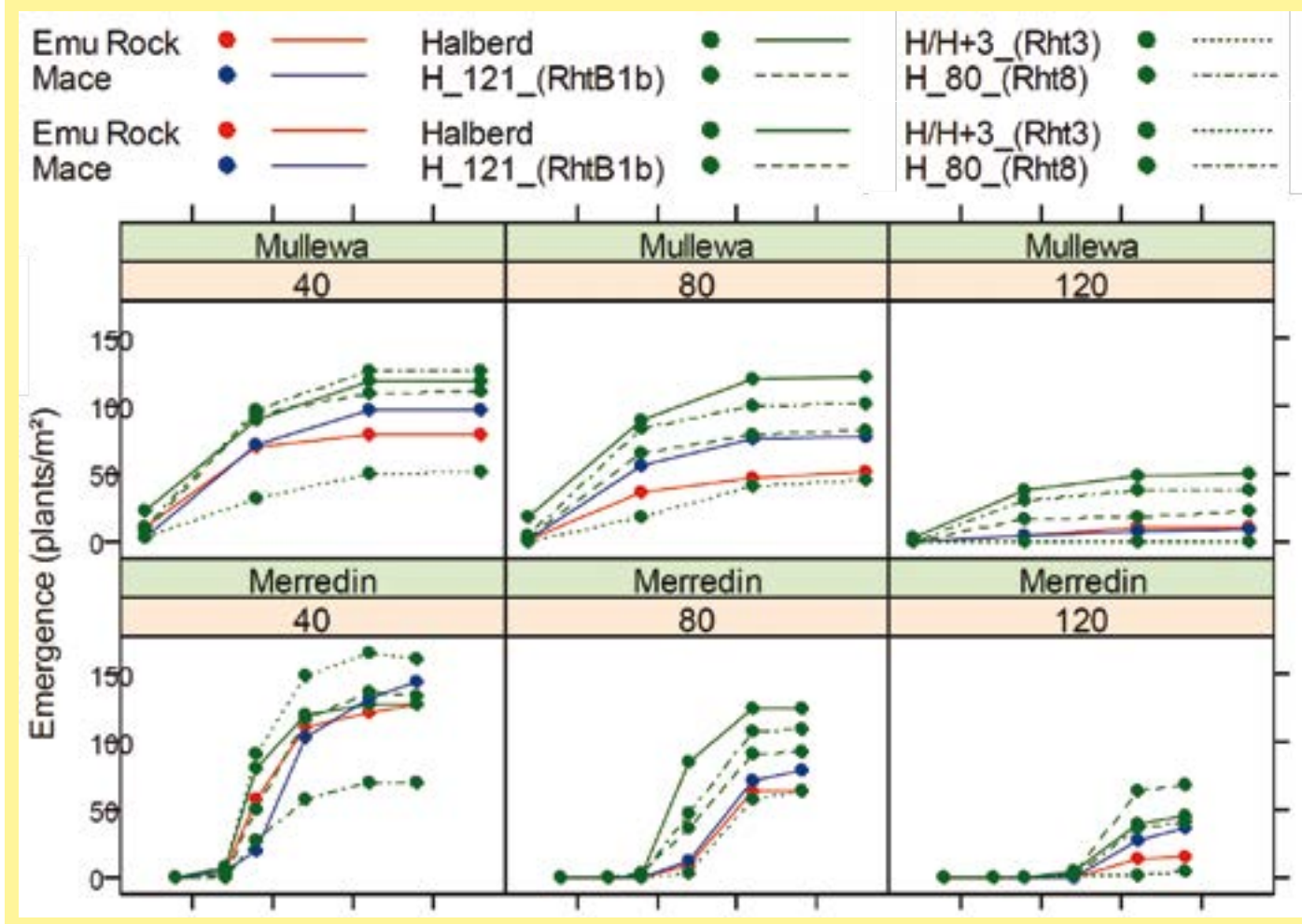
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FIGURE 3: Patterns of emergence of wheat genotypes with different dwarfing genes sown at target depths of 40, 80 or 120 mm at Mullewa and Merredin in 2016



markers for efficient selection and combining growth promoting genes for even better performance.

Preliminary sowing depth field studies

Field studies have commenced on these Halberd-based dwarfing gene lines and show that lines containing these genes produced coleoptiles of equivalent length to Halberd (up to 135 mm in length; Figure 2) and established well when sown at 100 mm depth in deep sowing experiments conducted at Mullewa and Merredin (WA) in 2016 (Figure.3).

Grain yields of lines containing the new dwarfing genes were equivalent to the yields of lines containing the commonly used Rht-B1b and Rht-D1b dwarfing genes while previous studies have shown the new dwarfing genes were linked to greater grain yields when sown deep owing to greater plant number with improved establishment.

The most likely useful new dwarfing genes, Rht13 and Rht18, have been bred into a range of current commercial wheats (see photos). Long coleoptile wheat breeding lines in Mace, Scout, Espada, EGA Gregory and Magenta have been delivered to Australian breeders for testing and use in breeding.

If there are no problems with these new dwarfing genes, we may see the first of the long coleoptile wheat varieties in five or six years in NVT testing!

Agronomic opportunities

Although there is real promise in the new genetics, there is

significant opportunity in coupling new genetics with existing seeding technologies. Deep sowing is an issue overseas and in the eastern Australian states. The availability of moisture-seeking points commonly used elsewhere should allow the reliable placement of seed at depths of 100 mm or greater. These points produce a slot deep into the soil at the base of which a seed is sown at 10–50 mm depth. That said, further research is required aimed at tools and methods to assess different moisture-seeking points to optimise seed placement at depth across a wide range of soil types.

To sum up

Wheat breeders now have the new dwarfing genes to breed longer coleoptile wheat varieties. Genes that increase coleoptile length have also been identified and tagged with markers.

These genes are expected to play an important role in improving emergence from depth in the presence of conventional dwarfing genes. Matching new genetics with appropriate agronomy and technologies should ensure the emergence and establishment of deep-sown wheats, particularly when sown early to make use of summer rains sitting deep in the soil profile, or to increase sowing opportunities in the traditional months of May and June.

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