Supplemental Table 1 The key predictors and timing of data acquisition (expressed as phenological time) in each year from all models generated in the study. For the random forest regression (RFR), the first five predictors are shown, with the prediction power from the cross-validation given in parentheses. For the stepwise multi-linear regression (S-MLR), the order reflects the stepwise progression, with the dominant predictor at each step given along with the number of times (out of 10) it was selected in the cross-validation process. Acronyms for vegetative indices (VIs) are the same as in Table 2 in the main manuscript. Acronyms for phenological stages are the same as in Table 3 in the main manuscript.

Predicted variable	Model type	Year	Order of predictors
Yield	M1 – S-MLR	2019	Yield_2018 (6)
		2020	Yield_2019 (9); ShallowEC$_a$_2019; DeepEC$_a$_2019; PM_2019
		2021	Yield_2020 (10); PM_2020 (5)
	M1 – RFR	2019	Yield_2018 (0.2694); DeepEC$_a$_2019 (0.2579); CropLoad2018 (0.192); ShallowEC$_a$_2019 (0.1647); PM_2018 (0.1159)
		2020	ShallowEC$_a$_2020 (0.3317); Yield_2019 (0.2816); DeepEC$_a$_2020 (0.2238); CropLoad_2019 (0.097); PM_2019 (0.0659)
		2021	Yield_2020 (0.4298); DeepEC$_a$_2021 (0.1389); ShallowEC$_a$_2021 (0.1126); CropLoad_2020 (0.108)
	M2 – S-MLR	2019	MSR_3 DBF (10); SR_20 DBF (8); RECI_8 DABB (9); Various VIs at various dates
		2020	DifVI_5 DBF (10); MTCI_Veraison (9); MTCI_1 DAF (6)
		2021	DifVI_4 DBF (10); Various VIs 9 DAF (8)
	M2 – RFR	2019	DifVI_3 DBF (0.1193); SR_20 DBF (0.0738); NDVI_20 DBF (0.0598); MSR_13 DBF70619 (0.0563); MSR_20 DBF (0.0505)
		2020	DifVI_13 DBF (0.189); DifVI_5 DBF (0.1036); SR_5 DBF (0.0493); NDVI_5 DBF (0.0418); NDVI_18 DBF (0.0316)
		2021	RECI_4 DBF (0.1009); DifVI_4 DBF (0.051); NDRE_4 DBF (0.0406); RECI_11 DBF (0.0263); SR_4 DBF (0.0245)
Yield	M3 – S-MLR	2019	MSR_3 DBF (10); SR_20 DBF (8); DeepEC (7); RECI_8 DABB (5)
		2020	DifVI_5 DBF (8); MTCI_Veraison (8); DeepEC$_a$_2020 (5)
		2021	DifVI_4 DBF (10); Yield_2020 (10); Various VIs at various dates…
	M3 – RFR	2019	DifVI_3 DBF (0.115); SR_20 DBF (0.0719); NDVI_20 DBF (0.0549); MSR_3 DBF (0.0531); SR_3 DBF0.0449
		2020	DifVI_13 DBF (0.1667); DifVI_5 DBF (0.1015); SR_5 DBF (0.0547); NDVI_5 DBF (0.0403); NDVI_18 DBF (0.0341)
		2021	RECI_4 DBF (0.0911); Yield_2020 (0.0738); DifVI_4 DBF (0.0469); NDRE_4 DBF (0.038); RECI_11 DBF (0.0245); SR_4 DBF (0.0205)
	M4 – S-MLR	2019	SR_29 DAF (10); NDRE_29 DAF90719 (9); Yield_2018 (9)
		2020	Yield_2019 (9); ShallowEC (8); DeepEC (8); MSR_090720 (8)
		2021	Yield_2020 (10); PM_2020 (7); CropLoad_2020 (2)
	M4 – RFR	2019	Yield2018 (0.149); SR_29 DAF (0.1447); DeepEC$_a$_2019 (0.1319); ShallowEC$_a$_2019 (0.1193); MSR_29 DAF (0.1154)
		2020	ShallowEC$_a$_2020 (0.2721); Yield_2019 (0.231); DeepEC$_a$_2020 (0.1647); CropLoad_2019 (0.0533); MSR_31 DAF (0.0486)
		2021	Yield_2020 (0.3894); ShallowEC$_a$_2021 (0.0877); CropLoad_2020 (0.0749); DeepEC$_a$_2021 (0.0572); MSR_22 DAF (0.0571)

Supplemental Table 1 *continued*   The key predictors and timing of data acquisition (expressed as phenological time) in each year from all models generated in the study. For the random forest regression (RFR), the first five predictors are shown, with the prediction power from the cross-validation given in parentheses. For the stepwise multi-linear regression (S-MLR), the order reflects the stepwise progression, with the dominant predictor at each step given along with the number of times (out of 10) it was selected in the cross-validation process. Acronyms for vegetative indices (VIs) are the same as in Table 2 in the main manuscript. Acronyms for phenological stages are the same as in Table 3 in the main manuscript.

Predicted variable	Model type	Year	Order of predictors
Pruning mass	M1 − S-MLR	2019	PM_2018 (10)
		2020	PM_2019 (10); ShallowEC$_a$_2020 (10); DeepEC$_a$_2020 (10)
		2021	PM_2020 (10); CropLoad_2020 (2)
	M1 − RFR	2019	PM_2018 (0.4886); CropLoad_2018 (0.3138); Yield_2018 (0.0762); ShallowEC$_a$_2019 (0.0624); DeepEC$_a$_2019 (0.0591)
		2020	CropLoad_2019 (0.4063); PM_2019 (0.2971); DeepEC$_a$_2020 (0.1247); ShallowEC$_a$_2020 (0.0926); Yield_2019 (0.0793)
		2021	PM_2020 (0.659); CropLoad_2020 (0.0842); Yield_2020 (0.067); DeepEC$_a$_2021 (0.053); ShallowEC$_a$_2021 (0.0479)
	M2 − S-MLR	2019	Various VIs at 4 DAV (8) or 25 DBV (2)
		2020	NDVI_13 DAV (10); Various VIs at various dates
		2021	SR/DifVI_4 DBF (9); Various VIs_160921 (7)
	M2 − RFR	2019	MTCI_4 DAV (0.0494); DifVI_20 DBF (0.0485); DifVI_4 DAV (0.0442); RECI_4 DAV (0.0333); SR_4 DAV (0.0315);
		2020	SR_ 24 DAV (0.0591); MSR_13 DAV (0.0413); SR_18 DBF (0.0292); SR_13 DAV (0.0261); NDVI_13 DAV (0.0257)
		2021	MTCI_17 DAF (0.0286); SR_24 DBV (0.0211); SR_17 DAF (0.0206); MSR_17 DAF (0.0186); MTCI_24 DBV (0.0182)
Pruning mass	M3 − S-MLR	2019	PM_2018 (10)
		2020	PM_2019 (10); RECI_5 DBF (10); MSR_13 DAV (6)
		2021	PM_2020 (10); Various VIs at various dates…
	M3 − RFR	2019	PM_2018 (0.3693); CropLoad_2018 (0.2813); DifVI_20 DBF (0.0206); MTCI_4 DAV (0.0119); RECI_20 DBF (0.0105)
		2020	CropLoad_2019 (0.2431); PM_2019 (0.2354); SR_24 DAV (0.022); MSR_13 DAV (0.0174); MTCI_12 DAF (0.0126)
		2021	PM_2020 (0.2805); CropLoad_2020 (0.137); MTCI_17 DAF (0.0141); Yield_2020 (0.0125); MSR_17 DAF (0.0105); SR_24 DBV (0.0103)
	M4 − S-MLR	2019	PM_2018 (10)
		2020	PM_2019 (10); ShallowEC$_a$_2020 (10); SR_090720 (8)
		2021	PM_2020 (10); CropLoad_2020 (2)
	M4 − RFR	2019	PM_2018 (0.4658); CropLoad_2018 (0.2837); Yield_2018 (0.0411); SR_29 DAF (0.0329); ShallowEC$_a$_2019 (0.0293)
		2020	CropLoad_2019 (0.3704); PM_2019 (0.2813); DeepEC$_a$_2020 (0.0734); ShallowEC$_a$_2020 (0.0483); Yield_2019 (0.0461)
		2021	PM_2020 (0.6398); CropLoad_2020 (0.058); Yield_2020 (0.0415); DeepEC$_a$_2021 (0.0366); ShallowEC$_a$_2021 (0.0306)