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The Effect of Sowing Depth on Wheat

- Newly identified height genes Rht13 and Rht18 reduce plant height comparable to Rht1 or Rht2 genes, but increases coleoptile length by around 35%
- The 1AS modifier and an unknown modifier (identified in Sunchaser⒫) increases coleoptile length by about 12% in the presence of the Rht1 or Rht2 genes
- Coleoptile lengths of wheats with Rht1 and Rht2 genes vary across a range of about 15% from shortest to longest
- Longer coleoptiles are effective in improving plant establishment when sown either shallow or deep
- Where conditions are favourable, independent of coleoptile length, deep sowing (~110mm) compared to shallow sowing (~40mm):
  - Reduces plant establishment
  - Delays emergence by several days
  - Delays heading by 1-11 days
  - Reduces plant height by around 10%
  - Reduces lodging
  - Reduces grain yield
- Soil structure interacts with seedling establishment, with poorly structured soils leading to lower plant establishment independent of coleoptile length
- To maximise yield, deep sowing should be avoided, unless it is the only way to achieve germination in a timely manner

Photo – AGT deep sowing trial, Collingullie, NSW, 2020

Methodology

Split plot trials of wheat genotypes that varied for coleoptile length were conducted over three seasons across several locations (Table 1). The 2019 experiment suffered severe terminal stress, so whilst the establishment data is relevant, the yield data was severely compromised and data from this experiment has been excluded from this summary.

Table 1. Deep sowing experiments 2019 - 2021

Site	Year	Sowing date	Sowing depths – shallow/deep (mm)	Mean yield – shallow (t/ha)	Soil type	Outcome
Collingullie	2019	May 22nd	40/80	1.4	Loamy red soil surface crusting	Severe terminal stress
Collingullie	2020	May 15th	45/110	6.9	Heavy red soil, surface crusting	Low stress
Narrabri	2020	May 7th	50/150	4.0	Deep grey-black self mulching clay	Low stress
Collingullie	2021	May 18th	40/110	4.7	Heavy red soil, surface crusting	Low stress
Roseworthy	2021	June 4th	40/110	5.7	Brown	Low stress
Northam	2021	May 18th	40/120	6.1	Brown sandy loam	Low stress

Results

Table 2. Coleoptile length (millimetres) of various Rht genes and Rht gene combinations.

	Rht1	Rht1+unknown	Rht2	Rht2+1AS	Rht13	Rht18
Mean coleoptile length	97	113	93	109	133	129
Ballista⏀			88			
Beckom⏀	96					
Boree⏀			87			
Calibre⏀				108		
Catapult⏀			94			
Coolah⏀	92					
Coota⏀	99					
Denison⏀			99			
Hammer CL Plus⏀			95			
LRPB Mustang⏀	91					
LRPB Trojan⏀			98			
Mace⏀			96			
Magenta⏀				107		
Scepter⏀			85			
Sting⏀			104			
Sunblade CL Plus⏀	96					
Suncentral⏀	100					
Sunchaser⏀		113				
Sunflex⏀	102					
Sunmaster⏀	98					
Suntop⏀	98					
Vixen⏀			86			
WB88.F09					133	
WBM18						130
WC17_151						128
Yitpi⏀				113		

Source: AGT coleoptile length experiments 2017-2022

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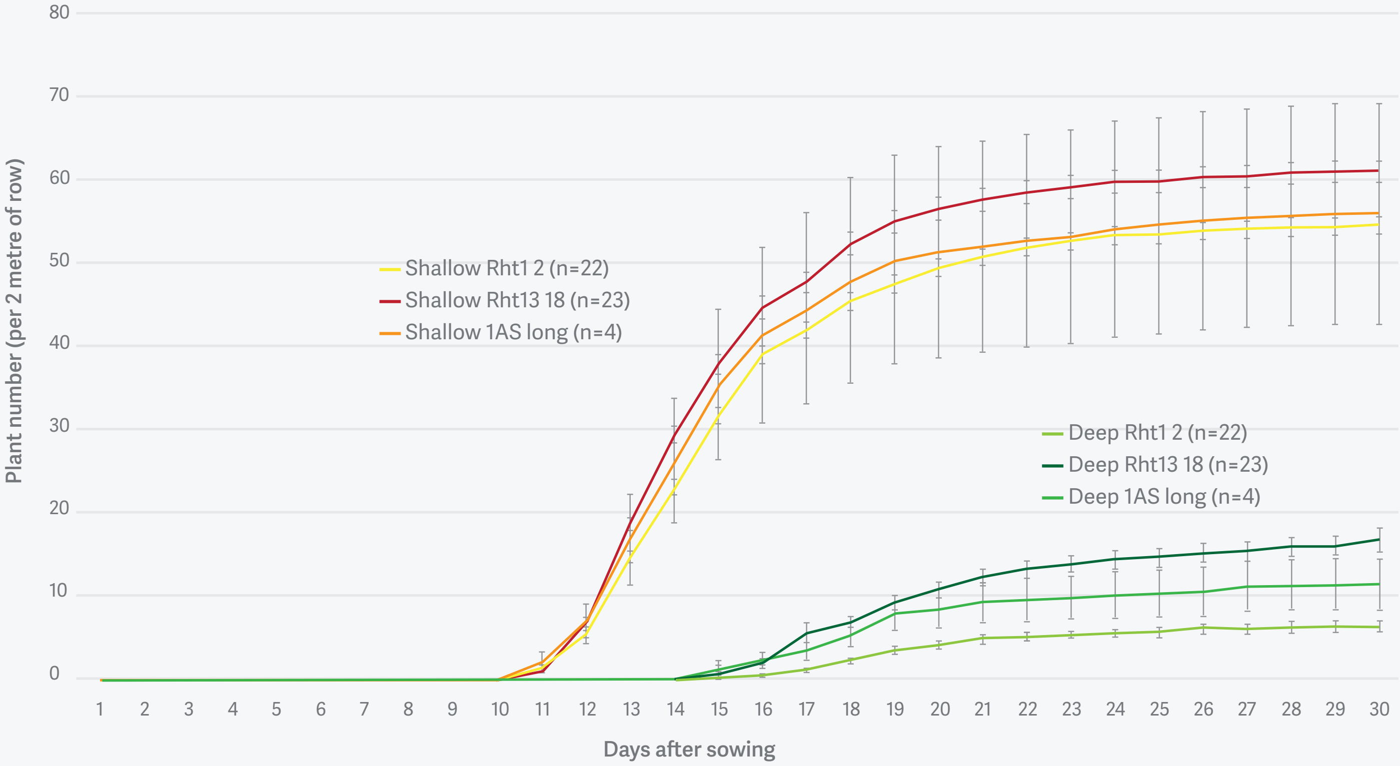
Across all experiments, a delay in emergence was observed from the deeper sown treatments.

Figure 1 shows an approximate five day delay in emergence at the Collingullie experiment in 2020.

Figure 1. Seedling emergence at 30 days after sowing grouped by Rht or 1AS gene.



Source: Jordan Bathgate, honours thesis, Collingullie, NSW, 2020

Table 3. Effect of deep sowing on time to heading and plant height.

Experiment	Delay in heading by sowing deeper relative to shallow sown (days)	Average plant height of deep relative to shallow sown (%)	Change in lodging score of deep relative to shallow sown (lower scores = less lodging)
Collingullie 2020	2	92	-2.4
Narrabri 2020	11	NA	NA
Collingullie 2021	1	86	NA
Roseworthy 2021	4	NA	NA
Northam 2021	3	NA	-1.8

Source: AGT deep sowing experiments, 2020-2021

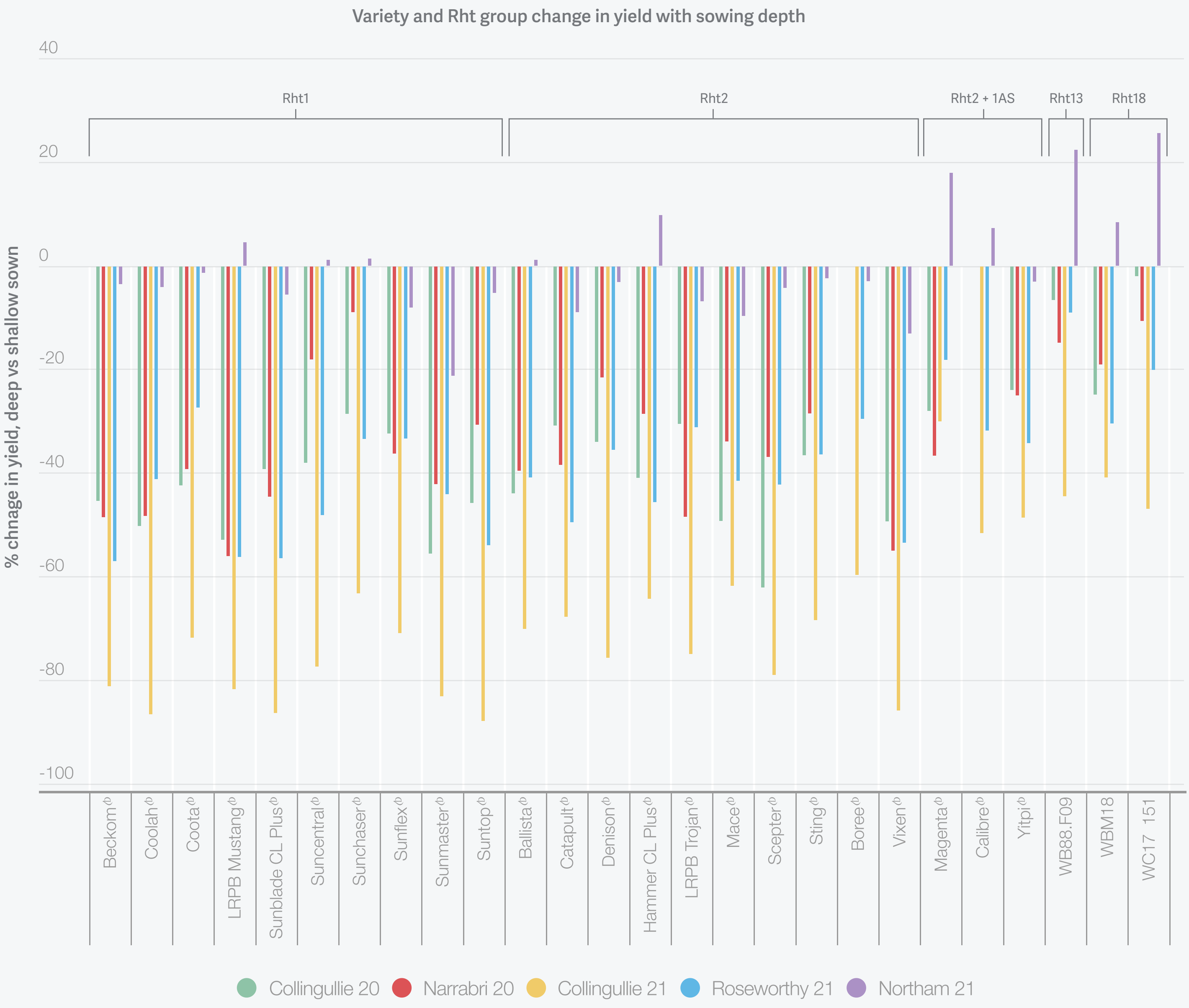
Table 4. Correlation of coleoptile length and grain yield and estimate of the effect of coleoptile length on grain yield when sown deep.

Experiment	Correlation of coleoptile length (mm) and % change in grain yield	R2	Deep sown average yield kg/ha	Effect of 10mm extra coleoptile length on grain yield (kg/ha)
Collingullie 2020	0.86	0.57	4543	390
Narrabri 2020	0.80	0.71	2799	224
Collingullie 2021	0.30	0.56	1555	46
Roseworthy 2021	0.71	0.44	3502	248
Northam 2021	0.50	0.39	6025	301

Source: AGT deep sowing experiments, 2020-2021

Effect of sowing depth on yield is summarised for the 5 sites in Figure 2 and correlations to coleoptile length shown in Table 4. In all sites apart from Northam in 2021, grain yield of the deep sown treatments were lower than the shallow sown treatments, despite coleoptile length, although the longer the coleoptile the less the loss in yield when sown deep. At Northam in 2021 there was very little effect of sowing depth on the number of plants established and as a result some of the treatments had a higher yield when sown deep than shallow. In this light soil type and favourable establishment conditions the seed probably needed to be sown at >120mm to see a decline in the number of plants established.

Figure 2. Effect of variety and its associated coleoptile length on yield across 5 experiments sown in 2020 and 2021.



Discussion

Soil type interaction

In light textured soils such as the Northam site, seedlings were able to establish at depth because the leaves which emerge from the coleoptile were able to push through the soil more easily. This was also observed at Narrabri in 2020 on a self-mulching grey clay soil that was relatively dry at the surface, and again the leaves were able to push through the soil to establish a plant. By contrast, at Collingullie with a hard setting heavy red soil, sowing at 110mm depth resulted in large clods of soil being dislodged and creating a very uneven soil around the establishing seedlings. Many of the plants that did establish did so by emerging through the cracks between the clods; creating an uneven distribution of seedlings that was certainly not ideal for establishment of a successful crop.

Costs of sowing deep

To sow seed at depth requires more energy to pull the sowing implement through the soil. This then increases fuel consumption, may reduce sowing speed and increases wear and tear on the equipment, contributing to increased cost in establishing the crop.

Herbicide interaction

The possibility of sowing deeper allowing a broader range of pre-emergent herbicides to be used has been raised by many. To date there is very little data to demonstrate the effects of this interaction, so this remains a theoretical benefit of longer coleoptiles.

Variety development

Breeding companies are currently deploying all of the genetic sources that contribute to longer coleoptiles into varieties for Australian growers.

Two recently released, well adapted varieties with longer coleoptiles are Calibre$^{\Phi}$ and Sunchaser$^{\Phi}$, offering growers tools to deploy if they have a reason to want to sow at greater depth.

Rht1 and Rht2 genes were incorporated into wheat varieties in the 1960's, reducing plant height and improving lodging tolerance and harvest index. The challenge for breeders will be to preserve these important traits in varieties whilst trying to incorporate Rht13 and Rht18 genes to improve coleoptile length.

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