Supplemental Data for:

Triolo R, Roby JP, Plaia A, Hilbert G, Buscemi S, Di Lorenzo R and van Leeuwen C. 2018.
Hierarchy of factors impacting grape berry mass: Separation of direct and indirect effects on major berry metabolites.
Am J Enol Vitic 69:103-112. doi: 10.5344/ajev.2017.16087.

Supplemental Table 1 Soil profile description and soil analysis of experimental blocks.

Block G1: PEYROSOL. Physiographic position: plain; slope: 0%; total soil depth: 150 cm; presence of coarse surface fragments.

	Horizon 1	Horizon 2	Horizon 3	Horizon 4	Horizon 5
Depth (cm)	0-10	10-45	45-70	70-120	120-150
Structure	granular	blocky	blocky	single grain	blocky
Textural class	sandy	sandy silt	sandy silt	sandy	sandy silt
Clay (‰)	67	78	87	32	148
Fine silt (‰)	88	75	79	49	58
Coarse silt (‰)	101	101	55	25	34
Fine sand (‰)	224	192	181	115	204
Coarse sand (‰)	519	554	597	779	555
Coarse fragments (%)	15	25	70	>80	<2
Color (Munsell Soil Color Charts)	7.5 YR 3/2	7.5 YR 4/2	7.5 YR 3/2	7.5 YR 4/1	7.5 YR 4/3
Redoximorphic characteristics	absent	absent	absent	absent	few mottles (7.5 YR 5/6)
Moisture	slightly moist	dry	dry	dry	dry
Roots	few, medium diameter, oblique orientation, alive	common, all diameter, horizontal and oblique orientation, alive	common, fine and medium diameter, vertical and oblique orientation, alive	many, fine and medium diameter, alive	common, fine and medium diameter, horizontal and oblique orientation, alive
Porosity	medium	medium	medium	high	low
Organic matter (%)	1.8	0.8	<0.8	<0.6	<0.8
Total nitrogen (%)	0.12	0.057	0.03	0.021	0.023
C/N ratio	8.8	7.7	16.5	16.1	20.5
Miner. coeff. k2 (%)	1.1	1.6	1.9	1.9	1.4
pH of water	5.5	6	6.6	7.7	6.3
Total limestone (g/kg)	<1	<1	<1	<1	<1
CEC (meq/100g)	6.3	4.6	4.3	2.3	8.1

Supplemental Table 1 continued next page.

Supplemental Data for:

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Supplemental Table 1 *(continued)* Soil profile description and soil analysis of experimental blocks.

Block G7: PEYROSOL. Physiographic position: plain; slope: 0%; total soil depth: 160 cm; presence of coarse surface fragments.

	Horizon 1	Horizon 2	Horizon 3	Horizon 4	Horizon 5
Depth (cm)	0-10	10-65	65-100	100-140	140-160
Structure	granular	blocky	single grain	single grain	single grain
Textural class	sandy	sandy silt	sandy silt	sandy	sandy
Clay (‰)	115	122	34	34	34
Fine silt (‰)	95	94	36	36	36
Coarse silt (‰)	95	93	11	11	11
Fine sand (‰)	207	201	124	124	124
Coarse sand (‰)	488	490	795	795	795
Coarse fragments (%)	10	15	80	80, coarse diameter	80, fine and medium diameter
Color (Munsell Soil Color Charts)	7.5Y 3/2	7.5Y 4/2	7.5Y 3/2	7.5Y 4/1	7.5Y 4/3
Redoximorphic characteristics	none	none	none	none	none
Moisture	slightly moist	dry	dry	dry	dry
Roots	few, fine and medium diameter, vertical and oblique orientation, alive	common, all diameter, vertical and oblique orientation, alive	many, fine and medium diameter, vertical and oblique orientation, alive	common, fine and medium diameter, vertical and oblique orientation, alive	few, fine and medium diameter, vertical and oblique orientation, alive
Porosity	4.3	4	23.4	23.4	23.4
Organic matter content (%)	2.1	0.9	<0.7	<0.7	<0.7
Total nitrogen (%)	0.111	0.062	<0.020	<0.020	<0.020
C/N ratio	11.2	8.1	19.5	19.5	19.5
Mineralization coeff. k2 (%)	1.20	1.80	1.6	1.6	1.6
pH of water	5.5	6.4	5.7	5.7	5.7
Total limestone (g/kg)	<1	2	<1	<1	<1
CEC (meq/100g)	6.8	5.1	3.2	3.2	3.2

Supplemental Table 1 continued next page.

Supplemental Data for:
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Supplemental Table 1 *(continued)* Soil profile description and soil analysis of experimental blocks.

Block G8: PEYROSOL. Physiographic position: plain; slope: 0%; total soil depth: 160 cm; presence of coarse surface fragments.

	Horizon 1	Horizon 2	Horizon 3
Depth (cm)	0-10	10-65	65-160
Structure	granular	blocky	single grain
Textural class	sandy	sand-silt	sandy
Clay (‰)	80	98	27
Fine silt (‰)	90	80	31
Coarse silt (‰)	81	110	2
Fine sand (‰)	190	202	101
Coarse sand (‰)	560	511	838
Coarse fragments (%)	30	40	90
Color (Munsell Soil Color Charts)	7.5YR 3/1	7.5YR 3/2	7.5YR 3/2
Redoximorphic characteristics	none	none	none
Moisture	slightly moist	dry	dry
Roots	few	common, all diameter, horizontal and oblique orientation, alive	many, fine and medium diameter, vertical and oblique orientation, alive
Porosity	7	5.2	30.6
Organic matter content (%)	2.1	1	<0.7
Total nitrogen (%)	0.125	0.070	0.022
C/N ratio	10	8.3	18.5
Mineralization coeff. k2 (%)	1.6	1	1.90
pH of water	6.6	5.1	6.8
Total limestone (g/kg)	<1	<1	<1
CEC (meq/100g)	7.2	5.9	2.4

Supplemental Table 1 continued next page.

Supplemental Data for:
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Supplemental Table 1 *(continued)* Soil profile description and soil analysis of experimental blocks.

Block S5: ARENOSOL Rédoxique. Physiographic position: plain; slope: 0%; total soil depth: 170 cm; absence of coarse surface fragments.

	Horizon 1	Horizon 2	Horizon 3	Horizon 4	Horizon 5
Depth (cm)	0-10	10-75	75-100	100-140	140-170
Structure	granular (organic matter)	blocky	blocky	blocky	single grain
Textural class	sandy	sand-silt	sand-silt	sandy	sandy
Clay (‰)	112	130	170	78	40
Fine silt (‰)	84	85	93	58	13
Coarse silt (‰)	76	75	77	34	1
Fine sand (‰)	247	230	237	210	188
Coarse sand (‰)	482	470	423	619	758
Coarse fragments (%)	0	2	0	0	10
Color	7.5YR 3/1	7.5YR 5/1	7.5YR 5/1	7.5YR 4/3	7.5YR 4/2
Redoximorphic characteristics	none	few black mottles (7.5YR 2.5/1)	many black mottles (7.5YR 2.5/1)	few black mottles (7.5YR 2.5/1)	none
Moisture	slightly moist	dry	slightly moist	slightly moist	dry
Roots	very few, medium diameter, horizontal and oblique orientation	common, fine and medium diameter, horizontal and oblique orientation, alive and dead	very few, fine and medium diameter, vertical orientation, alive	very few, medium diameter, horizontal and oblique orientation	common, fine and medium diameter, vertical and oblique orientation, alive and dead
Porosity	4.3	3.5	2.5	709	18.9
Organic matter content (%)	2.7	<0.8	<0.6	<0.7	<0.8
Total nitrogen (%)	0.170	0.050	0.027	0.022	<0.020
C/N ratio	9.3	9	12.9	18.8	22.1
Mineralization coeff. k2 (%)	1.20	1.65	1.40	1.60	1.90
pH of water	6.2	7.1	7.5	7.3	6.9
Total limestone (g/kg)	<1	<1	<1	<1	<1
CEC (meq/100g)	10.4	8.6	12.8	9.8	2.8

Supplemental Table 1 continued next page.

Supplemental Data for:

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Supplemental Table 1 *(continued)* Soil profile description and soil analysis of experimental blocks.

Block S6: ARENOSOL Rédoxique. Physiographic position: plain; slope: 0%; total soil depth: 160 cm; absence of coarse surface fragments.

	Horizon 1	Horizon 2	Horizon 3	Horizon 4	Horizon 5
Depth (cm)	0-10	10-55	55-105	105-130	130-160
Structure	granular (organic matter)	blocky	blocky	blocky	single grain
Textural class	sandy	sandy	sandy	sand-silt	sandy
Clay (‰)	120	166	190	120	52
Fine silt (‰)	70	73	75	82	1
Coarse silt (‰)	97	85	70	87	5
Fine sand (‰)	262	284	275	365	111
Coarse sand (‰)	442	393	390	345	831
Coarse fragments (%)	0	0	0	0	0
Color	7.5YR 3/1	7.5YR 4/1	7.5YR 4/1	7.5YR 4/2	7.5YR 4/3
Redoximorphic characteristics	none	common oxidation-reduction mottles and few black mottles (7.5YR 2.5/1)	Common1 oxidation-reduction mottles and few black mottles (7.5YR 2.5/1)	common oxidation-reduction mottles	common oxidation-reduction mottles
Moisture	slightly moist	dry	dry	dry	dry
Roots	few, coarse diameter, horizontal orientation, alive	few, medium and coarse diameter, oblique orientation, alive	few, medium and coarse diameter, oblique orientation, alive and dead	many, fine and medium diameter, oblique orientation, alive and dead	many, fine and medium diameter, vertical orientation, alive
Porosity	3.7	2.4	2.0	2.9	16.0
Organic matter content (%)	3.6	1	<0.7	<0.7	<0.6
Total nitrogen (%)	0.214	0.077	0.033	0.024	<0.020
C/N ratio	9.7	7.4	11.6	16.0	18.3
Mineralization coeff. k2 (%)	1.10	1.60	1.50	1.30	1.90
pH of water	6.3	7.1	7.1	7.7	7.3
Total limestone (g/kg)	<1	<1	<1	<1	<1
CEC (meq/100g)	12.5	8.8	10.9	13	5

Supplemental Table 1 continued next page.

Supplemental Data for:

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Supplemental Table 1 *(continued)* Soil profile description and soil analysis of experimental blocks.

Block S7: ARENOSOL Rédoxique. Physiographic position: plain; slope: 0%; total soil depth: 150 cm; presence of coarse surface fragments.

	Horizon 1	Horizon 2	Horizon 3	Horizon 4	Horizon 5
Depth (cm)	0-10	10-50	50-100	100-140	140-150
Structure	granular	blocky	blocky	blocky	single grain
Textural class	sandy	sandy	sand-silt	sandy	sandy
Clay (‰)	153	142	205	158	66
Fine silt (‰)	77	71	68	53	31
Coarse silt (‰)	73	74	88	50	30
Fine sand (‰)	250	291	249	230	306
Coarse sand (‰)	446	423	390	509	566
Coarse fragments (%)	0	0	0	0	0
Color	7.5YR 3/1	7.5YR 4/1	7.5YR 4/1 with some mottles 7.5YR 4/6	7.5YR 4/1	7.5YR 4/2
Redoximorphic characteristics	none	very few black mottles (7.5YR 2.5/1)	common mottles (7.5YR 2.5/1 and 7.5YR 4/6)	common mottles (7.5YR 4/6)	common mottles (7.5YR 4/6)
Moisture	slightly moist	dry	slightly moist	slightly moist	slightly moist
Roots	common, medium diameter, horizontal orientation, alive	many, all diameter, oblique and horizontal orientation, alive	common, fine and medium diameter, oblique and vertical orientation, alive	few, fine diameter, oblique and horizontal orientation	many, fine and medium diameter, vertical orientation, alive
Porosity	2.9	3.0	1.9	3.2	8.5
Organic matter content (%)	4.0	0.6	<0.6	<0.7	<0.7
Total nitrogen (%)	0.222	0.048	0.029	0.023	<0.020
C/N ratio	10.4	7.8	12.0	17.9	19.5
Mineralization coeff. k2 (%)	1	1.80	1.30	1.40	1.90
pH of water	5.9	6.9	7.1	7.1	7.1
Total limestone (g/kg)	<1	<1	<1	<1	<1
CEC (meq/100g)	11.9	6.9	13.8	11.5	6.9

Supplemental Data for:
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Supplemental Table 2 Output of the R-code of stepwise procedure (backward) for selection of the significant impacting factors on berry mass. BW: berry mass; delta13C: vine water status; nass: vine nitrogen status; seed factors weight: berry seed content. Df, degrees of freedom; Sum sq, sum of squares; RSS, residual sum of squares; AIC, Akaike information criterion.

> step(mod_BW)
Start: AIC=-402.87
BW ~ delta13c * nass * seedweight - 1

	Df	Sum Sq	RSS	AIC
- delta13c:nass:seedweight	1	0.015603	2.2912	-404.13
<none>			2.2756	-402.87

Step: AIC=-404.13
BW ~ delta13c + nass + seedweight + delta13c:nass + delta13c:seedweight + nass:seedweight - 1

	Df	Sum Sq	RSS	AIC
- nass:seedweight	1	0.016357	2.3075	-405.36
- delta13c:seedweight	1	0.030117	2.3213	-404.72
<none>			2.2912	-404.13
- delta13c:nass	1	0.186693	2.4779	-397.67

Step: AIC=-405.36
BW ~ delta13c + nass + seedweight + delta13c:nass + delta13c:seedweight - 1

	Df	Sum Sq	RSS	AIC
- delta13c:seedweight	1	0.016658	2.3242	-406.59
<none>			2.3075	-405.36
- delta13c:nass	1	0.183750	2.4913	-399.09

Step: AIC=-406.59
BW ~ delta13c + nass + seedweight + delta13c:nass - 1

	Df	Sum Sq	RSS	AIC
<none>			2.3242	-406.59
- seedweight	1	0.08808	2.4123	-404.57
- delta13c:nass	1	0.33369	2.6579	-394.10

Call:
lm(formula = BW ~ delta13c + nass + seedweight + delta13c:nass - 1, data = dati)

Coefficients:	delta13c	nass	seedweight	delta13c:nass
	-0.0366353	-0.0084677	1.1116585	-0.0003784

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Supplemental Table 3 Output of the R-code of analysis of variance Type I performed on three different models (one for each factor) to test the significance of the additive effect (or direct effect) of water status, nitrogen status, and berry seed content on berry sugar concentration. BW: berry mass; delta13C: vine water status; nass: vine nitrogen status; seed weight: berry seed content. Df, degrees of freedom; Sum sq, sum of squares.

Model 1:
mod1_brix<-lm(Brix~BW*delta13c-1, data=dati)
anova(mod1_brix)
Response: Brix

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
BW	1	48522	48522	34483.43	< 2.2e-16 ***
delta13c	1	993	993	705.57	< 2.2e-16 ***
BW:delta13c	1	250	250	177.70	< 2.2e-16 ***
Residuals	105	148	1		

Model 2:
mod2_brix<-lm(Brix~BW*nass-1, data=dati)
anova(mod2_brix)
Response: Brix

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
BW	1	48522	48522	13110.471	< 2.2e-16 ***
nass	1	227	227	61.451	3.935e-12 ***
BW:nass	1	775	775	209.286	< 2.2e-16 ***
Residuals	105	389	4		

Model 3:
Mod3_brix<- lm(Brix~BW *seedweight-1, data=dati)
anova(mod3_brix)
Response: Brix

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
BW	1	48522	48522	14335.774	< 2.2e-16 ***
seedweight	1	147	147	43.375	1.837e-09 ***
BW:seedweight	1	888	888	262.478	< 2.2e-16 ***
Residuals	105	355	3		

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Supplemental Table 4 Output of the R-code of analysis of variance Type I performed on three different models (one for each factor) to test the significance of the additive effect (or direct effect) of water status, nitrogen status, and berry seed content on berry sugar content. BW: berry mass; delta13C: vine water status; nass: vine nitrogen status; seed weight: berry seed content. Df, degrees of freedom; Sum sq, sum of squares.

Model 1:
mod1_sugarcontent<-lm(sugarcontent ~BW*delta13c-1, data=dati)
anova(mod1_sugarcontent)
Response: sugarcontent

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
BW	1	63750	63750	18.4667	4.288e-05***
delta13c	1	181	181	0.0524	0.819528
BW:delta13c	1	36711	36711	10.6342	0.001558**
Residuals	92	317601	3452		

Model 2:
mod2_sugarcontent<-lm(sugarcontent ~BW*nass-1, data=dati)
anova(mod2_sugarcontent)
Response: sugarcontent

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
BW	1	63750	63750	18.4667	4.288e-05***
nass	1	3438	3438	0.9959	0.320930
BW:nass	1	29656	29656	8.5904	0.004262**
Residuals	92	317601	3452		

Model 3:
Mod3_sugarcontent<-lm(sugarcontent ~BW *seedweight-1, data=dati)
anova(mod3_sugarcontent)
Response: sugarcontent

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
BW	1	63750	63750	18.4667	4.288e-05***
seedweight	1	6410	6410	1.8568	0.176324
BW:seedweight	1	2791	2791	0.8085	0.370897
Residuals	92	317601	3452		