Supplemental Information for:

Full title: Soil compaction drives an intra-genotype Leaf Economics Spectrum in wine grapes

Short title: Leaf trait variation and soil compaction in grape

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Table S1. Mean 'Chardonnay' leaf trait values and associated standard deviations across 15 plants, growing across five planting rows in 2020, differing in soil bulk density. Each trait-by-row cell reflects the mean and standard deviations on nine leaves. Also shown are the results of an analysis of variance (ANOVA) evaluating differences in traits as a function of planting row. Trait acronyms are defined and presented in Table 1 in the main text.

	Mean trait values (± standard deviations) across planting rows					**Analysis of variance**	
Trait	**Row 1**	**Row 2**	**Row 3**	**Row 4**	**Row 5**	***F***	***p***
A_{max} (μmol CO_2 m^{-2} s^{-1})	19.87±3.5	12.38±2.82	11.3±2.13	14.0±5.1	9.49±1.37	13.47	<0.001
A_{mass} (μmol CO_2 g^{-1} s^{-1})	0.28±0.05	0.15±0.04	0.13±0.02	0.18±0.06	0.1±0.02	24.19	<0.001
R_{dark} (μmol CO_2 m^{-2} s^{-1})	0.96±0.2	0.59±0.15	0.67±0.17	0.68±0.29	0.81±0.24	4.239	0.006
R_{mass} (μmol CO_2 g^{-1} s^{-1})	0.013±0.003	0.007±0.003	0.008±0.003	0.009±0.004	0.009±0.004	7.62	<0.001
LLCP (μmol PAR m^{-2} s^{-1})	15.33±4.33	13.48±3.08	13.76±2.68	13.73±4.72	17.77±3.9	2.015	0.111
Φ (mol CO_2 mol $PPFD^{-1}$)	0.068±0.016	0.044±0.017	0.049±0.018	0.049±0.012	0.047±0.013	7.72	<0.001
Area (cm^2)	117.02±19.69	79.99±33.66	88.96±15.63	82.76±14	94.12±9.35	4.766	0.003
LMA (g m^{-2})	72.28±4.26	81.5±9.85	87.92±4.35	76.87±4.34	94.28±7.86	16	<0.001
Dry mass (g)	0.85±0.15	0.67±0.34	0.79±0.17	0.64±0.11	0.89±0.15	2.712	0.043
Carbon (% mass)	44.61±0.6	43.13±0.75	43.41±0.48	43.19±0.39	42.89±0.34	14.52	<0.001
Nitrogen (% mass)	2.6±0.18	2.21±0.19	2.07±0.05	2.25±0.18±	2.13±0.1	17.07	<0.001

Table S2. Variation in 11 'Chardonnay' leaf traits as a function of bulk density (as a fixed factor), while accounting for plant identity (as a random factor). Traits expressing a statistically significant relationship with bulk density (where $p \leq 0.05$ for the slope parameter) are highlighted in bold. Also shown are marginal r^2 values, which represent the proportion of variation in a given leaf trait explained by fixed factors alone (i.e., bulk density and model intercept), as well as condition r^2 values, which represent the proportion of trait variation explained by fixed and random factors. Sample sizes for all models were 45 leaves, measured in 2020 across 15 individual vines, and log-transformed trait values were used in models according to results presented in Table 1. Trait acronyms and units are presented in Table 1.

	Model Intercept			Model Slope			Explained Variance	
Trait	**Estimate**	**S.E.**	***p***	**Estimate**	**S.E.**	***P***	**Marginal r^2**	**Conditional r^2**
***log-*A_{max}**	**4.6**	**0.7**	**<0.001**	**-1.3**	**0.4**	**0.008**	**0.311**	**0.674**
***log-*A_{mass}**	**1.0**	**0.8**	**0.232**	**-1.8**	**0.5**	**0.003**	**0.403**	**0.798**
R_{dark}	1.2	0.6	0.038	-0.3	0.4	0.409	0.031	0.489
log-R_{mass}	-3.2	0.8	<0.001	-1.0	0.5	0.07	0.127	0.405
LLCP	7.2	9.2	0.441	4.8	5.7	0.418	0.03	0.497
***log-*Φ**	**-1.8**	**0.4**	**<0.001**	**-0.8**	**0.3**	**0.009**	**0.243**	**0.424**
log-Area	5.4	0.5	<0.001	-0.5	0.3	0.097	0.093	0.278
log-LMA	**3.7**	**0.2**	**<0.001**	**0.5**	**0.1**	**0.004**	**0.319**	**0.534**
Dry mass	0.9	0.4	0.036	-0.1	0.3	0.737	0.004	0.187
log-Carbon	**3.9**	**0.03**	**<0.001**	**-0.1**	**0.02**	**0.002**	**0.41**	**0.694**
log-Nitrogen	**1.4**	**0.2**	**<0.001**	**-0.3**	**0.2**	**0.04**	**0.241**	**0.872**

Table S3. Contributions of leaf traits towards two primary axes in a principal component analysis (PCA) across 45 ‘Chardonnay’ wine grape leaves, measured in 2020 on 15 vines growing across a soil compaction gradient. Correlation coefficients and associated *p*-values are derived from the ‘dimdesc’ function in the ‘FactoMineR’ R package. Only traits significantly contributing to each PCA axis (where $p<0.05$) are shown. Trait acronyms and units are defined and presented in Table 1 in the main text.

PCA Axis	**Trait**	**Correlation**	***p* value**
Axis 1	R_{mass}	0.888	<0.001
	A_{mass}	0.831	<0.001
	Leaf N	0.782	<0.001
	Φ	0.644	<0.001
	Leaf area	0.484	<0.001
	LLCP	0.36	<0.001
	LMA	-0.615	<0.001
Axis 2	LLCP	0.767	<0.001
	LMA	0.69	<0.001
	Leaf area	0.431	<0.001
	R_{mass}	0.341	<0.001

Table S4. Results of a permutational multivariate analysis of variance (PerMANOVA) evaluating variation in seven Leaf Economics traits measured in 2020 across 45 leaves from 15 'Chardonnay' vines, growing across a soil compaction gradient. The Principle Component Analysis related to this PerMANOVA is presented visually in Figure 2 in the main text, and its significant factor loadings are presented in Table S2.

Factor	**D.F.**	**Sums Of Sqs.**	**Mean Sqs.**	***F* value**	r^2	***p* value**
Row	4	0.138	0.035	6.62	0.396	0.0002
Plant	2	0.005	0.002	0.44	0.013	0.788
Row*Plant	8	0.05	0.006	1.2	0.143	0.301
Residuals	30	0.157	0.005		0.448	
Total	44	0.349			1	

Table S5. Correlations among 11 leaf functional traits measured in 2020 on 45 'Chardonnay' leaves from 15 individual vines growing across a soil bulk density gradient, in Niagara-on-the-Lake, Ontario, Canada. Numbers in the upper-right portion of the matrix refer to Pearson correlation coefficients (*r*), and numbers in the bottom-left portion of the matrix are associated *p*-values. Bold values denote statistically significant relationships. Trait acronyms and units are defined and presented in Table 1 in the main text.

	A_{max}	A_{mass}	R_{dark}	R_{mass}	**LLCP**	Φ	**Leaf area**	**LMA**	**Dry mass**	**Leaf C**	**Leaf N**
A_{max}	-	**0.963**	**0.364**	**0.444**	0.015	**0.52**	**0.372**	**-0.408**	0.134	**0.551**	**0.401**
A_{mass}	**<0.001**	-	**0.324**	**0.466**	-0.035	**0.503**	0.27	**-0.638**	-0.041	**0.618**	**0.528**
R_{dark}	**0.014**	**0.03**	-	**0.936**	**0.816**	**0.628**	**0.416**	-0.058	**0.319**	0.268	**0.355**
R_{mass}	**0.002**	**0.001**	**<0.001**	-	**0.731**	**0.644**	**0.333**	**-0.31`**	0.149	**0.395**	**0.451**
LLCP	0.921	0.82	**<0.001**	**<0.001**	-	0.089	0.212	0.162	0.244	-0.086	0.181
Φ	**<0.001**	**<0.001**	**<0.001**	**<0.001**	0.562	-	**0.418**	-0.219	0.246	**0.54**	0.269
Leaf area	**0.012**	0.073	**0.005**	**0.026**	0.163	**0.004**	-	0.148	**0.897**	**0.368**	0.164
LMA	**0.005**	**<0.001**	0.706	**0.038**	0.287	0.148	0.332	-	**0.521**	**-0.522**	**-0.645**
Dry mass	0.381	0.792	**0.033**	0.329	0.106	0.103	**<0.001**	**<0.001**	-	0.101	-0.141
Leaf C	**<0.001**	**<0.001**	0.075	**0.007**	0.576	**<0.001**	**0.013**	**<0.001**	0.51	-	**0.425**
Leaf N	**0.006**	**<0.001**	**0.017**	**0.002**	0.235	0.074	0.282	**<0.001**	0.356	**0.004**	-

Table S6. Contributions of leaf traits, including leaf C concentrations, towards two primary axes in a principal component analyses (PCA) across 45 ‘Chardonnay’ leaves measured in 2020 on 15 vines growing across a soil compaction gradient. Correlation coefficients and associated *p*-values are derived from the ‘dimdesc’ function in the ‘FactoMineR’ R package. Only traits significantly contributing to each PCA axis (where $p<0.05$) are shown. Trait acronyms and units are defined and presented in Table 1 in the main text.

PCA Axis	**Trait**	**Correlation**	***p* value**
Axis 1	A_{mass}	0.855	<0.001
	R_{mass}	0.832	<0.001
	Leaf C	0.769	<0.001
	Leaf N	0.757	<0.001
	Φ	0.661	<0.001
	Leaf area	0.494	<0.001
	LMA	-0.647	<0.001
Axis 2	LLCP	0.859	<0.001
	LMA	0.584	<0.001
	R_{mass}	0.453	<0.001
	Leaf area	0.389	<0.001

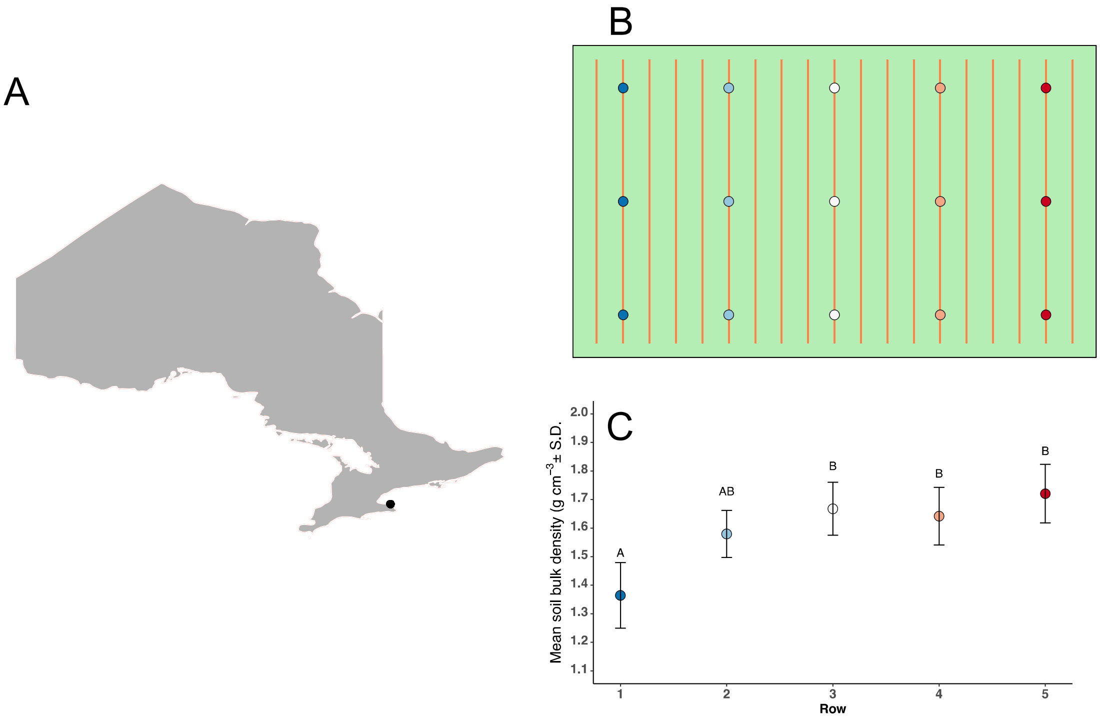

Figure S1. Location of the Niagara College Teaching Vineyard in Niagara-on-the-Lake, Ontario, Canada (Panel A), alongside the 2020 study design (Panel B) and soil bulk density values at sampling row locations (Panel C). Points in the upper-right green panel correspond to locations of study 'Chardonnay' vines (n=15 total), where spacing among sampled plants was 13-15 m, and point colors correspond to different sampling rows. Rows were distributed across a soil bulk density gradient, shown in the bottom-right panel where points correspond to mean (±S.D.) soil bulk density. Different letters above these points denote statistically significant differences (Tukey HSD $p \leq 0.05$) in mean bulk density. Note that in Panel B above, our study actually entailed 10 interceding planting rows, though only three are shown in the schematic to improve readability.

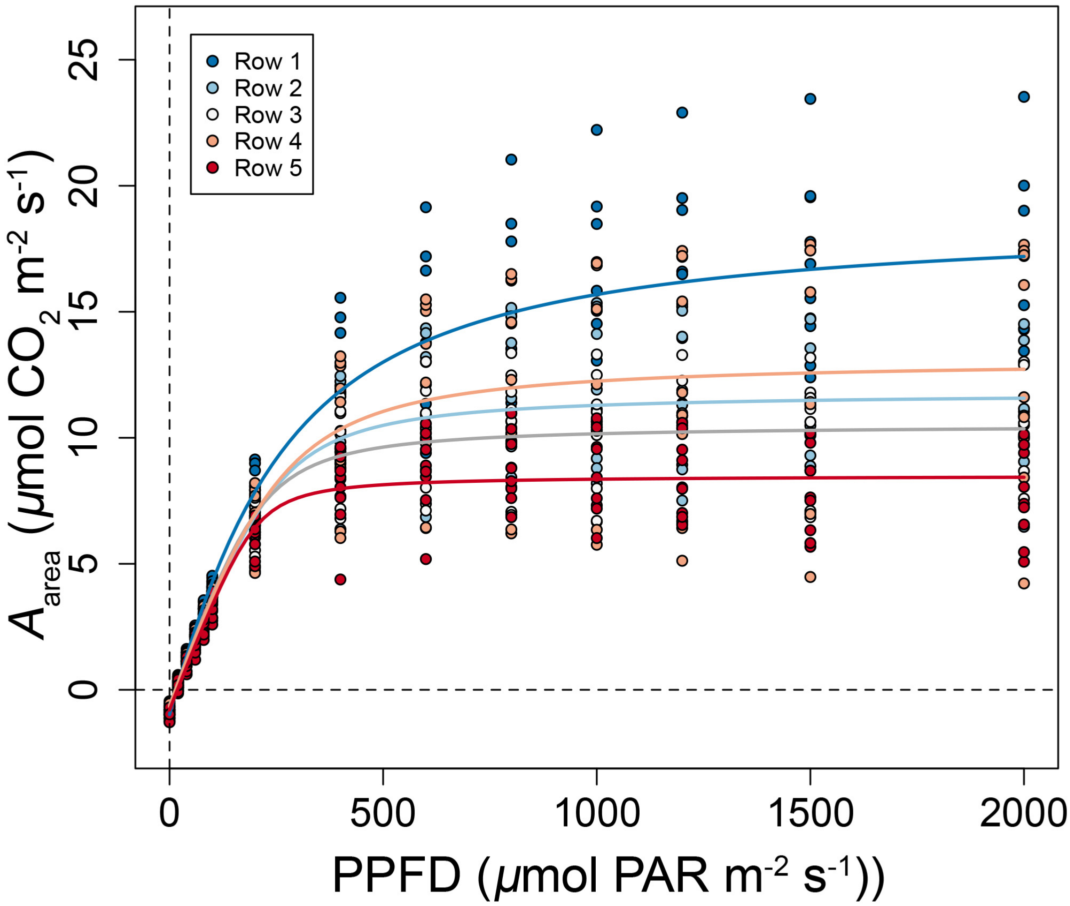

Figure S2. Leaf level photosynthesis rates as a function of photosynthetically active photon flux density across 45 'Chardonnay' leaves measured in 2020 on 15 individual vines, growing across five sampling rows (denoted by different colors), which correspond to a bulk density gradient. Shown here for visualization purposes only, are individual light response curves fitted for all data points within a given row (where n=126 individual observations per row, corresponding to the following: 14 data points per leaf * 3 leaves per plant * 3 plants per sampling row). For our analysis presented throughout the main text, light response curves were fitted and parameters extracted for each leaf individually; these individual curves are not presented here to aid in visualization of differences in leaf physiological characteristics across the bulk density gradient (see Figure 1 in the main text).