2021 Victoria Crop Technology Centre
Gnarwarre, Victoria

Barley Waterlogging Damage: What can we learn?

- Water logging during late stem elongation (the critical period) reduced grain number significantly in early sown Planet barley and severe stress resulted in complete crop failure.
- 6 row slower developing winter barley had more viable stems and more grains per spike making recovery better from waterlogging.
- 6 row winter barley achieved 9.9t/ha in the absence of significant water logging and 3.1t/ha under severe water logging stress.
- RGT Planet yielded 7.8t/ha in the absence of significant water logging and 0.3t/ha under severe water logging stress.
- Apart from sowing earlier and using slower developing genetics, there was little evidence of genetic differences in field waterlogging tolerance.
- Water logging was more detrimental to barley than wheat on site.
- Little evidence to suggest more N recovered yield from water logging and/or later sowing, the lowest N treatment (10 units of N) yielded 5.65, 50 Units of N yielded 7.11 and the highest N treatment (290 units of N) yielded 6.32t/ha.

Trials at the Victoria Crop Technology Centre were badly affected by waterlogging throughout the winter of 2021 making yield results variable and interpretation more difficult. Unfortunately, most of the barley experiments were completely submerged. However, there were sections of the site that were slightly elevated and it was possible to evaluate enough replicates of a 6 row winter variety Pixel and RGT Planet side by side in non-water logged conditions through to completely stressed and submerged. This enables us to test what yields were possible in the absence of water logging and what yields are possible when subject to different water logging stress levels. The plots were scored based on % plot affected based on water submersion and visual symptoms during stem elongation and the peak period of damage (Table 1). All plots were harvested by machine harvest and hand cuts were taken for yield components.

Table 1. Summary of treatments used for yield analysis of water logging damage from 27 April sowing, side by side analysis of Winter vs Planet spring barley.

Water Log Scale	1 Non limited	2 Mild Stress	3 Moderate Stress	4 Severe Stress
% Plot Affected	<20%	20-40%	40-60%	>60%
No of Reps per variety*	4	4	6	6
Winter Barley vs Spring Barley Planet				

Figure 1 demonstrates the difference in growth responses reflecting different development types and sowing times. Early sown (27 April) Planet reached stem elongation earlier than the winter barley or the later sown Planet. Treatments that developed later and remained vegetative during waterlogging survived waterlogging better.

Winter barley sown 27 April | Planet barley sown 27 April | Planet barley sown 28 May

Figure 1. Picture of Severely stressed waterlogged plots at the start of October at Gnarwarre.
The differences in response to water logging were reflected in biomass, % viable stems, the number of grains per spike and final grain yield. Grain weights were similar across all water logging stresses in Planet and slightly lower in Pixel when waterlogged. The majority of yield loss differences came from the proportion of stems that had a viable head and the number of grains per spike. Increasing water logging stress decreased grains per spike significantly as this coincided with the critical period for grain number determination (30 days prior to flowering). The 6 row winter barley had more grains per spike under all conditions and highlights the importance of delayed development and more potential grain sites (Table 2).

Table 2. Differences in yield components in 6 row Pixel barley and Planet barley under moderate and non- limited conditions

	Viable Heads/m^2	Actual Grains/spike	Grain Weight	Grain Yield (t/ha)
Non Limited				
Planet	646a	27.9b	44.9a	7.8b
Pixel	481c	53.5a	44.3a	9.9a
Moderate Stress				
Pixel	506bc	29.6b	42.3b	5.7c
Planet	448cd	7.5c	44.9a	1.5d

Biomass numbers were similar between cultivars under mild and moderate stress levels, however slow developing barley had greater biomass under significant stress. 6 row winter barley achieved greater yields of 9.9t/ha when water logging was absent and 3.1t/ha under severe water logging stress. Whereas RGT Planet yielded 7.8t/ha when water logging was absent and 0.3t/ha under sever water logging stress (Figure 2 and Figure 3).

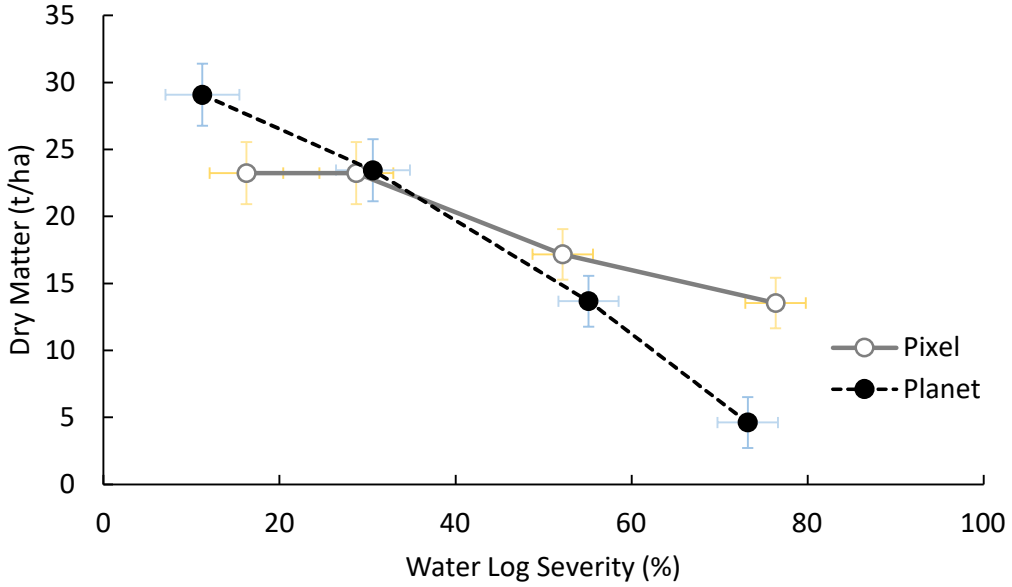

Figure 2. Relationship between dry matter and water logging severity in Pixel (6 row winter barley) and Planet barley.

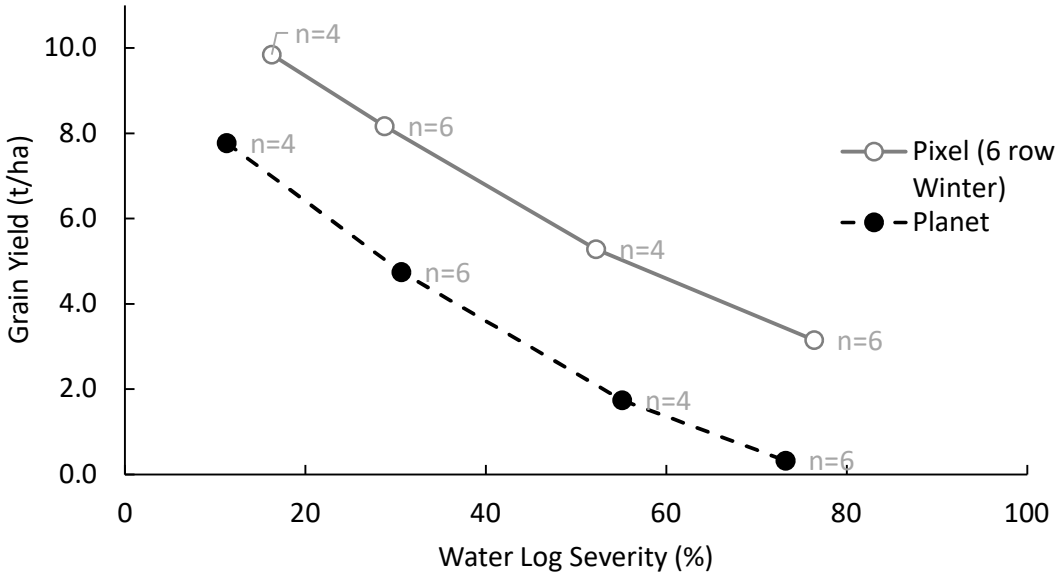

Figure 3. Relationship between dry matter and water logging severity in Pixel (6 row winter barley) and Planet barley.

What about delaying sowing and more N?

A separate experiment was located on the site that was sown to RGT Planet barley later (28 May) see Figure 1. This experiment also suffered significant water logging stress and extra N was applied as Urea. 100kg MAP was drilled at sowing (to supply 10 kg N) to the lowest N treatment and in crop applications included 50% at tillering and 50% at the onset of stem elongation. While results were variable, the lowest N treatment yielded 5.65t/ha, and an additional 40 units of N yielded 7.11t/ha. However, increasing N application over and above 50 units to 290 units of N did not further increase yield under water logging conditions Table 3. There was no significant effect on grain quality parameters.

Table 3. Responses to increasing N application in RGT Planet sown later at Gnarwarre (28 May 2021)

Nitrogen Applied (kg/ha)	Yield t/ha,	Protein %	Test Weight kg/hl	Retention %,	Screenings %
1 10N	5.65 c	11.7 -	66.6 -	89.4 -	3.4 -
2 50N	7.11 a	11.7 -	68.0 -	89.5 -	3.1 -
3 95N	6.32 ab	12.1 -	67.0 -	88.2 -	3.7 -
4 160N	6.23 ab	11.3 -	67.7 -	91.1 -	2.7 -
5 225N	6.23 ab	11.7 -	67.2 -	89.6 -	3.3 -
6 290N	6.32 ab	11.5 -	67.7 -	90.1 -	3.0 -
LSD P=.05	0.87	1.1	1.2	3.7	1.4
Treatment Prob(F)	0.050	0.750	0.232	0.728	0.761
CV	10.5	6.95	1.39	3.15	33.88

Genetic differences in tolerance to water logging?

For less severe waterlogging, the use of nitrogen can sometimes help mitigate the damage. When waterlogging is very severe, sometimes delaying sowing is the only option such as in spring, this has been shown to work well in Tasmania. The most obvious and effective methods is to use different engineering solutions to improve drainage, including the use of raised bed, surface drainage, controlled traffic farming and tillage. Combining genetic solutions and some of the ideas of winter barley with the engineering controls have the potential to assist in reducing waterlogging damage. We also included the waterlogging tolerant Planet (Planet WL) developed by Prof Meixue Zhou, Tasmanian Institute of Agriculture, University of Tasmania. The trial was significantly damaged by water logging and plots were harvested by hand to get a dry matter and yield estimate, the yield component data has not yet been processed. However, based on the dry matter data, the slower developing winter cultivars had more biomass, and there was no difference between spring cultivars and the waterlogging tolerant Planet (Planet WL). At other sites less exposed to waterlogging this line has yielded similar to Planet.

Table 4. Final maturity dry matter of selected cultivars in the elite variety screening trial sown on 28 May and subjected to water logging at Gnarwarre. (P value <0.05, LSD 2.1).

Cultivar	Maturity Dry Matter (t/ha)
Cassiopee (winter)	11.75a
Laureate (Spring)	10.35ab
Pixel (winter)	12.76a
Planet (spring)	8.42b
Planet WL (spring)	**9.73b**
Rosalind (spring)	9.44b