Alternative dwarfing genes improve wheat emergence from deep sowing

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Key messages

- The dwarfing gene *Rht-8* did not shorten the coleoptiles of the tall variety Halberd, whereas the gene *Rht-1*, common in Australian cultivars, shortened coleoptiles by approximately 40 mm.
- Genotypes with shorter coleoptiles had poorer emergence from deep (~120 mm) sowing than other genotypes.
- Establishment was reduced more by deep sowing in warm soil at Mullewa than in cool soil at Merredin.
- The impact of deep sowing on grain yield depends on the capacity and seasonal opportunity to compensate for low crop density with increases in other yield components such as grain numbers per m^2 and grain weight.

Aims

To compare the effects of alternative dwarfing genes *Rht-8* and *Rht-3* with *Rht-1* (syn. *Rht-B1b*) on wheat emergence from a range of sowing depths under WA wheatbelt conditions.

Method

Sowing depth trials comparing responses of 6 wheat lines with different dwarfing genes were conducted at 2 locations (Mullewa, sown 5 May, and Merredin, sown 10 June) in 2016. Trials were laid out as randomised block designs with 3 replicates, and a factorial treatment structure of each line sown at 3 different target depths (40, 80, and 120 mm) using a tined cone seeder. The lines (H_80_(Rht8), H/H+3_(Rht3), and H_121_(RhtB1b)) were derived from crossing sources of the dwarfing genes *Rht-8*, *Rht-3*, and *Rht-B1b* respectively with the tall variety Halberd, and backcrossing to Halberd up to five times, thus creating lines up to 99% genetically identical to Halberd. The tall parent Halberd was also included as well as Mace and Emu Rock as commercial checks. Mace and Emu Rock both contain *Rht-B1b.* Seed of Halberd and the three test lines was grown in the Merredin MEF in 2015 so seed was all sourced from the same growing environment. Target density was 120 plants/m^2 in both trials. Emergence was assessed by regular counts of emerged seedlings in one permanent 0.5 m × 5 row (1.1 m) quadrat per plot beginning within a week after sowing, and at Merredin independent counts were done in 2 m row at two locations per plot 6 weeks after sowing as well. Plots were harvested with a mechanical plot harvester at crop maturity and plot weights used to calculate grain yield.

Results

Coleoptile lengths and seeding depth

Coleoptile length was measured at Mullewa on unemerged plants dug up from the 120 mm seed depth treatments 2 weeks after sowing (Figure 1). H_80_(Rht8) did not reduce coleoptile length compared to the tall Halberd, but coleoptile length was similar in all genotypes with *Rht-B1b*. Data were not collected for H/H+3_(Rht3) which was expected to have even shorter coleoptiles than H_121_(RhtB1b). Actual seed depth was also measured at Mullewa by digging up emerged seedlings and measuring the distance from the seed to the soil surface. Actual depths were somewhat deeper than target: 72, 102, and 135 mm respectively for targets of 40, 80, and 120 mm.

Crop emergence

Emergence patterns are shown in Figure 2. Emergence was faster at Mullewa but deep sowing delayed emergence in all genotypes. Time to 50% emergence (time taken for emergence of 50% of seedlings that did eventually emerge) was delayed by 4 and 6 days at Merredin when sown at 80 and 120 mm compared to 40 mm, although this is an underestimate of the delay induced at 120 mm because emergence continued beyond 25 days after sowing. Deep sowing also reduced total emergence, and the reduction was generally greater the shorter the coleoptiles. At Mullewa total emergence was reduced by an average of 27% and 86% in genotypes carrying *Rht-B1b* sown respectively at 80 and 120 mm compared to 40 mm, but only by an average of 9% and 64% for Halberd and H_80_(Rht8). Merredin data were more variable but while sowing 80 mm deep reduced establishment similarly to Mullewa, sowing at 120 mm did not reduce establishment as much as at Mullewa. H_121_(RhtB1b) and H_80_(Rht8) were no more sensitive to deep sowing than Halberd itself at Merredin. Seedlings continued to emerge in the 120 mm sowing after the last date shown in Figure 2 and counts 6 weeks after sowing showed average reductions of 36% and 72% in Mace, Emu

Rock, and H/H+3_(Rht3) sown at 80 and 120 mm compared to 40 mm, but only 19% and 54% for Halberd, H_121_(RhtB1b) and H_80_(Rht8) (Figure 3A).

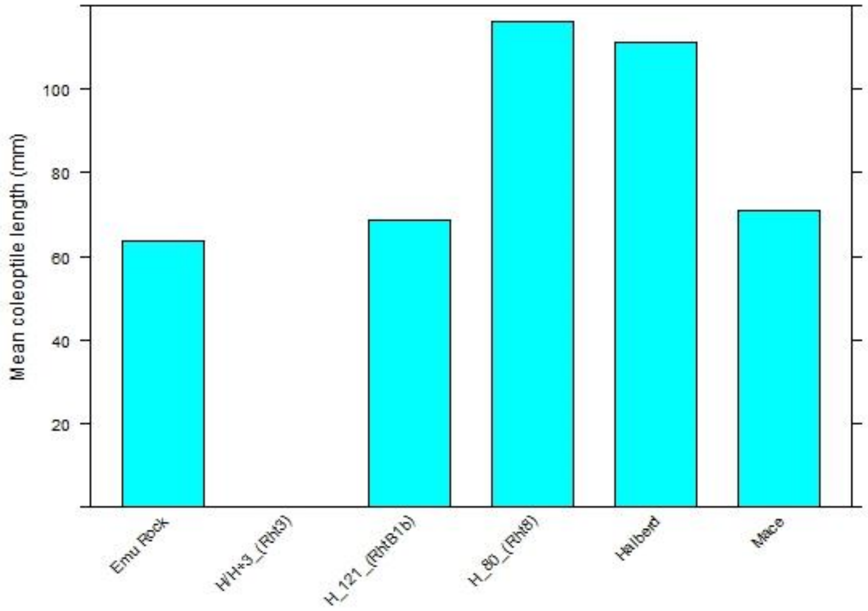

Figure 1. Coleoptile lengths of a tall wheat genotype (Halberd) and genotypes with dwarfing genes *Rht-B1b* and *Rht-8* in a Halberd background. Emu Rock and Mace are current commercial cultivars with *Rht-B1b*.

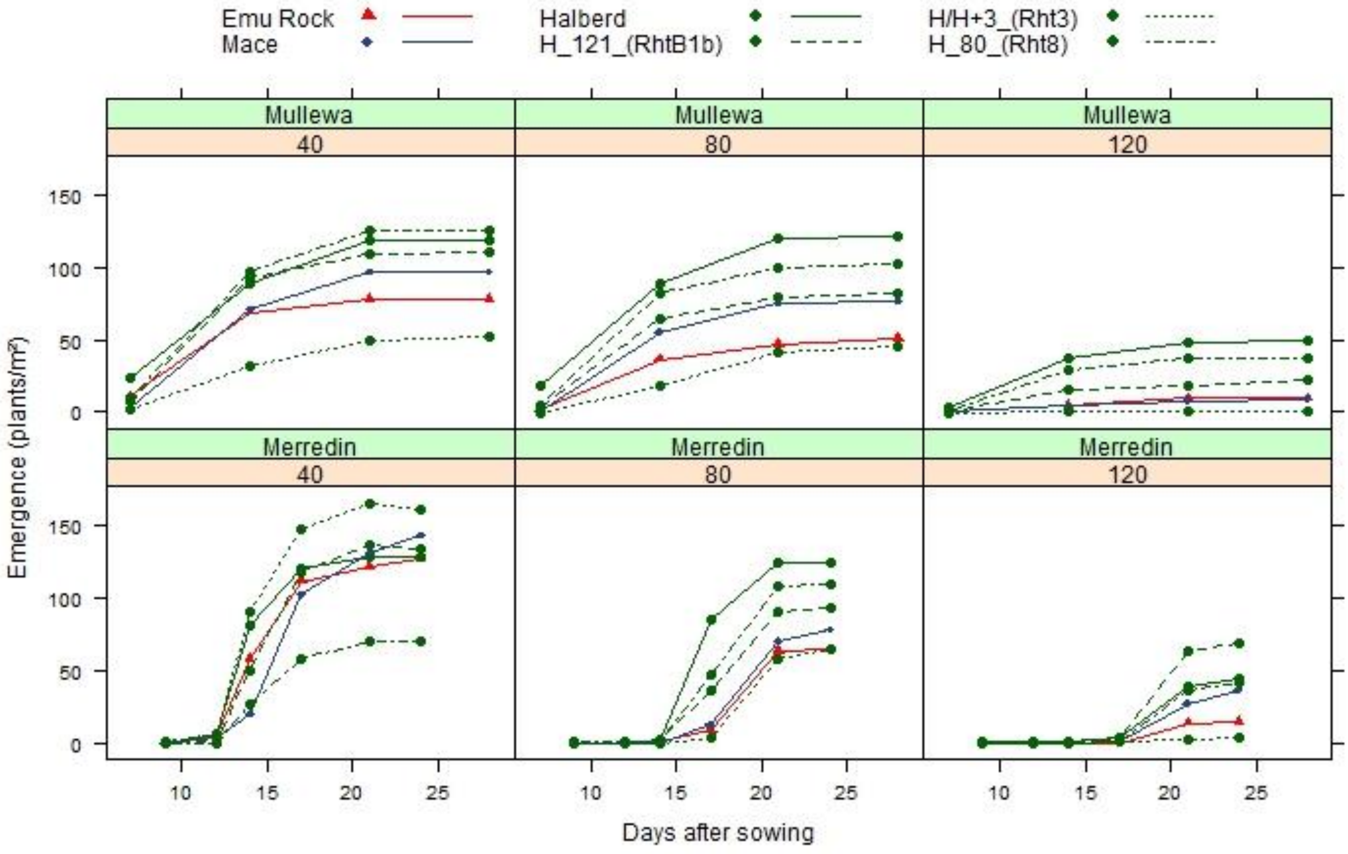

Figure 2. Patterns of emergence of wheat genotypes with different dwarfing genes sown at target depths of 40, 80, or 120 mm at Mullewa and Merredin in 2016.

Crop height and grain yield

Crop height prior to harvest was measured at Merredin. Although deep sowing reduced height significantly it had a much smaller effect than genotype. Genotypes ranked for height as expected based on the dwarfing gene present: Halberd, with no dwarfing genes, was tallest, followed by H_80_(Rht8). Height was similar for all genotypes carrying *Rht-B1b* (Emu Rock, Mace, and H_121_(RhtB1b)) and H/H+3_(Rht3) was much shorter than all other genotypes

(Figure 3B). Deep sowing significantly reduced grain yield of all genotypes at both sites (Figure 4). The reduction was greater at Mullewa than Merredin, especially when sown 120 mm deep, due to greater responsiveness to density (Figure 5). The most sensitive genotype to deep sowing in terms of grain yield was H/H+3_(Rht3) at both sites. At Mullewa Halberd and H_80_(Rht8) experienced smaller yield reductions than other genotypes (42 compared to 51-75% when sown at 120 mm), but at Merredin all genotypes other than H/H+3_(Rht3) experienced similar yield reductions (9-28% when sown at 120 mm).

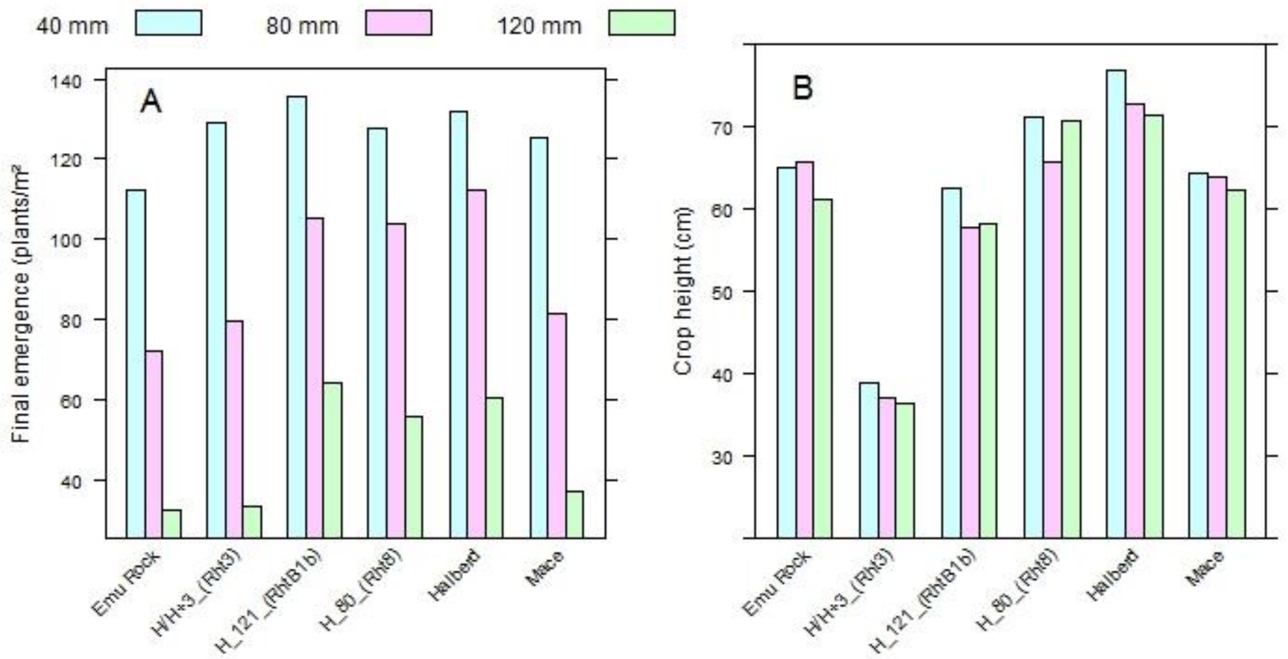

Figure 3. Final emergence 6 weeks after sowing (A) and crop height just prior to harvest (B) of wheat genotypes with different dwarfing genes sown at target depths of 40, 80, and 120 mm at Merredin in 2016.

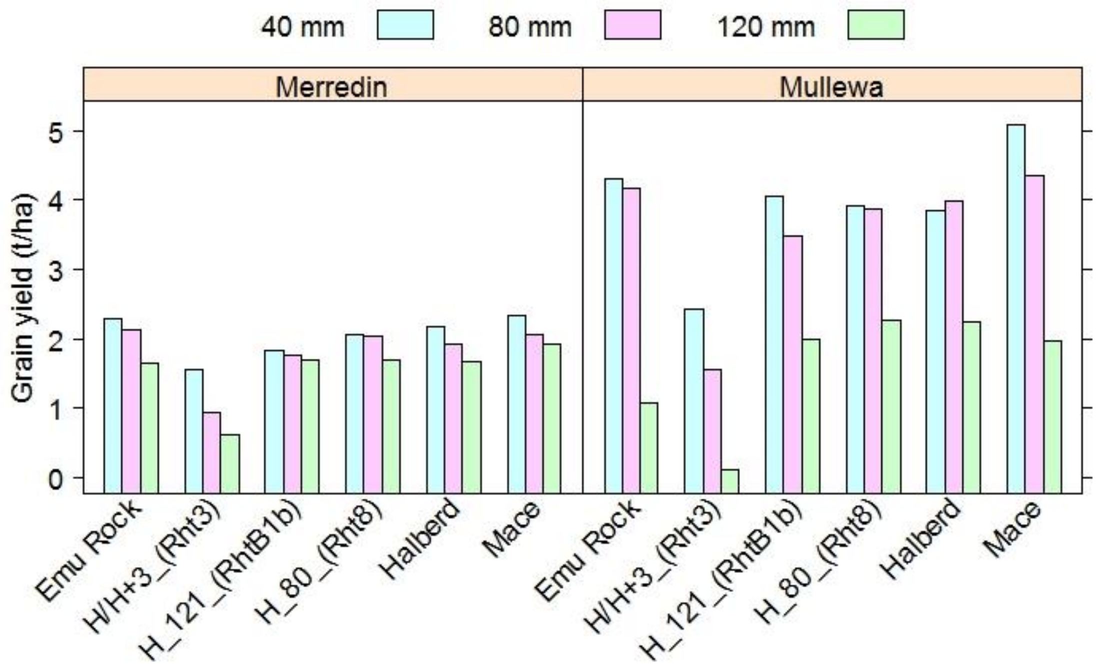

Figure 4. Grain yield of wheat genotypes with different dwarfing genes sown at target depths of 40, 80, and 120 mm at Mullewa and Merredin in 2016.

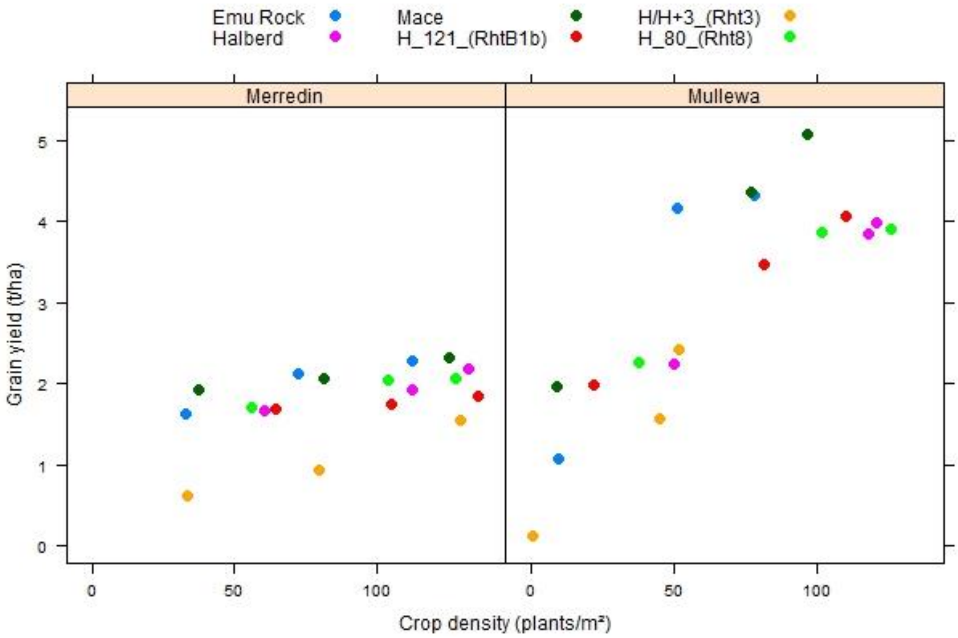

Figure 5. Relationships between grain yield and crop density for wheat genotypes differing in dwarfing genes sown at target depths of 40, 80, and 120 mm at Mullewa and Merredin in 2016.

Conclusion

The ability to establish wheat crops from seed placed 80 mm or deeper in the soil could be useful in situations where the soil surface is dry but the subsoil moist, a situation WA farmers will increasingly face in the future as climate change increases March and April rain while reducing rainfall in the traditional sowing months of May and June. Although establishment of all genotypes was reduced by deep sowing, at Mullewa shorter coleoptiles caused by *Rht-B1b*, the dwarfing gene present in most current commercial Australian cultivars, increased sensitivity to deep sowing and the presence of *Rht-3*, which shortens coleoptiles even more, increased it even more. On the other hand, the presence of *Rht-8*, which has little effect on coleoptile length, did not change deep sowing sensitivity compared to a tall genotype with no dwarfing genes. At Merredin *Rht-B1b* in a Halberd background did not affect deep sowing sensitivity either. This may be due to the additional coleoptile shortening effects of high temperature: because Mullewa is further north than Merredin, and the Mullewa trial was planted a month earlier, the soil was warmer. The mean soil temperature recorded at nearby DAFWA weather stations over the 4 weeks after sowing was 20° at Mullewa but only 12° at Merredin. This may also explain why trials in other years have shown greater sensitivity to deep sowing at Mullewa than at Dalwallinu or Merredin (e.g. French (2014) "Wheat variety response to dry sowing and seeding depth", Agribusiness Crop Updates, Perth). It also suggests that the Mullewa results may be more relevant to situations where farmers want to chase deep moisture, since the conditions described above are most likely to occur early in the growing season in April rather than May or June.

There was considerable yield compensation for reduced establishment, especially at Merredin where the lower yield potential curtailed the density response. *Rht-3* reduced the ability to compensate for low density as well as lowering yield potential. The other dwarfing genes did not affect these processes. Dwarfing genes therefore not only affect coleoptile length and crop height, and these other effects must be evaluated to make best use of these genes in Australian wheat variety improvement.

Key words

Wheat, deep sowing, coleoptile length, dwarfing genes

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