# SUPPLEMENTARY DATA

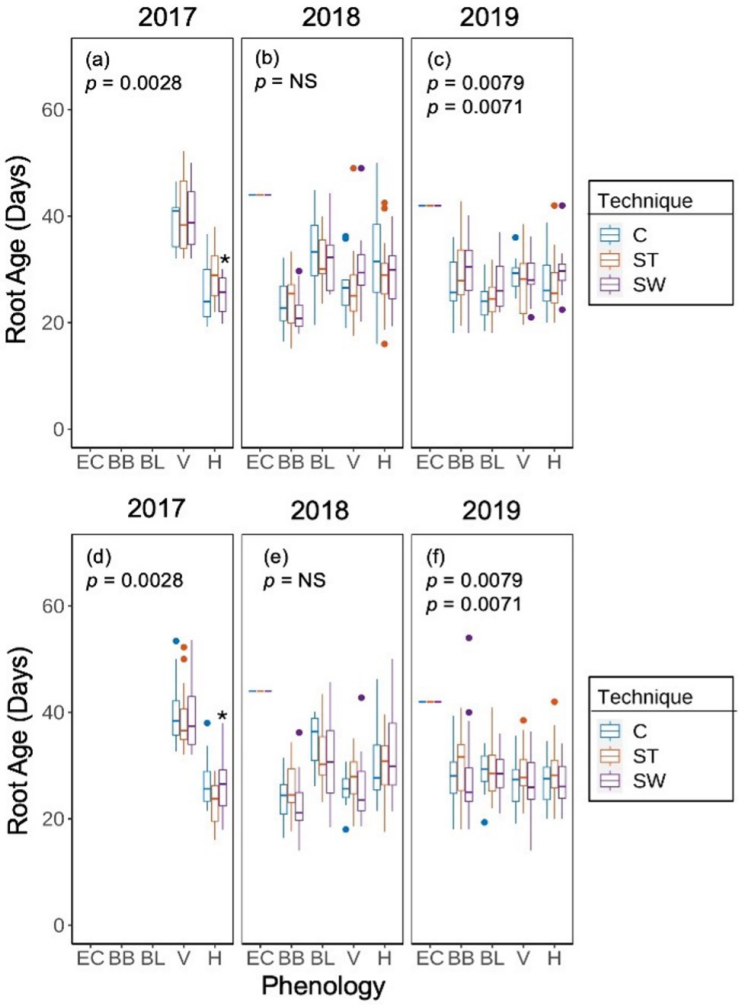



**Figure S1.** Distribution of observed mean fine root tip age in the 1–60-day age class at each phenological stage in response to shoot tip management practices (control, C; shoot tuck, ST; shoot wrap, SW) applied early (a–c) and late (d–f), when shoots extended 30 and 90 cm above the top catch wire, respectively, to Cabernet franc vines in Lansing, NY. Panels show 2017 (a, d), 2018 (b, e), and 2019 (c, f). Boxplots summarise arithmetic mean ages calculated from living root tips within each tube and soil depth group at each observation, including roots subsequently censored at the end of the study. Root age was calculated from first appearance to the observation date. Horizontal lines indicate medians, boxes span the 25th-75th percentiles, and whiskers extend to the most extreme observations within 1.5 interquartile ranges of the corresponding box edges. Points beyond the whiskers are plotted individually. Phenological stages are EC, ecodormancy; BB, budbreak; BL, bloom; V, veraison; and H, harvest. NS indicates a non-significant result. *P*-values are denoted for technique x timing x phenology-year in Figure S1a to S1f).

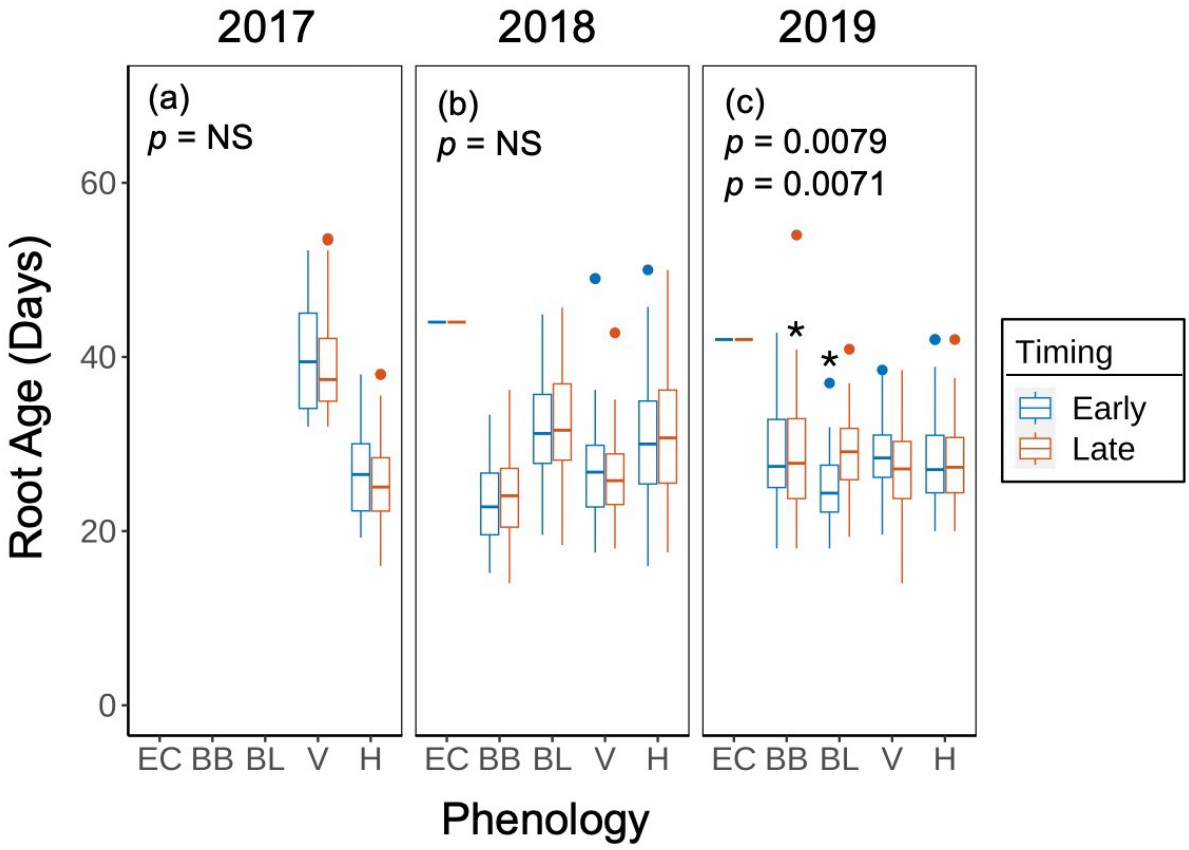



**Figure S2.** Distribution of observed mean fine root tip age in the 1–60-day age class at each phenological stage in response to early and late application of shoot tip management practices, when shoots extended 30 and 90 cm above the top catch wire, respectively, to Cabernet franc vines in Lansing, NY, in 2017 (a), 2018 (b), and 2019 (c). Boxplots summarise arithmetic mean ages calculated from living root tips within each tube and soil depth group at each observation, across the three shoot tip management practices, including roots subsequently censored at the end of the study. Root age was calculated from first appearance to the observation date. Horizontal lines indicate medians, boxes span the 25th–75th percentiles, and whiskers extend to the most extreme observations within 1.5 interquartile ranges of the corresponding box edges. Points beyond the whiskers are plotted individually. Phenological stages are EC, ecodormancy; BB, budbreak; BL, bloom; V, veraison; and H, harvest. Asterisks indicate significant differences between application timings at the indicated phenological stage and year, based on Tukey-adjusted pairwise comparisons ($P < 0.05$). NS indicates a non-significant result. *P*-values in Figure S2c denote timing x phenology-year at budbreak ($P = 0.0079$) and at bloom ($P = 0.0071$).

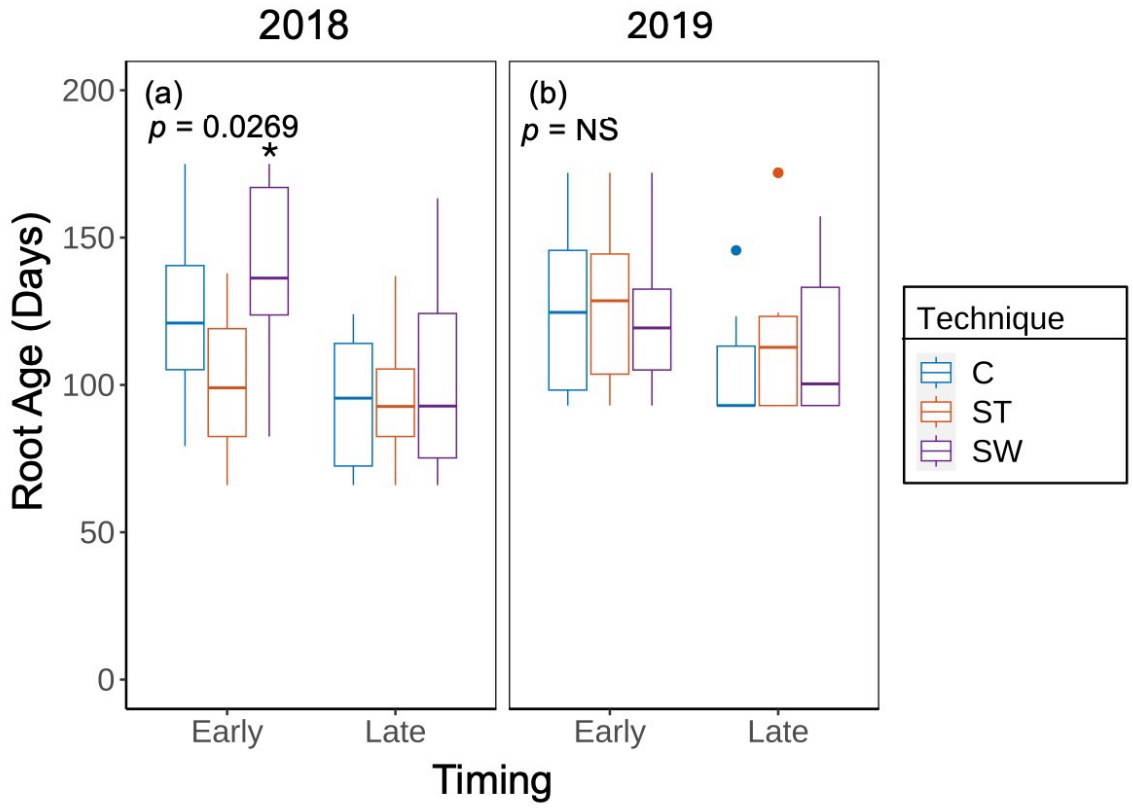



**Figure S3**. Distribution of observed mean fine root tip age in the 61–179-day age class at budbreak in response to shoot tip management practices (control, C; shoot tuck, ST; shoot wrap, SW) applied early and late, when shoots extended 30 and 90 cm above the top catch wire, respectively, to Cabernet franc vines in Lansing, NY, in 2018 (a) and 2019 (b). Boxplots summarise arithmetic mean ages calculated from living root tips in this age class within each tube and soil depth group, including roots subsequently censored at the end of the study. Root age was calculated from first appearance to the observation date. Horizontal lines indicate medians, boxes span the 25th–75th percentiles, and whiskers extend to the most extreme observations within 1.5 interquartile ranges of the corresponding box edges. Points beyond the whiskers are plotted individually. Asterisks indicate significant differences among management practices within an application timing and year, based on Tukey-adjusted pairwise comparisons ($P < 0.05$). NS indicates a non-significant result.

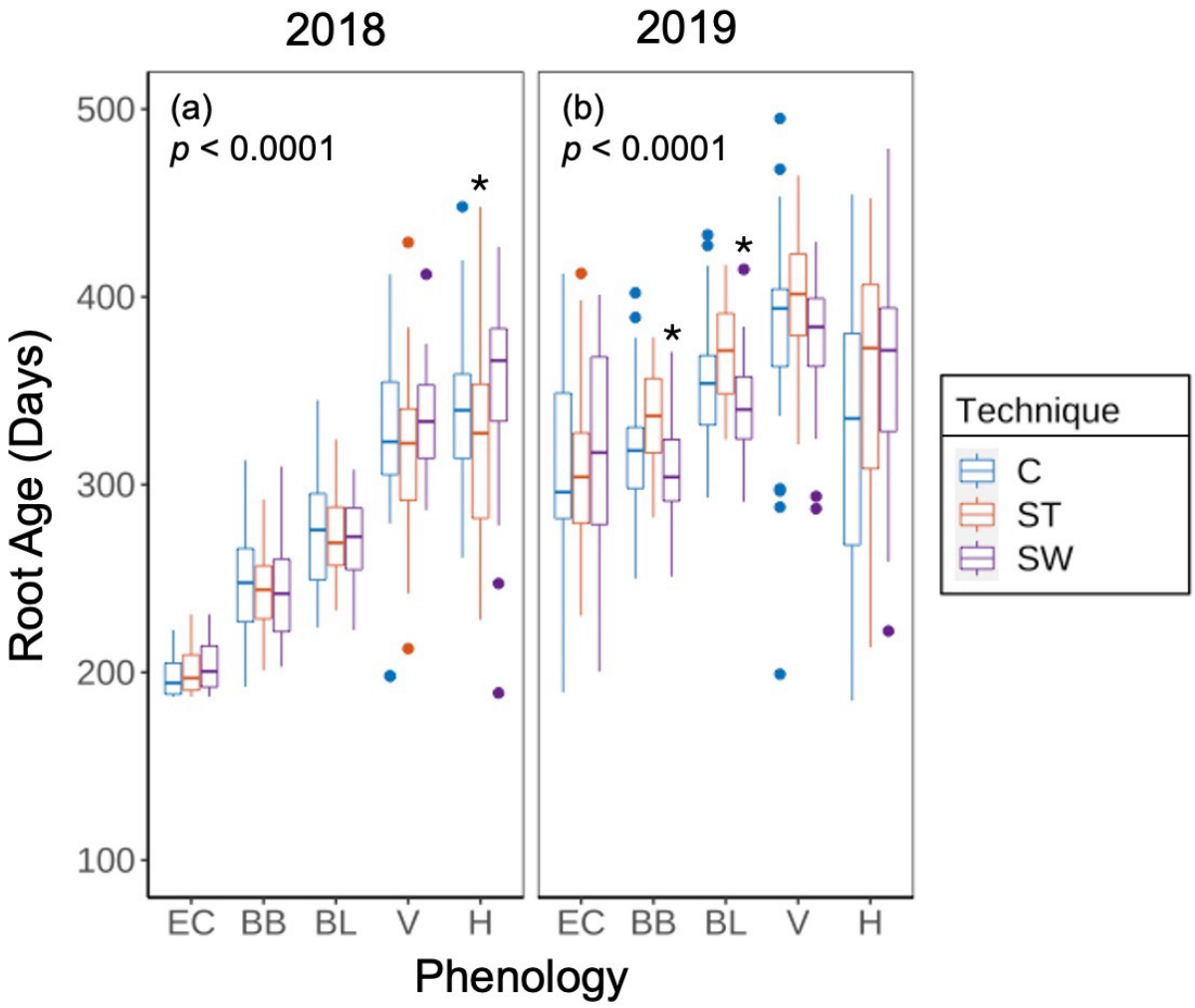



**Figure S4.** Distribution of observed mean fine root tip age in the ≥ 180-day age class at each phenological stage in response to shoot tip management practices (control, C; shoot tuck, ST; shoot wrap, SW) applied to Cabernet franc vines in Lansing, NY, in 2018 (a) and 2019 (b). Boxplots summarise arithmetic mean ages calculated from living root tips in this age class within each tube and soil depth group at each observation, across both application timings, including roots subsequently censored at the end of the study. Root age was calculated from first appearance to the observation date. Horizontal lines indicate medians, boxes span the 25th–75th percentiles, and whiskers extend to the most extreme observations within 1.5 interquartile ranges of the corresponding box edges. Points beyond the whiskers are plotted individually. Asterisks indicate significant differences among management practices within a phenological stage and year, based on Tukey-adjusted pairwise comparisons ($P < 0.05$). Phenological stages are EC, ecodormancy; BB, budbreak; BL, bloom; V, veraison; and H, harvest. *P*-values denote technique x phenology-year for Figure S4a and b.

**Table S1.** Summary of the principal aboveground responses previously reported for the same experimental vineyard and shoot tip management practices (Logan *et al.,* 2021) providing the physiological context for the belowground responses investigated in the present study.

| Shoot tip technique | Main aboveground responses | Potential implication for below responses |
|---|---|---|
| Hedging Control | Shoot apices removed; canopy leaf area reduced; vigorous lateral shoot regrowth. Reference treatment for comparisons within each year and application timing | Temporary reduction in source leaf area may alter carbon allocation to roots during canopy recovery. |
| Shoot tucking | Shoots repositioned without removing shoot tips; leaf area retained. Effects on lateral emergence were inconsistent: fruit-zone lateral shoot counts were reduced by 15 % under late application in 2018 and by 33 % under early application in 2019 compared with the corresponding hedging controls. Mean fruit-zone lateral shoot length did not differ significantly from the corresponding controls in 2017-2019. | Leaf area maintained while modifying canopy architecture ; expected to produce intermediate effects on root production and distribution. |
| Shoot wrapping | Shoots wrapped around the upper wire ; reduced lateral shoot development ; leaf area retained; reduced cluster compactness. Early wrapping reduced fruit-zone lateral shoot counts by 41 %, 23 % and 56 %, respectively. Late wrapping reduced lateral shoot counts by approximately 48 % in 2017 and 29 % in 2018; no significant reduction occurred in 2019. | Altered source-sink relationships while retaining shoot tissue; hypothesised to modify fine root production, root age structure and root distribution more strongly than the other treatments. |

*Note: Quantitative comparisons are from Table 2 of Logan et al., 2021 and refer to the hedging control within the same year and application timing. Reported reductions were statistically significant. Vegetative regrowth biomass was not measured. Potential belowground implications are hypotheses rather than measured mechanisms.*

**Table S2.** Calendar dates corresponding to grapevines phenological stages and the timing of early and late shoot tip management applications for each study year in Cabernet franc grafted onto 3309C rootstock growing under field conditions in Lansing, New York, USA. Ecodormancy was determined as the first full day after 800 chilling hour units were reached.

| Year | Ecodormancy | Bud Break | Bloom | Early Treatment | Late Treatment | Veraison | Harvest | Leaf fall |
|---|---|---|---|---|---|---|---|---|
| 2016 | -- | -- | Jun. 15 | -- | -- | Aug. 5 | Oct. 5 | Nov. 1 |
| 2017 | 1 Jan. | May 12 | Jun. 14 | Jun. 19 | Jul. 6 | Aug. 19 | Oct. 14 | Nov. 9 |
| 2018 | 29 Jan. | May 9 | Jun. 13 | Jun. 27 | Jul. 12 | Aug. 20 | Oct. 15 | Nov. 3 |
| 2019 | 10 Feb. | May 6 | Jun. 20 | Jul. 2 | Jul. 13 | Aug. 19 | Oct. 15 | Nov. 6 |

[1]*In 2018 and 2019, crop was picked based on crop health as opposed to ripeness.*

[2]*The above ground portion of the study started after budbreak in 2016 so dates are unknown.*

**Table S3.** Coefficients of variation (CV) comparing early (CV–Early) *vs*. late (CV–Late) application timing of aboveground shoot tip management practices (Control = C, Shoot Tuck = ST, and Shoot Wrap = SW) to Cabernet franc vines in Lansing, NY, for percent of roots in each of the four age groups (1–28, 29–60, 61–179, and 180+ days, (pooled by year and techniques)) by phenological stages. The coefficients of variations (CV) were pooled across all phenological stages (EC: Ecodormancy, BB: Budbreak, BL: Bloom, V: Veraison, H: Harvest) by timing for year.

| Phenology | Age group | CV–Early | CV–Late | Year | CV–early | CV–Late |
|---|---|---|---|---|---|---|
| EC | 1–28 | 0.0000 | 0.0000 | 2018 | 0.9387 | 0.9121 |
| BB | 1–28 | 0.5530 | 0.5392 | 2019 | 0.8634 | 0.8837 |
| BL | 1–28 | 0.5919 | 0.6643 | | | |
| V | 1–28 | 0.5906 | 0.5748 | | | |
| H | 1–28 | 0.7255 | 0.7182 | | | |
| EC | 29–60 | 0.6975 | 1.0069 | 2018 | 0.8120 | 0.7565 |
| BB | 29–60 | 0.6296 | 0.8346 | 2019 | 0.8094 | 0.8595 |
| BL | 29–60 | 0.6586 | 0.4689 | | | |
| V | 29–60 | 0.7903 | 0.6066 | | | |
| H | 29–60 | 0.6743 | 0.7910 | | | |
| EC | 61–179 | 0.4712 | 0.5031 | 2018 | 0.7839 | 0.7340 |
| BB | 61–179 | 0.9832 | 0.8958 | 2019 | 0.6755 | 0.7016 |
| BL | 61–179 | 0.8009 | 0.6983 | | | |
| V | 61–179 | 0.4465 | 0.4680 | | | |
| H | 61–179 | 0.3757 | 0.3902 | | | |
| EC | 180+ | 1.0956 | 0.7337 | 2018 | 0.7767 | 0.7180 |
| BB | 180+ | 0.8489 | 0.6468 | 2019 | 0.6477 | 0.7123 |

| | | | |
|---|---|---|---|
| BL | 180+ | 0.6446 | 0.6617 |
| V | 180+ | 0.6501 | 0.7984 |
| H | 180+ | 0.7352 | 0.6665 |

**Table S4.** Coefficients of variation (CV) comparing early (CV–Early) *vs*. Late (CV–Late) application timing of aboveground shoot tip management practices (Control = C, Shoot Tuck = ST, and Shoot Wrap = SW) to Cabernet franc vines in Lansing, NY, for percent of roots distributed across the soil (pooled by year and techniques) across three depth groups (top = 0–18 cm, middle = 19–36 cm, and deep = 36–55 cm) by phenological stages (EC: Ecodormancy, BB: Budbreak, BL: Bloom, V: Veraison, H: Harvest).

| Phenology | Location | CV–Early | CV–Late |
|---|---|---|---|
| EC | Deep | 0.8085 | 0.8811 |
| EC | Middle | 0.6565 | 0.7935 |
| EC | Top | 0.2507 | 0.4785 |
| BB | Deep | 0.7926 | 0.5340 |
| BB | Middle | 0.4933 | 0.4834 |
| BB | Top | 0.4677 | 0.3804 |
| BL | Deep | 0.8478 | 0.6205 |
| BL | Middle | 0.5006 | 0.6359 |
| BL | Top | 0.2969 | 0.4375 |
| V | Deep | 0.8081 | 0.5966 |
| V | Middle | 0.5241 | 0.4394 |
| V | Top | 0.3848 | 0.3303 |
| H | Deep | 0.8369 | 0.6518 |
| H | Middle | 0.5826 | 0.6106 |
| H | Top | 0.4008 | 0.5130 |

Logan, A. K., Mudrak, E. L., Bauerle, T. L., Vanden Heuvel, J. E., & Berdeja, M. P. (2026). Fine root dynamics in response to early and late shoot tip management practices in *Vitis vinifera* L. cv. Cabernet franc. *OENO One, 60*(4).
https://doi.org/10.20870/oeno-one.2026.60.4.9958

**Table S5.** Coefficients of variation (CV) comparing (CV–Early) *vs*. Late (CV–Late) application timing of aboveground shoot tip management practices (Control = C, Shoot Tuck = ST, and Shoot Wrap = SW) to Cabernet franc vines in Lansing, NY, for fine root tips produced by phenological stages (EC: Ecodormancy, BB: Budbreak, BL: Bloom, V: Veraison, H: Harvest).

| Phenology | CV-Early | CV-Late | Year | CV-Late |
|---|---|---|---|---|
| EC | 1.0629 | 0.8794 | 2017 | 0.8342 |
| BB | 0.9199 | 0.7805 | 2018 | 0.9857 |
| BL | 0.8483 | 0.7679 | 2019 | 0.8896 |
| V | 0.8291 | 0.7754 | | |
| H | 0.9849 | 1.0014 | | |

**Table S6.** Results of Cox proportional hazards regression analyses for predictor variables of root lifespan for all roots born in 2017, 2018, and 2019 in response to aboveground shoot tip management practices applied at two timings to Cabernet franc vines in Lansing, NY. The reference level for each categorical variable included in the model is in parentheses. Significant *P* values ($P < 0.05$) are in bold. A hazard ratio < 1 means a decrease in mortality risk, while a hazard ratio > 1 signifies an increase in mortality risk.

| Variable | Coefficient estimate | S.E. | Wald statistic | *P*-value | Hazard ratio |
|---|---|---|---|---|---|
| **Technique (Control)** | | | | | |
| SW | -0.0900 | 0.1092 | -0.82 | 0.4100 | 0.9140 |
| ST | -0.0151 | 0.1067 | -0.14 | 0.8900 | 0.9850 |
| **Timing (Early)** | | | | | |
| Late | -0.0222 | 0.0885 | -0.25 | 0.8000 | 0.9780 |
| **Year of Birth (2017)** | | | | | |
| 2018 | 0.0864 | 0.0234 | 3.70 | 0.0002 | 1.0903 |
| 2019 | -0.1225 | 0.0293 | -4.17 | <0.0001 | 0.8847 |
| **Depth (0–18 cm)** | | | | | |
| 18–36 cm | 0.0188 | 0.0207 | 0.91 | 0.3600 | 1.0189 |
| 36–55 cm | -0.0681 | 0.0224 | -3.04 | 0.0024 | 0.9342 |
| **Phenology (ED)** | | | | | |
| BB | 0.2239 | 0.0387 | 5.78 | <0.0001 | 1.2509 |
| BL | 0.1334 | 0.0375 | 3.56 | 0.0004 | 1.1427 |
| V | 0.0980 | 0.0383 | 2.56 | 0.0100 | 1.1030 |

| Variable | Coefficient estimate | S.E. | Wald statistic | *P*-value | Hazard ratio |
|---|---|---|---|---|---|
| H | 0.1312 | 0.0423 | 3.10 | 0.0019 | 1.1402 |
| LF | 0.0607 | 0.0446 | 1.36 | 0.1700 | 1.0625 |

**Table S7.** Results of Cox proportional hazards regression analyses comparing levels within each of the predictor variables of Cabernet franc grapevine root lifespan for all roots born in 2018 and 2019 in response to aboveground shoot tip management practices applied at two timings to Cabernet franc vines in Lansing, NY. The table includes the predictor variable factors, both factor and hazard levels, risk ratio, and *P*-values. Significant *P* values ($P < 0.05$) are in bold. A hazard ratio < 1 means a decrease in mortality risk, while a hazard ratio > 1 signifies an increase in mortality risk.

| Factors | Level 1/Level 2 | Hazard level 1/Hazard level 2 | *P*-value | Hazard ratio |
|---|---|---|---|---|
| Season | | | | |
| *Fall* | Fall/Spring | 1.031/1.000 | 0.2043 | 0.970 |
| | Fall/Summer | 1.031 /0.981 | **0.0011** | 0.952 |
| | Fall/Winter | 1.031/0.790 | **<0.0001** | 1.305 |
| *Spring* | Spring/Summer | 1.000/0.981 | 0.4508 | 1.019 |
| *Summer* | Spring/Winter | 1.000/0.790 | **<0.0001** | 1.266 |
| *Winter* | Summer/Winter | 0.981/0.790 | **<0.0001** | 1.242 |
| Treatment | | | | |
| *Control (C)* | C/ST | 0.966/0.955 | 0.9935 | 1.010 |
| *Shoot Tuck (ST)* | ST/SW | 0.955/0.916 | 0.8783 | 1.040 |
| *Shoot Wrap (SW)* | C/SW | 0.966/0.916 | 0.9238 | 1.050 |
| Timing | | | | |
| *Early* | Early/Late | 0.959/0.932 | 0.7384 | 1.030 |
| *Late* | Late/Early | 0.932/0.959 | | |
| Soil depth | | | | |
| *0–0.18 m* | Top/Deep | 0.969/0.914 | **<0.0001** | 1.061 |
| *0.18–0.36 m* | Middle/Top | 0.954/0.969 | **0.3397** | 1.016 |
| *0.36–0.55 m* | Deep/Middle | 0.914/0.954 | **0.0049** | 0.958 |
| Root diameter | | | | |
| *Absorptive fine (< 0.5 mm)* | Absorptive/Transport | 1.019/0.877 | **<0.0001** | **1.160** |
| *Transport fine (0.5 mm – 2 mm)* | Transport/Absorptive | 0.877/1.019 | | |
| Birth Year | | | | |
| 2017 | 2017/2018 | 0.852/1.095 | **<0.0001** | **0.778** |
| 2018 | 2018/2019 | 1.095/0.906 | **<0.0001** | **1.209** |
| 2019 | 2017/2019 | 0.852/0.906 | **0.0005** | **0.941** |

*shallow (0–18 cm), middle (18–36 cm), and deep (36–cm).*