

**Table S1.** HORTSYST model equations with state variables. State variables: photo-thermal time (PTI), dry matter production (DMP), nitrogen (N<sub>up</sub>), phosphorus (P<sub>up</sub>), potassium (K<sub>up</sub>), calcium (Ca<sub>up</sub>), magnesium uptake (Mg<sub>up</sub>). Output variables: leaf area index (LAI), crop transpiration (ET<sub>c</sub>). Input variables: Global solar radiation (R<sub>g</sub>), air temperature (T<sub>a</sub>) and relative humidity (RH).

| Variable                 | Equation                                                                                                                                                                                                                                                               | Units                              |
|--------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------|
| <b>PTI</b>               | PTI(j + 1) = PTI(j) + ΔPTI (1)                                                                                                                                                                                                                                         | MJ m <sup>-2</sup> d <sup>-1</sup> |
| <b>DMP</b>               | DMP(j + 1) = DMP(j) + ΔDMP (2)                                                                                                                                                                                                                                         | g m <sup>-2</sup>                  |
| <b>ETc</b>               | ETc(j + 1) = ETc(j) + ΔETc (3)                                                                                                                                                                                                                                         | kg m <sup>-2</sup>                 |
| <b>TT</b>                | $TT = \begin{cases} 0 & (T_a < T_{min}) \\ (T_a - T_{min}) / (T_{ob} - T_{min}) & (T_{min} \leq T_a < T_{ob}) \\ 1 & (T_{ob} \leq T_a \leq T_{ou}) \\ (T_{max} - T_a) / (T_{max} - T_{ou}) & (T_{ou} < T_a \leq T_{max}) \\ 0 & (T_a > T_{max}) \end{cases} \quad (4)$ | [dimensionless]                    |
| <b>AR</b>                | PAR (j) = 0.5 × R <sub>g</sub> (5)                                                                                                                                                                                                                                     | MJ m <sup>-2</sup>                 |
| <b>f<sub>i-PAR</sub></b> | f <sub>i-PAR</sub> = 1 - exp(-k × LAI(j)) (6)                                                                                                                                                                                                                          | [dimensionless]                    |
| <b>PTI</b>               | ΔPT = (Σ <sub>i=1</sub> <sup>24</sup> TT (i, j)) PAR(j) × f <sub>i-PAR</sub> (j) (7)                                                                                                                                                                                   | MJ m <sup>-2</sup> d <sup>-1</sup> |
| <b>LAI(j)</b>            | LAI(j) = $\left[ \frac{c_1 \times \Delta PTI(j)}{c_2 + \Delta PTI(j)} \right] \times d$ (8)                                                                                                                                                                            | m <sup>2</sup> m <sup>-2</sup>     |
| <b>ΔDMP</b>              | ΔDMP(j) = RUE × f <sub>i-PAR</sub> (j) × PAR(j) (9)                                                                                                                                                                                                                    | g m <sup>-2</sup>                  |
| <b>%N(j)</b>             |                                                                                                                                                                                                                                                                        |                                    |
| <b>%P(j)</b>             |                                                                                                                                                                                                                                                                        |                                    |
| <b>%K(j)</b>             | %Nutrient <sub>i</sub> (j) = a <sub>i</sub> × (ΔDMP) <sup>-b<sub>i</sub></sup> (10)                                                                                                                                                                                    | [dimensionless]                    |
| <b>%Ca(j),</b>           | i = 1 ... 5; 1 for %N, 2 (%P), 3 (%K), 4 (%Ca), and 5 (%Mg)                                                                                                                                                                                                            |                                    |
| <b>%Mg(j)</b>            |                                                                                                                                                                                                                                                                        |                                    |

|                  |                                                                                                                                   |  |                     |
|------------------|-----------------------------------------------------------------------------------------------------------------------------------|--|---------------------|
| $\Delta N_{up}$  |                                                                                                                                   |  | $g\ m^{-2}$         |
| $\Delta P_{up}$  | $\Delta Nutrient_i(j) = (\%Nutrient_i(j)/100) \times \Delta DMP(j)$ (11)                                                          |  | $g\ m^{-2}$         |
| $\Delta K_{up}$  | $i = 1 \dots 5; 1\ for\ \Delta N_{up}, 2\ (\Delta P_{up}), 3\ (\Delta K_{up}), 4\ (\Delta Ca_{up})$<br>and 5 ( $\Delta Mg_{up}$ ) |  | $g\ m^{-2}$         |
| $\Delta Ca_{up}$ |                                                                                                                                   |  | $g\ m^{-2}$         |
| $\Delta Mg_{up}$ |                                                                                                                                   |  | $g\ m^{-2}$         |
| $N_{up}$         | $N_{up}(j+1) = N_{up}(j) + \Delta N_{up}$ (12)                                                                                    |  | $g\ m^{-2}$         |
| $P_{up}$         | $P_{up}(j+1) = P_{up}(j) + \Delta P_{up}$ (13)                                                                                    |  | $g\ m^{-2}$         |
| $K_{up}$         | $K_{up}(j+1) = K_{up}(j) + \Delta K_{up}$ (14)                                                                                    |  | $g\ m^{-2}$         |
| $Ca_{up}$        | $Ca_{up}(j+1) = Ca_{up}(j) + \Delta Ca_{up}$ (15)                                                                                 |  | $g\ m^{-2}$         |
| $Mg_{up}$        | $Mg_{up}(j+1) = Mg_{up}(j) + \Delta Mg_{up}$ (16)                                                                                 |  | $g\ m^{-2}$         |
| $ETc(i)$         | $ETc(i) = A \times (1 - \exp(-k \times LAI(j))) \times Rg(i) + LAI(DPV)B_{(d,n)}$ (17)                                            |  | $g\ m^{-2}\ h^{-1}$ |
| $ETc(j)$         | $\Delta ETc = \sum_{i=1}^{24} ETc(i)$ (18)                                                                                        |  | $kg\ m^{-2}d^{-1}$  |