Supplementary material

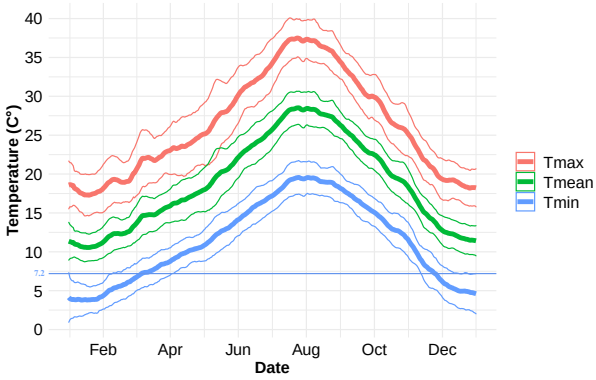


Figure S1. Daily temperature variation over a year computed on mean, maximum and minimum temperature data collected from 1972 to 2019. For each metric, the colored area indicates the variation over 47 years in the experimental station of Tassaout. Min temperature below 7.2° C is approximatively occurring during 120 days starting from mid-November to the beginning of march, a suitable period of chilling requirement of olive tree (see Figure 3 and Results).

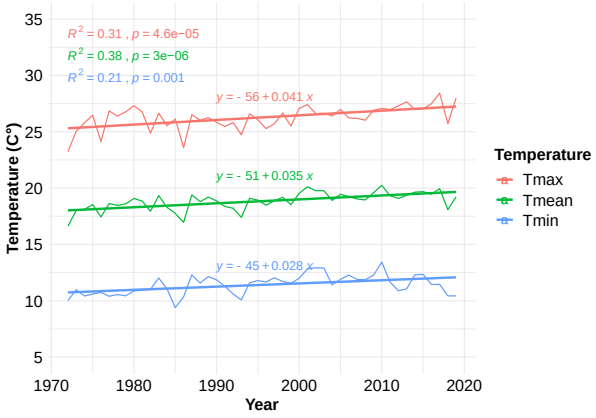


Figure S2. Annual temperature trends (mean, maximum and minimum) in the worldwide collection of Marrakech (WOGBM) during the period 1972-2019. Global warming is clearly shown since there is a temperature increase of 0.35 (mean temperature), 0.41 (maximum) and 0.28 ° C (minimum) on average for each decade.

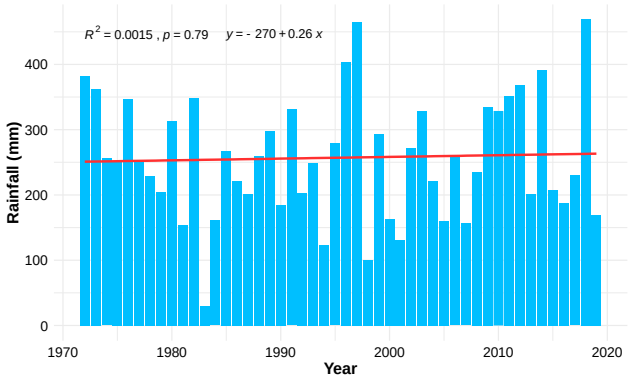


Figure S3. Rainfall variation over 47 years from 1972 to 2019 in the experimental station of Tassaout.

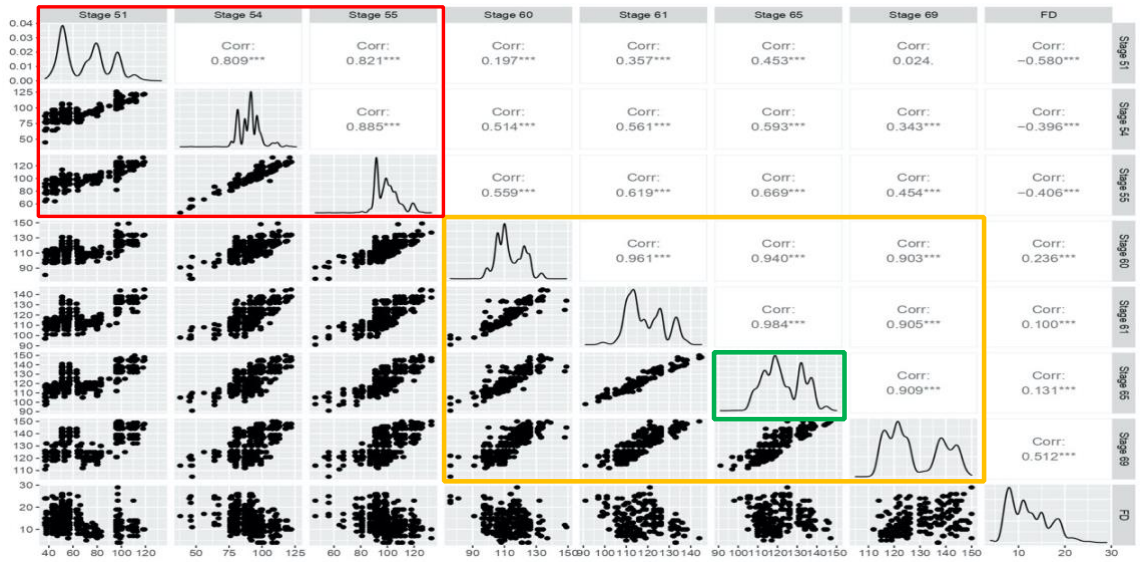


Figure S4. Correlation between phenological stages from bud burst (stage 51) to the end of flowering (stage 69) and the flowering duration for the 331 cultivars of the worldwide collection Marrakech over six years 2014-2019 investigated by Pearson correlation analysis A significant correlation is evidenced between phenological stages related to the inflorescence emergence (stages 51, 54 and 55) and to flowering (stages 61, 65 and 69). Strikingly, the budburst stage 51 is significantly negatively correlated to the flowering duration measured as the DOY (day of the year) difference between the beginning of flowering (stage 61) to the end of flowering (69). Interestingly, blooming time (stage 65) is significantly correlated to all phenological stages including those related to the inflorescence emergence.

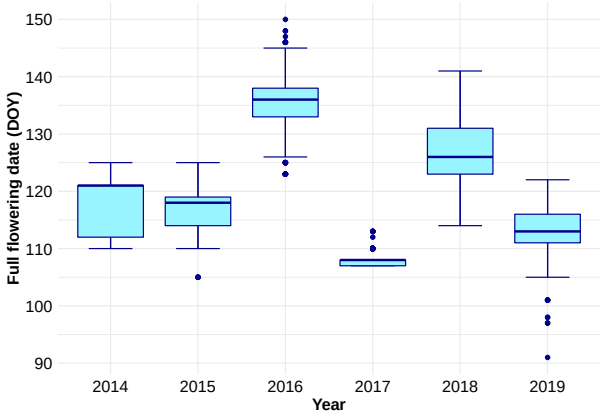
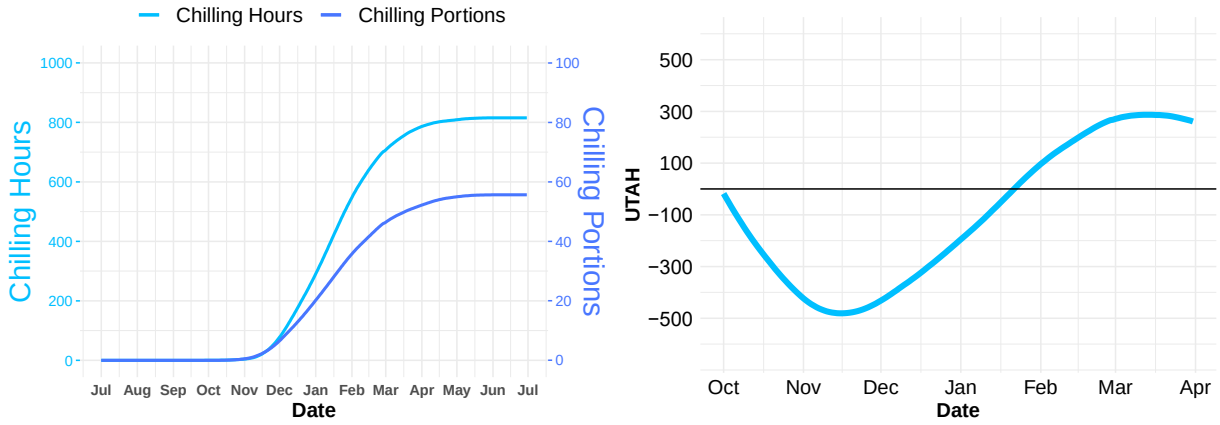


Figure S5. Boxplots of full flowering dates observed in the cultivars of the worldwide collection of Marrakech (WOGBM). The first and the third quartiles are represented by both sides of the box and the whiskers' tips represent the standard deviation of the mean value. The line in the middle is always the median. We clearly note a huge interannual variability of blooming time in one geographical site (the experimental station of Tassaout) likely due to interannual temperature variation described in the Figure S1 and S2.



(**a**) (**b**)

Figure S6. Assessment of chill availability (The beginning to the end of chilling accumulation) using the most widely used chill models, the Chilling Hours model (CHM), the Utah model (UM) and the Dynamic model (DM). Based on 15 days running mean of daily temperatures in the experimental station of Tassaout, Morocco, over 47 years from 1972 to 2019, chill availability was assessed using the ChillR package according to CHM and DM models (Figure S6a) and UTAH model (Figure S6b). Whatever the model used, chill is available during a period of 152 days starting from first week of November to the end of March and the beginning of April.

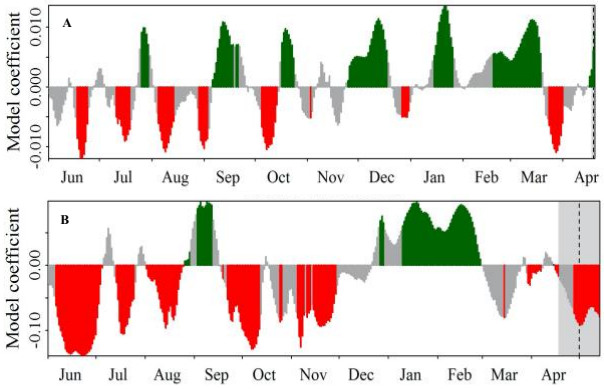


Figure S7. Delineation of the chilling and forcing phases by the PLS approach for two series of recorded data for 6 seasons. (A) seasons with the lowest variability for chilling and blooming dates, (B) seasons with the highest variability of chilling and blooming dates.

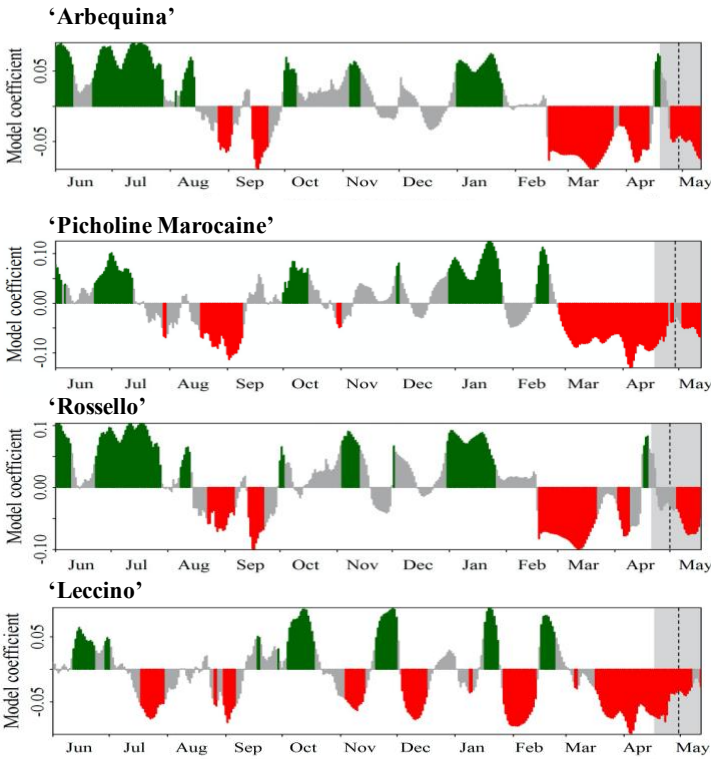


Figure S8. Chilling and forcing phases by the PLS approach of four different cultivars representative of four groups of chilling (see table S6).

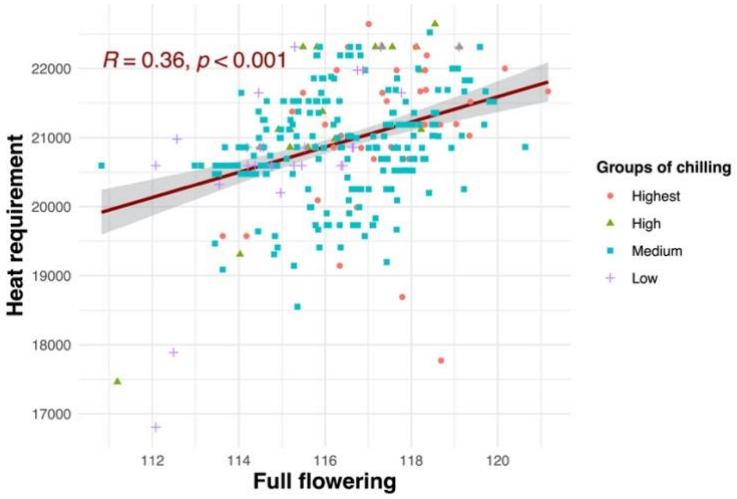


Figure S9. Correlation between olive cultivar effect of full flowering time and the heat requirements (GDH). P<0.001 statistically significant.

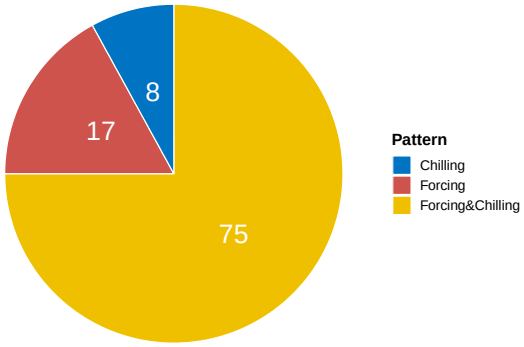


Figure S10. Percentage of patterns of the effect of temperatures on flowering dates of olive cultivars.

Table S1. List of 331 studied olive cultivars, identified using 20 SSR markers and 11 endocarp traits by El bakkali et al 2019 [1]. the number of trees, cultivar's origin of collection, accession code, accession name and cultivars for which PLS analysis was done are mentioned. (Excel file).

Table S2. Analysis of variance of full flowering dates (Stage 65) according to BBCH scale of olive, Sanz Cortés et al., 2002) as a function of cultivar, year and cultivar*year interaction. Alpha is 0.05. Df is the degree of freedom. Levels of significance: ns (not significant); * (p<0.05); **(p<0.01); ***(p<0.001).

	Df	Sum of Squares	Mean Square	F value	Pr >F	Signification
Cultivar	330	38451	117	23.31	<0.001	***
Year	5	485049	97010	19284.54	<0.001	***
Cultivar*Year	1157	25238	22	4.34	<0.001	***
Residuals	4600	23140	5			

Table S3. Analysis of variance and Tukey test mean comparison of cultivar's full flowering dates. Means with different letters are significantly different at Alpha of 5%. (Excel file).

Table S4. Best number of clusters of cultivars by their full flowering dates according to the results of eight indices. Dissimilarity measures were calculated between cultivars by Euclidean distance, and agglomeration was done by word's method (1963). Four clusters were chosen to be the best number of clusters according to the majority rule by Charrad et al. [2]. In this case four out of eight indices proposed four as the best number of clusters. For more information about NbClust function in R and indices computation see the publication of Charrad et al. [2] (Full reference in main document).

Index	KL	CH	Hartigan	CCC	Scott	Marriot	Hubert	Dindex
Number of clusters	5	12	4	3	4	8	4	4
Value Index	29.48	1381.48	144.15	116.66	124.17	201.33	5	15

Table S5. Analysis of variance and Tukey test of four groups of full flowering dates suggested by NbClust function in R [2] and obtained by Hierarchical clustering using Euclidean distance for dissimilarity measures and Ward's method for agglomeration. FFD is Full flowering date. Alpha is 0.05.

Sum of Squares	Mean Square	F value	Pr >F	Tukey grouping	Mean FFD	N	FFD group
33551	11184	1055.1	<0.001	A	128	30	Extra late blooming
				B	125	96	Late blooming
				C	123	126	Mid blooming
				D	119	97	Early blooming

Table S6. Best number of clusters of cultivars by their BLUP of full flowering dates according to results of eight indices. Dissimilarity measures were calculated between cultivars by Euclidean distance, and agglomeration was done by word's method (1963). Four clusters were chosen to be the best number of clusters according to the majority rule by Charrad et al. [2]. In this case four out of eight indices proposed 4 as the best number of clusters.

Index	**KL**	**CH**	**Hartigan**	**CCC**	**Scott**	**Marriot**	**Hubert**	**Dindex**
Number of clusters	8	15	4	3	4	9	4	4
Value Index	239.88	645.60	1005.35	101.37	165.37	1108.71	5	15

Table S7. Best number of clusters of cultivars by their chilling requirements (See materials and methods section) according to the results of twenty-six indices. Dissimilarity measures were calculated between cultivars by Euclidean distance, and agglomeration was done by word's method (1963). Four clusters were chosen to be the best number of clusters according to the majority rule by Charrad et al. [2]. In this case seven out of twenty-six indices proposed 4 as the best number of clusters.

Index	**KL**	**CH**	**Hartigan**	**CCC**	**Scott**	**Marriot**	**TrCovW**	**TraceW**	**Friedman**
Number clusters	7	15	4	15	4	4	4	4	5
Value Index	4,02	4370,51	197,51	53,13	633,51	4,51E+14	4166720,19	4478,92	4046,46
Index	**Rubin**	**Cindex**	**DB**	**Silhouette**	**Duda**	**PseudoT2**	**Beale**	**Ratkowsky**	**SDbw**
Number clusters	7	10	5	5	14	14	14	3	15
Value Index	-229,44	0,1526	0,2464	0,8088	7,5988	-8,684	-3,0373	0,53	0,005
Index	**Ball**	**PtBiserial**	**Frey**	**McClain**	**Dunn**	**Hubert**	**SDindex**	**Dindex**	
Number clusters	4	3	7	3	3	5	5	4	
Value Index	2501,58	0,86	5,32	0,11	0,53	0	0,21	0	

Table S8. The chilling and heat requirements of analyzed WOGBM cultivars. Delineated by the PLS approach and estimated by the dynamic model (DM) for chilling and GDH model for forcing. FFD is Full flowering date, BLUP is Best linear unbiased prediction, CR is chilling requirement, HR is heat requirement and Std is standard deviation. (Excel file).

References

1. El Bakkali, A.; Essalouh, L.; Tollon, C.; Rivallan, R.; Mournet, P.; Moukhli, A.; Zaher, H.; Mekkaoui, A.; Hadidou, A.; Sikaoui, L.; et al. Characterization of Worldwide Olive Germplasm Banks of Marrakech (Morocco) and Cordoba (Spain): Towards management and use of olive germplasm in breeding programs. *PLoS One* **2019**, *14*, e0223716, doi:https://doi.org/10.1371/journal.pone.0223716.
2. Charrad, M.; Ghazzali, N.; Boiteau, V.; Niknafs, A. NbClust: An R Package for Determining the Relevant Number of Clusters in a Data Set. *Journal of Statistical Software* **2014**, *61*, 1 - 36, doi:https://doi.org/10.18637/jss.v061.i06.