

2017 Hail Damage Studies

Zuger, R.J. & I.C. Burke

The objective of the study was to evaluate the effects of hail damage at different wheat stages on yield and end quality. This study was repeated in 2018 and will be repeated a third time in 2019.

Five studies were established around the PNW in four different wheat varieties; two soft white winter wheat Puma studies, one winter club Cara study, one soft white spring Seahawk study, and one hard red winter wheat study. Treatments were applied by hand at specific wheat stages to both below and above flag leaves (FL), detailed in Table 1 through 5. Each study was conducted in a randomized complete block with 4 replications with plots 5' by 10' long plots. All studies were harvested in August by hand cutting wheat heads from a 1-meter quadrant in each plot. The Central Ferry soft white winter wheat studies was the only exception and was harvested in mid-July. Heads were sorted between broken and nonbroken stems in the field and placed in separate bags to make subsamples and then counted in the lab. Head count data for the soft white winter wheat were square-root transformed. Tillers without heads or absent heads were counted in the field and added to the total number of tillers. Broken and nonbroken sub-samples weights were combined to calculate yield. One hundred seeds were randomly selected from each sub-sample and weighed, and protein content and falling numbers were determined by the WSU Wheat Quality Lab. All data were subjected to an analysis of variance using the statistical package built into the Agricultural Research Manager software system (ARM 8.5.0, Gylling Data Management).

Broken head counts were the majority of the harvested heads in most treatments. Watery ripe, milk, soft dough, and hard dough stages had mostly broken heads. The above flag leaf treatments commonly had less broken heads than the below flag leaf treatments within a wheat stage. Stems of plants treated at the boot stage and the anthesis stage recovered with all varieties, except the winter club, having more nonbroken heads than broken. Treatments at anthesis resulted in 50/50 broken and nonbroken heads for most varieties, except the soft white winter wheat, one study had more nonbroken heads and the other had more broken heads.

There were no differences total number of tillers for any treatment and any variety.

Overall, below leaf flag treatments applied at anthesis and watery ripe stages caused yield loss compared to the nontreated control. Soft white winter wheat study 1 had the lower yields for anthesis below flag leaf, watery ripe below flag leaf, and milk above flag leaf treatments than the nontreated control and all other treatments. For study 2, watery ripe below flag leaf was the only treatment to cause yields lower than the nontreated. No other treatment had a significant effect on yield for the soft white winter wheat. Similar results were found for the hard red winter wheat with lower yields for anthesis and watery ripe applied below flag leaf with no other treatment causing a significant loss in yield. There was no difference in yield for the club winter wheat and soft white spring wheat.

For 100 seed weight, overall either treatment applied at watery ripe or milk stage caused a reduction in 100 seed weight for the broken heads for all varieties. The winter club resulted a reduction in 100 seed weight of broken heads for all treatments. There was no difference in 100 seed weight of nonbroken heads for any variety except the winter club wheat which had a reduced weight for both milk treatments and the above flag leaf soft dough and hard dough treatments.

Protein content for the broken heads significantly reduced for the soft white winter wheat, hard red winter wheat, and the winter club wheat as the hail damage was applied at later stages. The nonbroken heads for the soft white winter wheat had no difference in protein content, and the nontreated control on the lowest protein content for the hard red winter wheat and winter club wheat. There was no difference in protein content for either the broken or nonbroken heads for the soft white spring wheat.

There was no effect on falling number for any variety except the hard red winter wheat which had lower falling number as treatments were applied at later stages.

Table 1 (ICB2217). Soft white winter wheat total number of heads, total number of tillers, yield, 100 seed weight, protein content, and falling numbers following hail damage treatments. All treatments were applied by hand at wheat stage indicated in treatment timing. FL = flag leaf. Pullman, WA, 2017. Means followed by the same letter are not statistically significantly different ($\alpha=0.05$).

Treat Timing Wheat Stage	Application Date	Application Description	Head Counts		Tillers		Yield		100 Seed Weight		Protein Content		Falling Number	
			Broken #/m ²	Nonbroken #/m ²	Total #/m ²	Total bu/A	Broken g	Nonbroken g	Broken %	Nonbroken %	Broken #	Nonbroken #		
Nontreated	-	-	10 f	680 a	700 ab	149 ab	3.76 ab	3.67	-	9.33	-	-	-	462 a
Boot	June 7	Below FL	70 e	600 ab	680 ab	152 a	3.54 ab	3.76	10.15 abcd	10.20	483	462 a	462 a	
Anthesis	June 16	Below FL	430 abc	120 d	580 b	107 d	3.77 ab	3.89	10.85 ab	9.60	433	382 b	382 b	
		Above FL	160 d	460 b	630 ab	125 abcd	3.74 ab	3.63	11.40 abc	9.70	430	470 a	470 a	
Waxary ripe	June 28	Below FL	620 a	50 e	670 ab	114 cd	3.10 cd	3.95	11.13 a	-	415	-	415	
		Above FL	530 ab	220 cd	750 a	130 abcd	3.01 d	3.71	11.00 ab	10.20	436	453 a	453 a	
Milk	July 5	Below FL	610 a	50 e	660 ab	132 abcd	3.48 bc	3.85	9.65 bcd	-	423	-	423	
		Above FL	400 bc	200 cd	610 ab	118 bcd	3.49 bc	3.84	9.93 abcd	9.93	438	471 a	471 a	
Soft dough	July 13	Below FL	590 ab	40 e	630 ab	141 abc	3.81 ab	3.75	8.98 d	-	440	-	440	
		Above FL	330 c	310 c	640 ab	141 abc	3.70 ab	3.67	8.98 d	9.50	435	437 a	437 a	
Hard dough	July 24	Below FL	550 ab	10 e	570 b	135 abcd	4.06 a	3.80	9.35 cd	-	445	-	445	
		Above FL	470 abc	190 cd	670 ab	143 abc	3.72 ab	3.79	8.78 d	9.13	455	451 a	451 a	
LSD			2.92t	3.14t	99.97	20.09	0.33	NS	0.92	NS	NS	NS	29.81	

Table 2 (ICB2317). Hard red winter wheat total number of heads, total number of tillers, yield, 100 seed weight, protein content, and falling numbers following hail damage treatments. All treatments were applied by hand at wheat stage indicated in treatment timing. FL = flag leaf. Davenport, WA, 2017. Means followed by the same letter are not statistically significantly different ($\alpha=0.05$).

Treat Timing Wheat Stage	Application Date	Application Description	Head Counts		Tillers		Yield		100 Seed Weight		Protein Content		Falling Number	
			Broken #/m ²	Nonbroken #/m ²	Total #/m ²	Total bu/A	Broken g	Nonbroken g	Broken %	Nonbroken %	Broken #	Nonbroken #		
Nontreated	-	-	4 c	570 a	570 a	154 a	4.45	3.89	-	11.3 b	-	-	538 ab	
Boot	June 6	Below FL	70 c	470 b	540	127 abc	4.50	3.94	15.0 a	11.7 ab	682 a	558 ab	558 ab	
Anthesis	June 13	Below FL	250 b	150 d	400	84 c	4.33	4.10	13.3 b	12.6 ab	715 a	594 a	594 a	
		Above FL	190 b	360 c	550	137 abc	4.40	3.87	11.6 bcd	12.0 ab	556 b	540 ab	540 ab	
Waxary ripe	June 27	Below FL	420 a	20 f	450	102 bc	3.73	3.71	12.4 bc	-	543 b	-	543 b	
		Above FL	420 a	110 de	530	127 abc	3.70	3.95	12.5 bc	13.6 a	471 b	491 b	491 b	
Milk	July 7	Below FL	480 a	10 f	490	134 ab	3.91	3.90	11.5 cd	-	543 b	-	543 b	
		Above FL	450 a	100 de	550	137 ab	3.83	3.82	11.3 cd	12.4 ab	535 b	581 a	581 a	
Soft dough	July 11	Below FL	440 a	40 ef	480	127 abc	4.03	4.01	11.3 cd	-	551 b	-	551 b	
		Above FL	460 a	70 ef	530	131 ab	3.83	3.95	11.3 cd	-	546 b	-	546 b	
Hard dough	July 25	Below FL	450 a	10 f	460	124 abc	3.99	3.60	11.4 cd	-	551 b	-	551 b	
		Above FL	460 a	40 ef	500	135 ab	4.05	3.90	10.6 d	-	495 b	-	495 b	
LSD			113.96	51.53	NS	26.94	NS	NS	1.03	1.27	NS	NS	56.65	

Table 3 (ICB2417). Soft white spring wheat total number of heads, total number of tillers, yield, 100 seed weight, protein content, and falling numbers following hail damage treatments. All treatments were applied by hand at wheat stage indicated in treatment timing. FL = flag leaf. Pullman, WA, 2017. Means followed by the same letter are not statistically significantly different ($\alpha=0.05$).

Trt Timing Wheat Stage	Application Date	Application Description	Head Counts		Tillers		Yield		100 Seed Weight		Protein Content		Falling Number	
			Broken	Nonbroken	Total	Nonbroken	Broken	Nonbroken	Broken	Nonbroken	Broken	Nonbroken	Broken	Nonbroken
			#/m ²	#/m ²	#/m ²	#/m ²	bu/A	g	%	g	%	#	#	
Non-treated	-	-	0 e	440 a	440	63	-	3.53	-	8.9	-	-	408	
Boot	June 26	Below FL	20 e	450 a	470	57	3.33	3.24	9.0	9.4	424 ab	414		
Anthesis	July 5	Below FL	270 c	210 c	480	58	3.07	3.25	9.9	9.4	460 ab	430		
		Above FL	190 d	290 b	480	64	3.35	3.40	9.1	9.0	415 ab	420		
Watery ripe	July 12	Below FL	410 ab	70 ef	480	52	2.98	3.40	9.9	9.2	476 a	437		
		Above FL	310 c	190 cd	500	59	3.08	3.25	9.6	9.5	427 ab	416		
Milk	July 17	Below FL	430 a	50 f	480	59	3.03	3.35	10.2	-	446 ab	-		
		Above FL	290 c	120 de	410	52	3.42	3.27	8.8	-	399 b	-		
Soft dough	July 20	Below FL	400 ab	20 f	420	58	3.43	3.27	8.8	-	429 ab	-		
		Above FL	320 bc	130 de	460	60	3.47	3.29	9.0	-	400 b	-		
Hard dough	August 2	Below FL	440 a	40 f	480	63	3.45	3.12	9.0	-	426 ab	-		
		Above FL	340 bc	150 cd	490	62	3.45	3.08	8.8	-	419 ab	450		
LSD			68.47	57.18	NS	NS	NS	NS	NS	NS	43.37	NS		

Table 4 (ICB2517). Winter club wheat total number of heads, total number of tillers, yield, 100 seed weight, protein content, and falling numbers following hail damage treatments. All treatments were applied by hand at wheat stage indicated in treatment timing. FL = flag leaf. Pullman, WA, 2017. Means followed by the same letter are not statistically significantly different ($\alpha=0.05$).

Trt Timing Wheat Stage	Application Date	Application Description	Head Counts		Tillers		Yield		100 Seed Weight		Protein Content		Falling Number	
			Broken	Nonbroken	Total	Nonbroken	Broken	Nonbroken	Broken	Nonbroken	Broken	Nonbroken	Broken	Nonbroken
			#/m ²	#/m ²	#/m ²	#/m ²	bu/A	g	%	g	%	#	#	
Non-treated	-	-	1 c	520 a	520	123	3.71 a	3.11 a	-	11.0 b	-	511		
Boot	June 6	Below FL	200 b	270 bc	470	100	3.14 b	3.39 a	12.4 ab	11.2 b	517	517		
Anthesis	June 13	Below FL	190 b	350 b	540	97	2.75 bcd	2.75 ab	13.6 a	11.5 b	526	513		
		Above FL	90 bc	510 a	590	124	3.03 bc	3.17 a	12.3 ab	11.2 b	477	501		
Watery ripe	June 27	Below FL	520 a	20 d	540	102	2.64 bcd	3.01 a	12.7 ab	-	464	-		
		Above FL	440 a	130 cd	580	111	2.59 cd	2.58 ab	12.5 ab	12.7 ab	507	552		
Milk	July 7	Below FL	520 a	60 d	580	98	2.35 d	2.15 b	12.4 ab	-	497	-		
		Above FL	450 a	150 cd	600	102	2.44 d	2.18 b	11.8 b	-	518	-		
Soft dough	July 18	Below FL	510 a	10 d	520	106	2.75 bcd	2.79 ab	11.6 b	-	529	-		
		Above FL	470 a	140 cd	610	113	2.59 cd	2.11 b	11.4 b	13.2 a	528	589		
Hard dough	July 25	Below FL	520 a	20 d	540	115	2.78 bcd	2.79 ab	11.3 b	-	508	-		
		Above FL	490 a	100 d	590	120	2.73 bcd	2.20 b	11.6 b	-	525	-		
LSD			113.00	109.53	NS	NS	0.34	0.53	1.02	1.25	NS	NS		

Table 5 (ICB3117). Soft white winter wheat total number of heads, total number of tillers, yield, 100 seed weight, protein content, and falling numbers following hail damage treatments. All treatments were applied by hand at wheat stage indicated in treatment timing. FL = flag leaf. Central Ferry, WA, 2017. Means followed by the same letter are not statistically significantly different ($\alpha=0.05$).

Trt Timing / Wheat Stage	Application Date	Application Description	Head Counts		Tillers		Yield		100 Seed Weight		Protein Content		Falling Number	
			Broken #/m ²	Nonbroken #/m ²	Total #/m ²	Total bu/A	Broken E	Nonbroken E	Broken %	Nonbroken %	Broken #	Nonbroken #		
Non-treated	-	-	0 c	390 a	390	98 a	3.61 bcd	3.73	-	10.2	-	-	394	
Boot	May 10	Below FL	10 c	340 a	350	90 ab	3.86 abc	3.90	-	9.7	-	-	374	
Anthesis	May 18	Below FL	40 b	310 a	360	86 ab	4.31 a	3.83	-	10.4	-	-	395	
		Above FL	10 c	350 a	360	98 a	3.88 abc	3.79	-	9.8	-	-	375	
Watery ripe	June 6	Below FL	350 a	20 cd	380	75 b	3.16 de	3.52	10.8 ab	-	-	-	390	
		Above FL	310 a	70 b	380	77 ab	3.04 e	3.45	11.2 ab	-	-	-	387	
Milk	June 12	Below FL	340 a	10 d	360	81 ab	3.42 bcde	3.44	11.4 a	-	-	-	375	
		Above FL	250 a	90 b	340	76 ab	3.32 cde	3.40	10.6 ab	-	-	-	378	
Soft dough	June 23	Below FL	300 a	20 cd	330	84 ab	4.02 ab	3.60	9.6 ab	-	-	-	374	
		Above FL	240 a	110 b	350	96 ab	4.04 ab	3.68	9.4 b	9.9	-	-	351	
Hard dough	June 29	Below FL	300 a	40 c	360	92 ab	3.95 ab	3.75	9.6 ab	10.2	-	-	359	
		Above FL	250 a	120 b	360	91 ab	3.95 ab	3.67	9.8 ab	-	-	-	382	
LSD			2.84t	2.00t	NS	13.28	0.39	NS	1.21	NS	NS	NS		