



Plant Growth Regulator Testing to Prevent Spring Barley Lodging in Tulelake

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Introduction: Tulelake's climate and soils are favorable for irrigated barley production, and growers consistently obtain some of the highest barley yields reported in California. A downside to these high yields is several barley varieties tend to lodge, the bending over of the stems near the ground level, in Tulelake. One solution to lodging is to apply a plant growth regulator (PGR) that shortens the internodes and strengthens the stem through inhibition of cell elongation. This study tested the effectiveness of PGRs applied at different timings and rates for reducing spring barley lodging. A similar study was conducted in 2018 and 2019 with winter wheat; report summaries are cited in IREC Research Report #187 and #192.

Methods: Two studies were conducted in 2020 at IREC. One study evaluated broadcast application of PGRs and one study evaluated chemigation of PGRs. The study sites were established in April 2020 using the spring 2-row malt barley variety 'Copeland'. The broadcast study was set up as a RCB design with four replications using 10 ft by 21 ft plots. Treatments included an Eastman PGR (Test PGR) with the active ingredient, chlormequat chloride, and a Syngenta PGR (Palisade) with the active ingredient, trinexapac-ethyl, broadcast applied at 20 gallons per acre alone and/or in combination with the fungicide Quilt Xcel for suppression of stripe rust. PGR treatments were applied at four application times: 3-leaf unfolded (growth stage 13), tillering (23), early stem elongation (31-32), and flag leaf emergence (38). The trial included a standard nitrogen fertilizer control (70# N/A) and high nitrogen fertilizer control (110# N/A).

The chemigation study was established to evaluate the effectiveness of the Eastman PGR applied using chemigation at early stem elongation (31-32) and flag leaf emergence (38). This study was setup in a RCB design with four replications. Plots were 42 ft by 30 ft. The test PGR was applied using solid-set sprinklers. The test PGR was injected into the irrigation lines at the end of a irrigation set for 30 minutes (0.1 inches of water as carrier) and then lines were shut-off immediately after flushing with a blue dye.

Evaluations for both studies included crop injury, stem thickness, plant height, stripe rust incidence, lodging, grain yield, and grain quality.

Results: PGR treatments did not cause phytotoxicity after application (data not shown). PGR treatments applied broadcast or chemigated at stem elongation or split applied at stem elongation and flag leaf emergence reduced plant height at anthesis compared to the high fertility control (Tables 1 and 2). PGR treatments applied broadcast or chemigated reduced lodging at anthesis and harvest compared to the high nitrogen fertilizer control (Tables 1 and 2 and Figure 1). Barley stem thickness, seedhead production, and the incidence of stripe rust were similar across treatments (Tables 1 and 2).

Broadcast PGR treatments increased barley grain yield compared to the controls (Table 3). PGR treatments also numerically had higher yield compared to the control in the chemigation trial (Table 4). PGRs

had a mixed effect on barley bushel weight; some treatments had higher bushel weight by a pound or two compared to other PGR treatments (Table 3). Seed weight (g) per 1000 barley seeds also differed between PGR treatments (Table 3). All PGR treatments in the broadcast study and one PGR treatment in the chemigation study lowered grain protein compared to the high fertility control (Tables 3 and 4).



Figure 1. Aerial view of barley plots at harvest showing differences in lodging.

Table 1. Influence of Plant Growth Regulator (PGR) Treatments on Barley Growth, Lodging, and susceptibility to stripe rust in 2020.

Trt #	Treatment Name ¹	Application Timing ²	Product Rate per acre	Stem thickness (mm) at anthesis	Stem thickness (mm) at harvest	Plant Height (cm) at anthesis	Plant Height (cm) at harvest	Lodging at anthesis 1-9 scale	Lodging at harvest 1-9 scale	# of seedhead per 3ft of row	Stripe rust % incidence
1	<i>Control Standard N Fertility</i>	--									
1	Quilt Xcel	D	28 fl oz	3.59a ³	3.31a	128a	122ab	7.5b	8a	112a	56a
2	<i>Control High N Fertility</i>	--									
2	Quilt Xcel	D	28 fl oz	3.67a	3.40a	131a	123a	4c	3.8b	151a	64a
3	Test PGR	B	15.5 fl oz								
3	Test PGR	C	15.5 fl oz								
3	Quilt Xcel	D	28 fl oz	3.72a	3.28a	117b	111cd	9a	8.8a	143a	68a
4	Test PGR	C	31 fl oz								
4	Quilt Xcel	D	28 fl oz	3.6a	3.33a	117b	115cd	9a	9a	133a	66a
5	Test PGR	D	31 fl oz								
5	Quilt Xcel	D	28 fl oz	3.67a	3.3a	122ab	117bc	9a	8.8a	150a	70a
6	Palisade	C	14.4 fl oz								
6	Quilt Xcel	D	28 fl oz	3.85a	3.51a	118b	109d	9a	9a	134a	69a
7	Test PGR	B	15.5 fl oz								
7	Test PGR	D	15.5 fl oz								
7	Quilt Xcel	D	28 fl oz	3.93a	3.37a	115b	112cd	9a	8.5a	148a	63a
8	Test PGR	C	15.5 fl oz								
8	Test PGR	D	15.5 fl oz								
8	Quilt Xcel	D	28 fl oz	3.6a	3.2a	117b	111cd	9a	9a	145a	68a
9	Test PGR	A	15.5 fl oz								
9	Test PGR	C	15.5 fl oz								
9	Quilt Xcel	D	28 fl oz	3.73a	3.3a	121ab	116bc	9a	8.3a	143a	68a

¹ All treatments with Quilt Xcel included nonionic surfactant added at 0.25% v/v; All PGR treatments were grown with high fertility (110# nitrogen fertilizer split-applied per acre); the standard fertility control received 70# nitrogen fertilizer split applied per acre.

² Application timings A= 3 leaf unfolded (growth stage 13); B=tillering (23); C=stem elongation (31-32); D=flag leaf emergence (38).

³ Treatment means with the same letter within columns are not statistically different using the Tukey HSD mean comparison test.

Table 2. Influence of Plant Growth Regulator (PGR) Chemigation Treatments on Barley Growth, Lodging, and susceptibility to stripe rust in 2020.

Trt #	Treatment Name ¹	Application Timing ²	Product Rate per acre	Stem thickness (mm) at anthesis	Plant Height (cm) at anthesis	Plant Height (cm) at harvest	Lodging at anthesis 1-9 scale	Lodging at harvest 1-9 scale	Stripe rust % incidence
1	Control High N Fertility	--							
1	Quilt Xcel	D	28 fl oz	3.6a	122a	123a	6.3b	5b	63a
2	Test PGR	C	31 fl oz						
2	Quilt Xcel	D	28 fl oz	3.6a	112b	116a	8.8a	7.8a	50a
3	Test PGR	D	31 fl oz						
3	Quilt Xcel	D	28 fl oz	3.6a	115b	117a	7.8a	7.5a	50a
4	Test PGR	C	16 fl oz						
4	Test PGR	D	16 fl oz						
4	Quilt Xcel	D	28 fl oz	3.5a	114b	118a	9a	8.3a	45a

¹ All treatments with Quilt Xcel included nonionic surfactant added at 0.25% v/v; All PGR treatments were grown with high fertility (110# nitrogen fertilizer split-applied per acre); the standard fertility control received 70# nitrogen fertilizer split applied per acre.

² Application timings A= 3 leaf unfolded (growth stage 13); B=tillering (23); C=stem elongation (31-32); D=flag leaf emergence (38).

³ Treatment means with the same letter within columns are not statistically different using the Tukey HSD mean comparison test.

Table 3. Influence of Plant Growth Regulator (PGR) Treatments on Barley Yield & Quality in Tulelake, CA 2020.

Trt #	Treatment Name ¹	Application Timing ²	Product		Grain yield (tons/acre)	Bushel weight (lbs)	Kernels per 10 seedheads	grams per 1000 seeds	Grain protein %
			Rate per acre	fl oz					
1	<i>Control Standard N Fertility</i>	--							
1	Quilt Xcel	D	28	fl oz	3.5b ³	51a	305a	47.3abc	10.2b
2	<i>Control High N Fertility</i>	--							
2	Quilt Xcel	D	28	fl oz	3.25b	49.8ab	289a	43.8d	12.3a
3	Test PGR	B	15.5	fl oz					
3	Test PGR	C	15.5	fl oz					
3	Quilt Xcel	D	28	fl oz	4.5a	50.9a	306a	46.6bc	9.8b
4	Test PGR	C	31	fl oz					
4	Quilt Xcel	D	28	fl oz	4.35a	49.9ab	289a	47.8abc	10b
5	Test PGR	D	31	fl oz					
5	Quilt Xcel	D	28	fl oz	4.1a	50.5a	281a	48.3ab	10.6b
6	Palisade	C	14.4	fl oz					
6	Quilt Xcel	D	28	fl oz	4.15a	48.2b	296a	48.5a	10.5b
7	Test PGR	B	15.5	fl oz					
7	Test PGR	D	15.5	fl oz					
7	Quilt Xcel	D	28	fl oz	4.33a	50a	293a	46.3c	10.3b
8	Test PGR	C	15.5	fl oz					
8	Test PGR	D	15.5	fl oz					
8	Quilt Xcel	D	28	fl oz	4.3a	49.7ab	294a	48.3ab	10b
9	Test PGR	A	15.5	fl oz					
9	Test PGR	C	15.5	fl oz					
9	Quilt Xcel	D	28	fl oz	4.22a	49.9ab	291a	46.8abc	10.2b

¹ All treatments with Quilt Xcel included nonionic surfactant added at 0.25% v/v; All PGR treatments were grown with high fertility (110# nitrogen fertilizer split-applied per acre); the standard fertility control received 70# nitrogen fertilizer split applied per acre.

² Application timings A= 3 leaf unfolded (growth stage 13); B=tillering (23); C=stem elongation (31-32); D=flag leaf emergence (38).

³ Treatment means with the same letter within columns are not statistically different using the Tukey HSD mean comparison test.

Table 4. Influence of Plant Growth Regulator (PGR) Chemigation Treatments on Barley Yield & Quality in Tulelake, CA 2020.

Trt #	Treatment Name ¹	Application Timing ²	Product Rate per acre	Grain yield (tons/acre)	Bushel weight (lbs)	Grain Protein %
1	Control High N Fertility	--				
1	Quilt Xcel	D	28 fl oz	3.92a	49.3a	11.3a
2	Test PGR	C	31 fl oz			
2	Quilt Xcel	D	28 fl oz	3.96a	50.6a	9.9b
3	Test PGR	D	31 fl oz			
3	Quilt Xcel	D	28 fl oz	4.03a	51.7a	10.6ab
4	Test PGR	C	16 fl oz			
4	Test PGR	D	16 fl oz			
4	Quilt Xcel	D	28 fl oz	4.12a	50.3a	10.5ab

¹ All treatments with Quilt Xcel included nonionic surfactant added at 0.25% v/v; All PGR treatments were grown with high fertility (110# nitrogen fertilizer split-applied per acre); the standard fertility control received 70# nitrogen fertilizer split applied per acre.

² Application timings A= 3 leaf unfolded (growth stage 13); B=tillering (23); C=stem elongation (31-32); D=flag leaf emergence (38).

³ Treatment means with the same letter within columns are not statistically different using the Tukey HSD mean comparison test.