Table 1. Enhanced point quadrat analysis (EPQA) characteristics of Grüner Veltilner vines with different crop load management treatments. Measurements were taken at pre-veraison (16 Jul 2015 and 28 Jul 2016) and post-veraison (25 Aug 2015 and 7 Sep 2016).

	Percent gaps (%)	Leaf layer number (n)	Occlusion layers (n)	Interior clusters (PIC) (%)	Interior leaves (PIL) (%)	Cluster exposure flux availability (CEFA) (%)	Leaf exposure flux availability (LEFA) (%)
Pre-veraison							
Treatment (T)[a]							
Control	11.46	1.01 a[b]	1.86 a	18.2 a	20.4 a	57.1	53.1
CT	12.50	0.84 ab	1.59 ab	11.8 ab	10.2 b	59.5	56.9
TBLR	14.93	0.42 c	1.39 b	14.3 ab	12.2 ab	64.0	54.4
FSLR	17.24	0.58 bc	1.50 ab	13.7 b	5.9 b	64.1	57.5
P-value (T)	0.318	< 0.001	0.009	0.079	0.008	0.208	0.627
Year (Y)							
2015	12.09	0.78	1.62	10.7	13.1	62.4	56.6
2016	15.97	0.65	1.55	14.8	11.3	59.9	54.3
P-value (Y)	0.109	0.777	0.475	0.064	0.496	0.363	0.627
P-value (TxY)	0.781	0.647	0.720	0.680	0.100	0.674	0.966
Post-veraison							
Treatment (T)							
Control	13.20	0.98 ab	1.78	22.0	13.9	55.3	57.1
CT	12.85	1.15 a	1.73	19.5	13.6	53.0	53.6
TBLR	9.38	1.12 a	1.88	23.4	14.3	60.5	53.4
FSLR	12.85	0.78 b	1.62	16.0	13.7	53.9	59.9
P-value (T)	0.669	0.019	0.128	0.253	0.995	0.133	0.075
Year (Y)							
2015	11.98	1.08	1.80	21.9	17.0	56.4	56.2
2016	12.15	0.94	1.71	18.5	10.8	54.9	55.8
P-value (Y)	0.945	0.105	0.224	0.253	0.007	0.544	0.846
P-value (TxY)	0.677	0.581	0.541	0.665	0.822	0.241	0.790

[a]CT = cluster thinning; TBLR = trace bloom leaf removal; FSLR = fruit set leaf removal
[b]Treatment means followed by different letters within a column are significantly different (Tukey's HSD test, *P* < 0.10)

Table 2. Main, lateral, and total leaf area at harvest for Grüner Veltilner vines with different crop load management treatments. Data are separated by year due to significant treatment by year interaction.

	Main leaf area (cm^2)	Lateral leaf area (cm^2)	Total leaf area (cm^2)
2015			
Treatment (T)[a]			
Control	1836.6	1691.2	3527.8
CT	1884.5	1582.7	3467.2
TBLR	1724.8	1758.6	3483.4
FSLR	1805.8	1878.6	3684.3
P-value (T)	0.951	0.666	0.955
2016			
Treatment (T)			
Control	1823.5 ab[b]	2026.6	3850.1 ab
CT	2009.8 a	2427.2	4437.0 a
TBLR	1894.7 ab	2217.6	4112.3 ab
FSLR	1556.4 b	1840.9	3397.3 b
P-value (T)	0.072	0.128	0.015

[a]CT = cluster thinning; TBLR = trace bloom leaf removal; FSLR = fruit set leaf removal
[b]Treatment means followed by different letters within a column are significantly different (Tukey's HSD test, *P* < 0.10)

Table 3. Effects of treatment and year on yield components, bunch rot, pruning weight, and crop load for Grüner Veltliner vines.

	Yield/ Vine (kg)	Clusters/ vine (n)	Cluster wt (g)	Pruning wt/ vine (kg)	Ravaz index (yield/prun. wt [kg/kg])	LA/yield (cm^2/g)	Cluster compactness (1-5)[b]	Rot severity (% cluster area)	Rot intensity (% clusters)
Treatment (T)[a]									
Control	8.89 a	49 a	190 b	1.18 ab	7.91 a	8.11 b	3.50 ab	4.42 a	71.7 a
CT	5.40 c	36 b	220 a	1.35 a	3.78 b	14.65 a	3.75 a	4.10 ab	69.2 a
TBLR	7.77 b	46 a	170 b	1.07 b	6.99 a	8.82 b	3.13 bc	2.81 ab	55.8 b
FSLR	7.71 b	45 a	170 b	1.19 ab	6.56 a	9.85 b	2.88 c	2.69 b	57.1 b
P-value (T)	< 0.001	< 0.001	< 0.001	0.031	< 0.001	< 0.001	0.001	0.012	0.005
Year (Y)									
2015	7.54	47 a	210 a	1.22	6.44	11.45 a	3.19	4.81 a	76.7
2016	7.34	35 b	160 b	1.18	6.17	9.27 b	3.44	2.19 b	50.2
P-value (Y)	0.418	< 0.001	< 0.001	0.469	0.588	0.005	0.048	< 0.001	< 0.001
P-value (TxY)	0.477	0.110	0.149	0.635	0.534	0.870	0.542	0.436	0.467

[a]CT = cluster thinning; TBLR = trace-bloom leaf removal; FSLR = fruit set leaf removal
[b]Scale range is from 1= very loose clusters, no berry contact, bending of the stem to 90° possible to 5 = very compact, berries not flexible, bending of the stem not possible (Ipach et al. 2005)
[c]Treatment means followed by different letters within a column are significantly different (Tukey's HSD test, *P* < 0.10)

Table 4. Effects of treatment and year on berry weight, total number of berries per cluster, and percentage of normal size, 'chicken' and infected berries, and live green ovaries for basal and distal clusters of Grüner Veltliner vines.

	Berry wt (g)	Total berries /clusters (n)	Normal size berries (%)	'Chicken' berries (%)	Rot-infected berries (%)	Live green ovaries (%)
			Basal cluster			
Treatment (T)[a]						
Control	1.65 ab[b]	160	89.02	3.91	4.58 a	1.81
CT	1.70 a	157	90.66	3.78	3.06 ab	2.17
TBLR	1.63 ab	140	89.36	3.46	4.16 ab	1.90
FSLR	1.56 b	157	89.41	4.91	2.67 b	2.40
P-value (T)	0.024	0.161	0.529	0.255	0.070	0.635
Year (Y)						
2015	1.57	138	87.19	6.14	5.29	0.02
2016	1.70	170	92.03	1.89	1.95	4.12
P-value (Y)	< 0.001	0.161	< 0.001	< 0.001	< 0.001	< 0.001
P-value (T x Y)	0.270	0.933	0.600	0.102	0.465	0.629
			Distal cluster			
Treatment (T)						
Control	1.68	109	88.02	4.71 ab	4.44 a	2.32
CT	NA[c]	NA	NA	NA	NA	NA
TBLR	1.65	93	91.17	3.56 b	2.41 b	2.12
FSLR	1.60	105	88.52	5.83 a	4.07 ab	1.46
P-value (T)	0.215	0.097	0.145	0.073	0.073	0.167
Year (Y)						
2015	1.56	86	86.69	7.30	5.09	0.02
2016	1.71	118	91.79	2.10	2.19	3.92
P-value (Y)	0.001	< 0.001	0.002	< 0.001	0.001	< 0.001
P-value (T x Y)	0.913	0.097	0.696	0.344	0.338	0.162

[a]CT = cluster thinning; TBLR = trace bloom leaf removal; FSLR = fruit set leaf removal
[b]Treatment means followed by different letters within a column are significantly different (Tukey's HSD test, *P* = 0.10)
[c]Distal cluster removed from CT treatment

Table 5. Effects of treatment and year on Grüner Veltliner juice composition for basal cluster, distal cluster, and combined basal and distal cluster at harvest 2015 and 2016.

	TSS (Brix)	pH	TA (g/ L)	TSS (Brix)	pH	TA (g/L)	TSS (Brix)	pH	TA (g/L)
	2015								
	Basal cluster			*Distal cluster*			*Basal + distal cluster*		
Treatment (T)[a]									
Control	21.4 b[b]	3.63	4.16	21.8	3.61	4.26	21.6 ab	3.61	4.20
CT	22.1 a	3.61	4.27	NA[c]	NA	NA	22.1 a	3.62	4.27
TBLR	21.3 b	3.64	4.29	21.9	3.61	4.43	21.7 ab	3.61	4.35
FSLR	22.1 a	3.62	4.25	21.4	3.61	4.44	21.3 b	3.62	4.33
P-value (T)	0.001	0.719	0.850	0.143	0.919	0.636	0.033	0.959	0.744
	2016								
	Basal cluster			*Distal cluster*			*Basal + distal cluster*		
Treatment (T)									
Control	21.1 bc	3.62 b	4.12	21.5	3.61	4.11	21.0 b	3.60 b	4.12
CT	23.0 a	3.77 a	4.07	NA	NA	NA	23.0 a	3.77 a	4.07
TBLR	21.9 ab	3.72 ab	4.24	22.2	3.72	4.10	22.1 ab	3.74 ab	4.10
FSLR	20.5 c	3.63 ab	4.21	21.2	3.64	4.10	20.8 b	3.63 ab	4.09
P-value (T)	0.005	0.025	0.959	0.261	0.110	0.989	0.009	0.016	0.999

[a]CT = cluster thinning; TBLR = trace bloom leaf removal; FSLR = fruit set leaf removal
[b]Treatment means followed by different letters within a column are significantly different (Tukey's HSD *P* < 0.10)
[c]NA: distal cluster removed from CT treatment

Table 6. Effects of treatment and year on Grüner Veltliner shoot efficiency, or source-sink balance.

	Total sugar (g)			Leaf area-to-yield ratio
	per shoot	per berry	per cm^2 leaf area	cm^2/g
Treatment (T)[a]				
Control	95.9 a[b]	0.355	0.026 a	8.11 b
CT	93.6 a	0.357	0.025 ab	14.65 a
TBLR	83.2 a	0.357	0.024 ab	8.82 b
FSLR	56.5 b	0.357	0.016 b	9.85 b
P-value (T)	< 0.001	0.998	0.089	< 0.001
Year (Y)				
2015	95. 5	0.371	0.028	11.45 a
2016	69.1	0.341	0.018	9.27 b
P- value (Y)	< 0.001	< 0.001	< 0.001	0.005
P- value (T x Y)	0.412	0.073	0.473	0.870

[a]CT = cluster thinning; TB = trace-bloom leaf removal; FSLR = fruit set leaf removal
[b]Treatment means followed by different letters within a column are significantly different (Tukey's HSD test, *P* < 0.10)

Table 7. Bud median low-temperature exotherm (LT_{50}; °C) of Grüner Veltliner vines with different crop load management treatments from November 2015 through March 2016 and from November 2016 through March 2017.

	November 2015	December 2015	January 2016	February 2016	March 2016
Treatment (T)[a]					
Control	-12.72 a[b]	-21.13	-22.91	-22.58	-19.82
CT	-13.09 b	-21.48	-22.78	-22.56	-19.68
TBLR	-13.06 b	-20.97	-22.94	-22.61	-19.95
FSLR	-13.07 b	-21.32	-22.87	-23.03	-19.70
P-value (T)	0.039	0.181	0.913	0.360	0.659
Treatment (T)					
Control	-13.20 a	-20.50	-22.53 ab	-21.92	-19.95
CT	-13.82 ab	-20.36	-22.17 a	-21.90	-19.79
TBLR	-14.11 b	-20.36	-22.24 a	-22.50	-20.01
FSLR	-13.46 ab	-20.82	-22.91 b	-22.52	-20.21
P-value (T)	0.030	0.543	0.035	0.210	0.556

[a]CT = cluster thinning; TBLR = trace bloom leaf removal; FSLR = fruit set leaf removal
[b]Treatment means followed by different letters within a column are different based are significantly different (Tukey's HSD test, *P* < 0.10)

Table 8. Production cost associated with early leaf removal and cluster thinning and price analysis of Grüner Veltliner

	Additional cost of crop load management ($/ha)[a]	Additional production cost ($/t)	Yield (t/ha)	Expected revenue[a] ($/ha)	Preferred price to maintain revenue ($/t)	Additional cost[b] ($/bottle)
Treatment (T)[e]				**2015**		
Control	0	0	25	36,969	1,361	0.00
CT	133	9	15	20,760	2,207	1.18
TBLR	102	5	20	27,381	1,672	0.43
FSLR	96	5	21	28,641	1,598	0.33
				2016		
Control	0	0	23	35,764	1,406	0.00
CT	133	9	14	19,309	2,372	1.34
TBLR	102	5	21	29,923	1,533	0.17
FSLR	96	5	21	29,098	1,579	0.23

[a]The average industry price per tonne for Grüner Veltliner was $1,361 in 2015 and $1,406 in 2016.
[b]The additional retail price for a 750 mL bottle of wine under the assumptions of 491.4 L wine (655.2 bottles) per tonne of grapes, and that the producer uses the grapes for winemaking instead of selling the grapes at market price.
[c]CT = cluster thinning; TBLR = trace bloom leaf removal; FSLR = fruit set leaf removal.