

Supplementary materials for article A modified version of RothC to model the direct and indirect effects of rice straw mulching on soil carbon dynamics, calibrated in two Valencian citrus orchards, Pesce et al. 2023

1. Pedotransfer function from Farina et al 2013 to calculate the hydraulic properties and equations for the calculation of Accumulated TSMD

$$\infty = \exp(-14.96 + 0.03135 * Clay + 0.0351 * Silt + 0.646 * (OC * 1.72) + 15.29 * BD - 0.192 * t - 4.671 * BD^2 - 0.000781 * Clay^2 - 0.00687 * (OC * 1.72)^2 + 0.0449 * (OC * 1.72)^{-1} + 0.0663 * \ln(Silt) + 0.1482 * \ln(OC * 1.72) - 0.04546 * BD * Silt - 0.4852 * BD * (OC * 1.72) + 0.00673 * Clay * t)$$

$$\theta_S = (0.7919 + 0.001691 * Clay - 0.29619 * BD - 0.000001491 * Silt^2 + 0.0000821 * (OC * 1.72)^2 + 0.02427 * Clay^{-1} + 0.01113 * Silt^{-1} + 0.01472 * \ln(Silt) - 0.0000733 * (OC * 1.72) * Clay - 0.000619 * BD * Clay - 0.001183 * BD * (OC * 1.72) - 0.0001664 * Silt * t)$$

$$\theta_R = 0.01$$

$$n = \exp(-25.23 - 0.02195 * Clay + 0.0074 * Silt - 0.194 * (OC * 1.72) + 45.5 * BD - 7.24 * BD^2 + 0.0003658 * Clay^2 + 0.002885 * (OC * 1.72)^2 - 12.81 * BD^{-1} - 0.1524 * Silt^{-1} - 0.01958 * (OC * 1.72)^{-1} - 0.2876 * \ln(Silt) - 0.0709 * \ln(OC * 1.72) - 44.6 * \ln(BD) - 0.02264 * BD * Clay + 0.0896 * BD * (OC * 1.72) + 0.00718 * Clay * t) + 1$$

$$m = 1 - 1/n$$

$$wc = \theta_R + (\theta_S - \theta_R) (1 + (\alpha * mbar)^n)^m)$$

Where:

wc is the water content at a given matric potential (cm³/cm³)

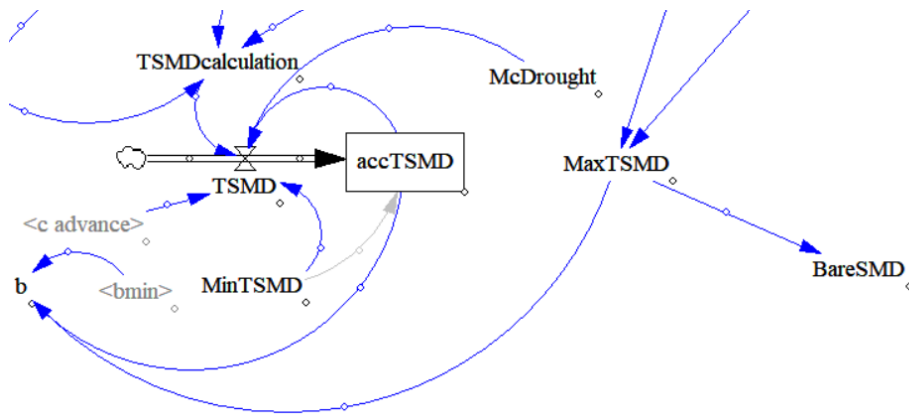
Silt is the percentage silt (%)

Clay is the percentage clay (%)

OC is the percentage organic carbon (%)

BD is the bulk density (g/cm³)

t is a qualitative variable having the value of 1



$d_accTSMD/dt = +TSMD$ (initial value fixed as MinTSMD, which is calculated from the maximum soil water content measured in the field)

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TSMD =IF THEN ELSE(accTSMD+TSMDcalculation>MinTSMD,
    MinTSMD-accTSMD,
    IF THEN ELSE(c advance=0.6,
        IF THEN ELSE(accTSMD+TSMDcalculation<McDrought,
            McDrought-accTSMD,
            TSMDcalculation),
        IF THEN ELSE(accTSMD<McDrought,
            IF THEN ELSE(TSMDcalculation<MinTSMD,
                MinTSMD-accTSMD,
                TSMDcalculation),
            IF THEN ELSE(accTSMD+TSMDcalculation<McDrought,
                McDrought-accTSMD,
                TSMDcalculation))))

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b = IF THEN ELSE( accTSMD>=0.444*MaxTSMD, 1,IF THEN ELSE(
    (accTSMD<=MaxTSMD),bmin,bmin+0.8*((MaxTSMD-accTSMD)/(MaxTSMD-0.444*MaxTSMD))))

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TSMD calculation = (Rainfall+Irrigation)-0.75*Open Pan Evaporation (as in standard RothC)

Where:

| Parameters | Value |
|------------|-------|
| bmin | 0.2 |
| Drought | -70 |
| MinTSMD | -20 |

2. Equations for the calculation of Accumulated TSMD in the modified version of RothC (the changes due to adaptation of the model as in Farina et al. 2013 are not shown here).

$d_accTSMD/dt = +TSMD$ (initial value fixed as MinTSMD, which is calculated from the maximum soil water content measured in the field)

TSMD = IF THEN ELSE(accTSMD+TSMDcalculation>MinTSMD,
MinTSMD-accTSMD,
IF THEN ELSE(c advance=0.6,
IF THEN ELSE(accTSMD+TSMDcalculation<(WTD-DeltaTSMD mulch),
(WTD-DeltaTSMD mulch)-accTSMD,
TSMDcalculation),
IF THEN ELSE(accTSMD<(WTD-DeltaTSMD mulch),
IF THEN ELSE(TSMDcalculation<MinTSMD,
MinTSMD-accTSMD,
TSMDcalculation),
IF THEN ELSE(accTSMD+TSMDcalculation<(WTD-DeltaTSMD mulch),
(WTD-DeltaTSMD mulch)-accTSMD,
TSMDcalculation))))

Where “c advanced” is the value of RothC parameter *c* (coverage) but for the next time step.

DeltaTSMD mulch = -5 mm (the effect of mulch in increasing soil moisture, determined directly from field observations of soil moisture, see also accompanying article Visconti et al. under review)

WTD = Drought+Amplitude*SIN((Time+Phase)*3.14/12) (this equation simulates the effect of a yearly fluctuating water table on the soil moisture)

3. Supplementary figures

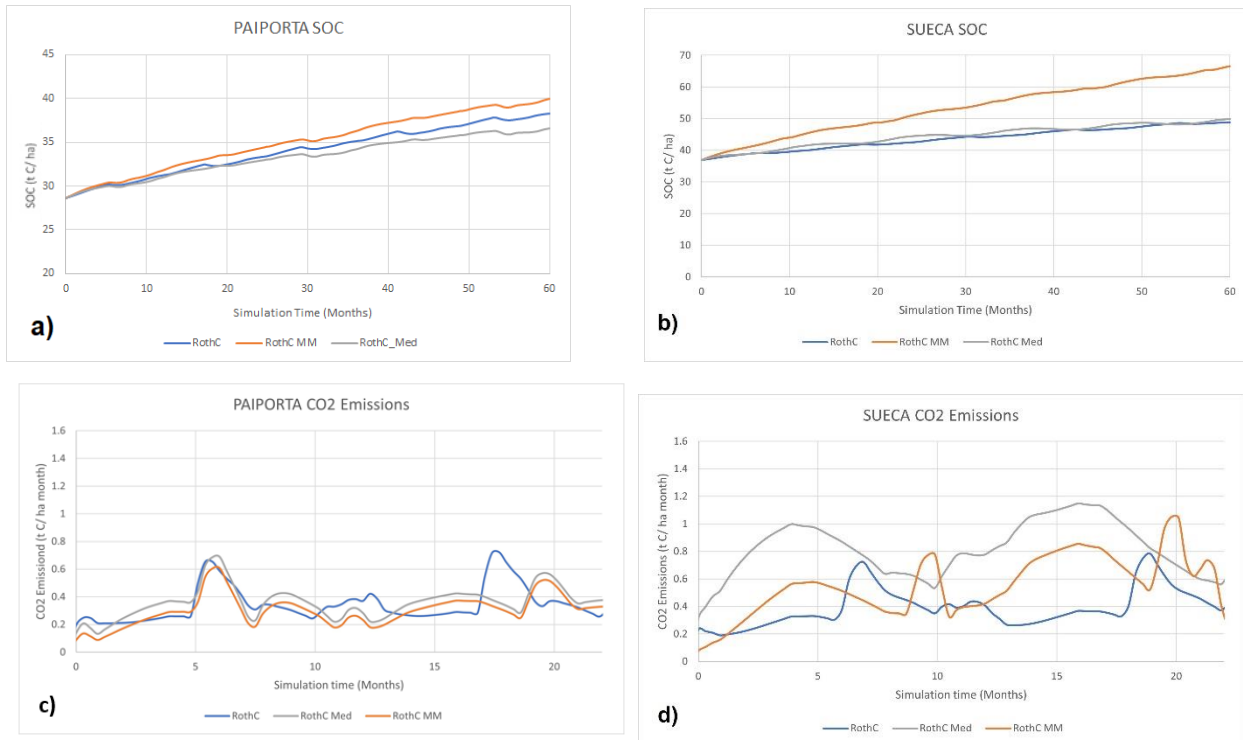


Figure S1: Comparison between the results obtained from basic RothC, RothC_Med, and RothC_MM, for the mulch treatment: a) SOC stock values predicted in Paiporta; b) SOC stock values predicted in Sueca; c) CO₂ soil emissions predicted in Paiporta; d) CO₂ soil emissions predicted in Sueca. It is hard to distinguish the three different models in Paiporta, and the importance of using the RothC_MM model is not apparent, when looking only at SOC stock. However, when looking at CO₂ soil emissions, basic RothC predicts a trend that is very different with respect to that predicted by RothC_Med and RothC_MM, even though these last two are hardly distinguishable. In Sueca, however, the RothC_MM predicts a much larger SOC stock increase; hence, using basic RothC or RothC_Med would result in an overestimation of the C input to the soil. In Sueca, moreover, the difference between soil CO₂ emissions is clearly visible, and the authors are convinced that, if only more measurements were taken from the field, it would be possible to discriminate the best model using such data.

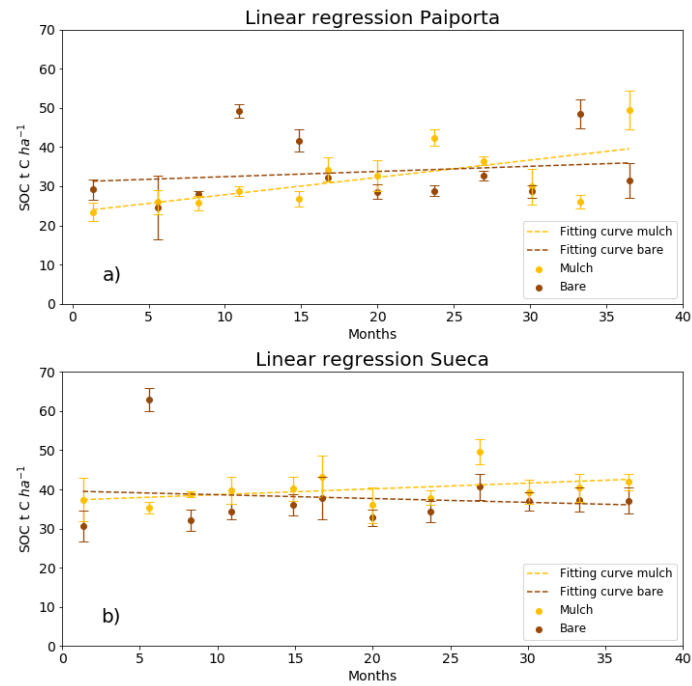


Figure S2: Linear model fitted to SOC measurements (also shown, with the relative error) to estimate the trend in time for a) Paiporta and b) Sueca.

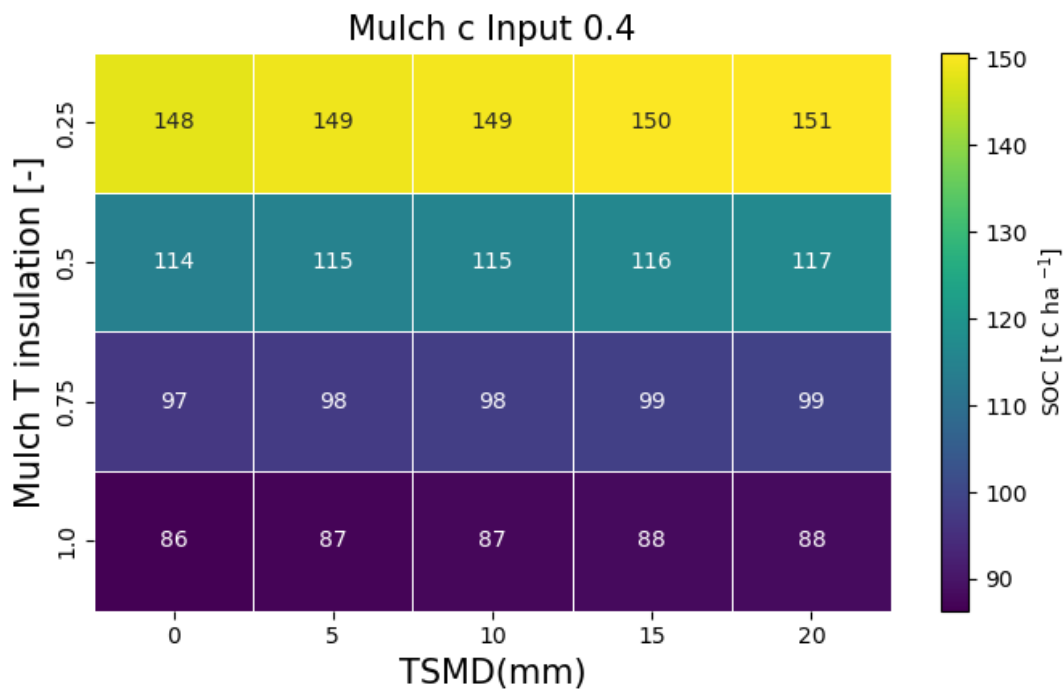


Figure S3: Heatmap displaying simulated SOC content with *Mulch C Input* parameter set to 0.4. The x-axis represents DeltaTSMD values, starting from 0 to -20. The y-axis represents Mulch T insulation values ranging from 0.25 to 1..

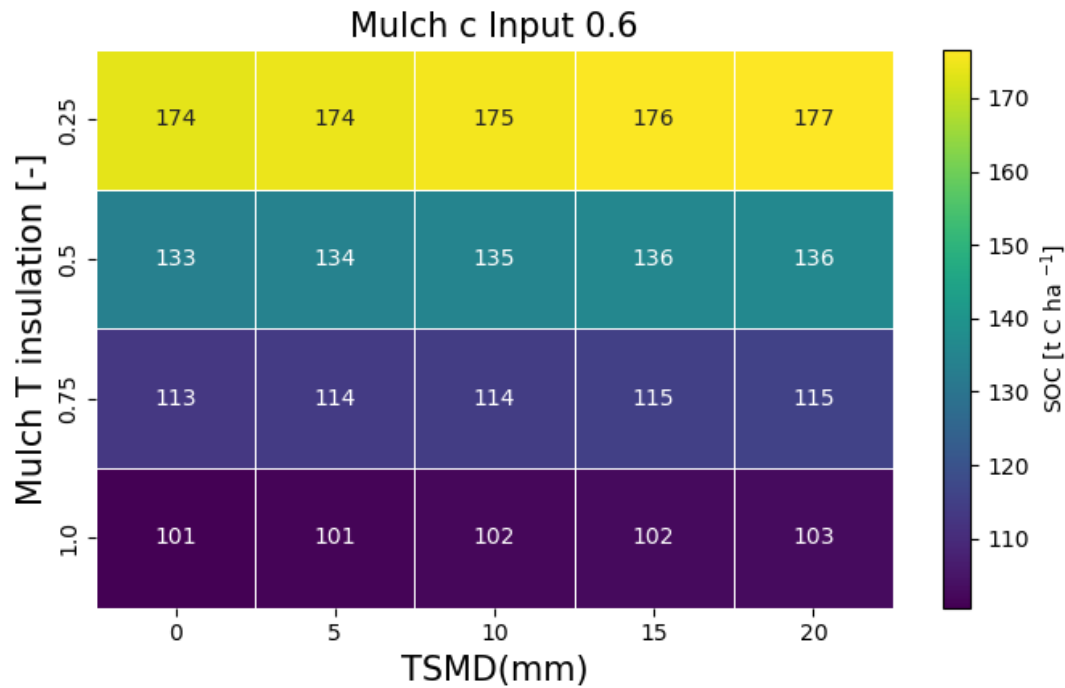


Figure S4: Heatmap displaying simulated SOC content with *Mulch C Input* parameter set to 0.6. The x-axis represents DeltaTSMD values, starting from 0 to -20. The y-axis represents Mulch T insulation values ranging from 0.25 to 1..

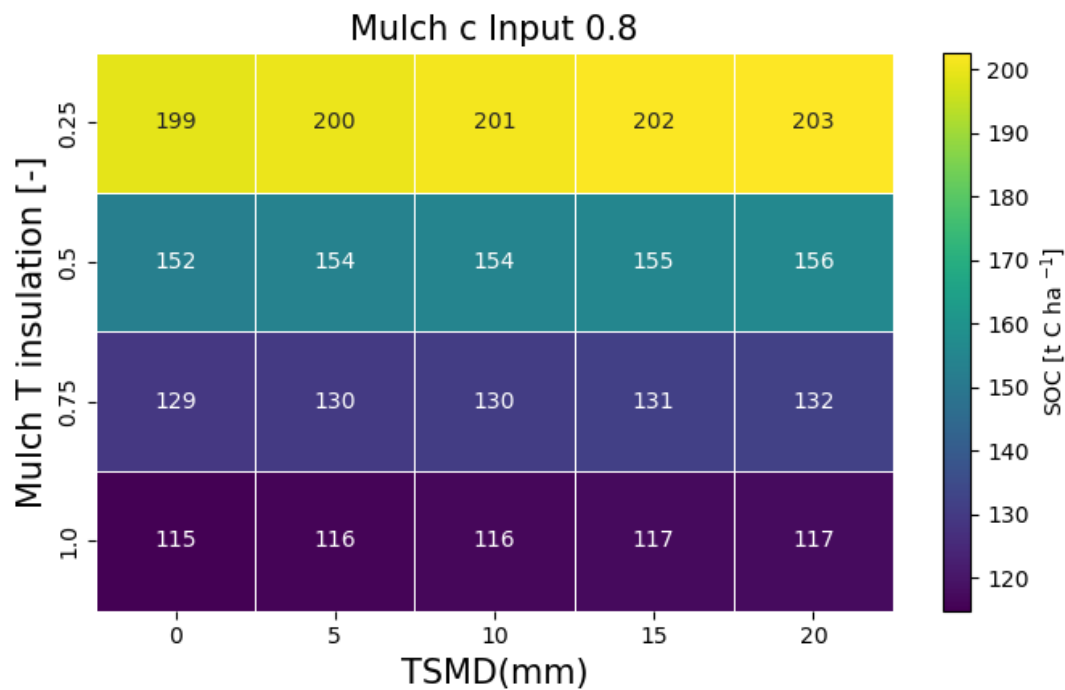


Figure S5: Heatmap displaying simulated SOC content with *Mulch C Input* parameter set to 0.8. The x-axis represents DeltaTSMD values, starting from 0 to -20. The y-axis represents Mulch T insulation values ranging from 0.25 to 1..

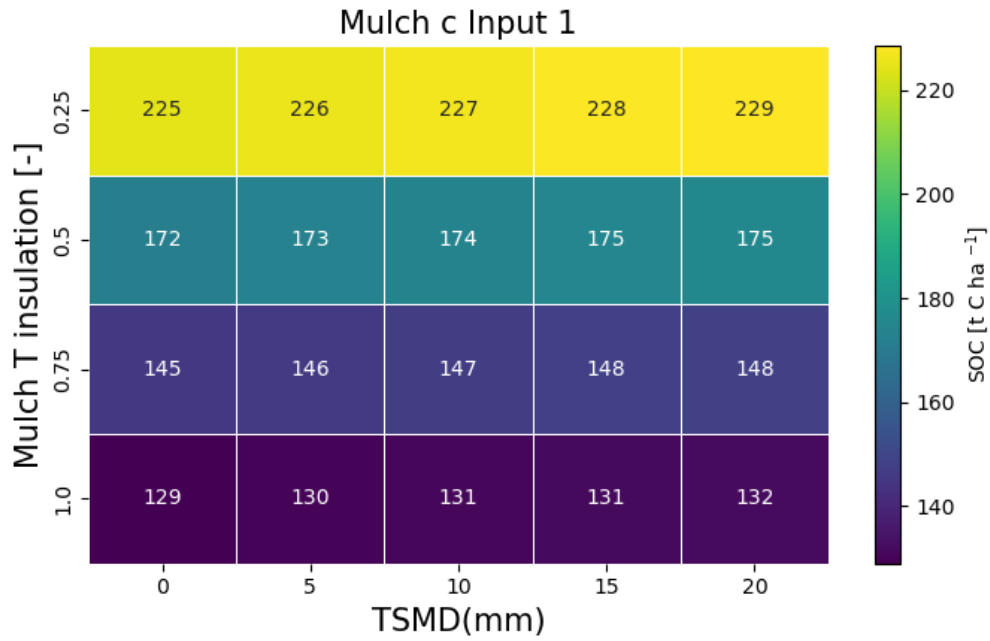


Figure S6: Heatmap displaying simulated SOC content with *Mulch C Input* parameter set to 1. The x-axis represents DeltaTSMD values, starting from 0 to -20. The y-axis represents Mulch T insulation values ranging from 0.25 to 1.

4. Supplementary Tables

| WRC parameters | Value |
|----------------|--------|
| θ_s | 0.3897 |
| θ_r | 0.09 |
| α | 0.0326 |
| n | 1.3821 |
| m | 0.2785 |

Table S1: Van Genuchten water retention curve parameters computed in bare treatment.

| WRC parameters | Value |
|----------------|--------|
| θ_s | 0.3500 |
| θ_r | 0.05 |
| α | 0.0277 |
| n | 1.2635 |
| m | 0.2063 |

Table S2 Van Genuchten water retention curve parameters computed in mulch treatment.

| RMSE | Value |
|-----------------|-------|
| <i>RothC</i> | 21.94 |
| <i>RothC_N</i> | 30.6 |
| <i>RothC_MM</i> | 8.51 |

Table S3 RMSE parameters computed between TSMD simulations and field data in Paiporta

| RMSE | Value |
|-----------------|-------|
| <i>RothC</i> | 22.19 |
| <i>RothC_N</i> | 29.59 |
| <i>RothC_MM</i> | 8.45 |

Table S4 RMSE parameters computed between TSMD simulations and field data in Sueca

| AIC score | Value |
|-----------------|-------|
| <i>RothC</i> | 38.35 |
| <i>RothC_N</i> | 41.68 |
| <i>RothC_MM</i> | 38.65 |

Table S5 AIC score in Paiporta

| AIC score | Value |
|-----------------|-------|
| <i>RothC</i> | 38.39 |
| <i>RothC_N</i> | 41.55 |
| <i>RothC_MM</i> | 38.39 |

Table S6 AIC score in Sueca