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Review

Chilling and Heat Requirements of Temperate Stone Fruit Trees (*Prunus* sp.)

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Abstract: Stone fruit trees of genus *Prunus*, like other temperate woody species, need to accumulate a cultivar-specific amount of chilling during endodormancy, and of heat during ecodormancy to flower properly in spring. Knowing the requirements of a cultivar can be critical in determining if it can be adapted to a particular area. Growers can use this information to anticipate the future performance of their orchards and the adaptation of new cultivars to their region. In this work, the available information on chilling- and heat-requirements of almond, apricot, plum, peach, and sweet cherry cultivars is reviewed. We pay special attention to the method used for the determination of breaking dormancy, the method used to quantify chilling and heat temperatures, and the place where experiments were conducted. The results reveal different gaps in the information available, both in the lack of information of cultivars with unknown requirements and in the methodologies used. The main emerging challenges are the standardization of the conditions of each methodology and the search for biological markers for dormancy. These will help to deal with the growing number of new cultivars and the reduction of winter cold in many areas due to global warming.

Keywords: almond; apricot; chilling hours; chilling units; chilling portions; European plum; growing degree hours; Japanese apricot; Japanese plum; peach; sour cherry; sweet cherry

1. Introduction

Temperate stone fruits belong to the genus *Prunus* in the Rosaceae and produce a fruit called drupe, whose seed is covered by the woody endocarp which in turn is covered by the endocarp. In most cultivated *Prunus* species, the edible part of the fruit is the endocarp, which includes the fleshy pulp (mesocarp) and skin (exocarp) such as apricot (*P. armeniaca* L.), European plum (*P. domestica* L.), Japanese apricot (*P. mume* Siebold and Zucc.), Japanese plum (*P. salicina* Lindl.), peach (*P. persica* L. Batsch), sour cherry (*P. cerasus* L.) and sweet cherry (*P. avium* L.) [1]. On the other hand, in almond (*P. dulcis* (Mill.) D.A. Webb), the edible part of the fruit is the seed. The annual global stone fruit production reached in 2017 more than 47 million t in 7.3 million ha [2]. The most cultivated species are peach (*P. persica* L. Batsch) (24.6 million t in 1.5 million ha), plum (including European and Japanese plum) (11.7 million t in 2.6 million ha), apricot (4.2 million t in 0.5 million ha), sweet cherry

(2.4 million t in 0.4 million ha), almond (2.2 million t in 1.9 million ha) and sour cherry (1.2 million t in 0.2 million ha) [2].

Stone fruit trees, like other temperate woody species, need to accumulate a cultivar-specific amount of chilling during winter to overcome dormancy and then experience warm temperatures to finally flower in spring [3–5]. These conditions the adaptation of species and cultivars to each region [6] and it is the main drawback for their extension to warmer latitudes [7]. Knowing the temperature requirements of a cultivar can be useful for growers to anticipate the future performance of their orchards and to design new orchards taking into account the predicted global warming [7–9]. In this work, the available information on chilling- and heat-requirements of cultivars of the most cultivated stone fruit crops (almond, apricot, peach, plum and cherry) is reviewed, paying special attention to the approach used for the determination of breaking dormancy, the method used to quantify chilling and heat temperatures, and the place where the experiments were conducted. There is extensive information available about chilling and heat requirements that has purposefully been omitted from this review. We have only included those studies that a) obtained results by using an experimental methodology (i.e., transferring shoots into a growth chamber sequentially during winter) or computational/statistical approaches that relate flowering dates to temperature data over a sufficiently long time series, and b) quantified chilling and heat temperatures using the common models (Chilling Hours model, Utah model or Dynamic model for chilling requirements, Growing Degree Hours for heat requirements).

2. Dormancy: Definition and Description

Stone fruit trees adapt to temperate regions by establishing a dormancy state during winter that allows surviving at low temperatures [10]. Dormancy characterizes by the absence of growth since flower primordia remain protected inside the buds. Growth is not only suppressed by the low temperatures since dormant trees do not respond to suitable conditions to grow and need exposure to a certain period of low temperatures to overcome dormancy [11]. It seems clear that dormancy is triggered by internal factors inherent to the plant [12]; however, up to now, most of these physiological factors remain unclear. The exposition to chilling temperatures allows a progressive restoration of growth capability. However, growth is not immediately restored [3], since low temperatures could continue and prevent buds from growing, and the exposure to warm temperatures is needed to grow after dormancy release [13]. Chilling and heat requirements are genetically determined and therefore are cultivar specific [14,15].

The phases of chilling and warm temperature accumulation are differently named, although they occur at the same phenological stage [16]. Lang et al. proposed one of the most used terms, naming the stages "endo-dormancy" while chilling accumulates, and "eco-dormancy" while heat accumulates and chilling prevents the plant from growing [11]. On the other hand, a recent proposal by Considine and Considine considered that dormancy only refers to when it is internally caused, and the lack of growth by external factors correspond to a quiescence state [17].

Dormancy has acquiring rising importance for a sustainable fruit production under a global warming context [8,9,18–20]. However, the physiological processes behind remain unknown and a reliable biological factor linked to the dormancy breaking is still missing [12].

3. Dormancy prediction

The characterization of the temperature requirements of a cultivar is crucial for the design and management of the fruit orchards since they determine the flowering date and a flowering overlap is needed for cross-pollination in case of self-incompatible cultivars [21]. It is also a key trait in breeding programs since it determines both the adaptation to different climates and the blooming and ripening dates [22]. However, the lack of a whole understanding of the process makes obtaining reliable data complex [6]. In most works, the determination of the temperature requirements of a particular cultivar consists of two phases (Figure 1): first, the establishment of the dormancy and forcing periods

(Figure 1a), either experimentally (Figure 1a.1) [23,24] or statistically (Figure 1a.2) [25–27]; and the subsequent temperature quantification in both phases (Figure 1b) by using temperature-based models for chilling (Figure 1b.1) [28–30] and heat quantification (Figure 1b.2) [29]. One of the main challenges of determining the temperature requirements is establishing the transition from dormancy to eco-dormancy (Figure 1a) and thus the periods in which chilling (Figure 1b.1) and warm temperatures (Figure 1b.2) are quantified.

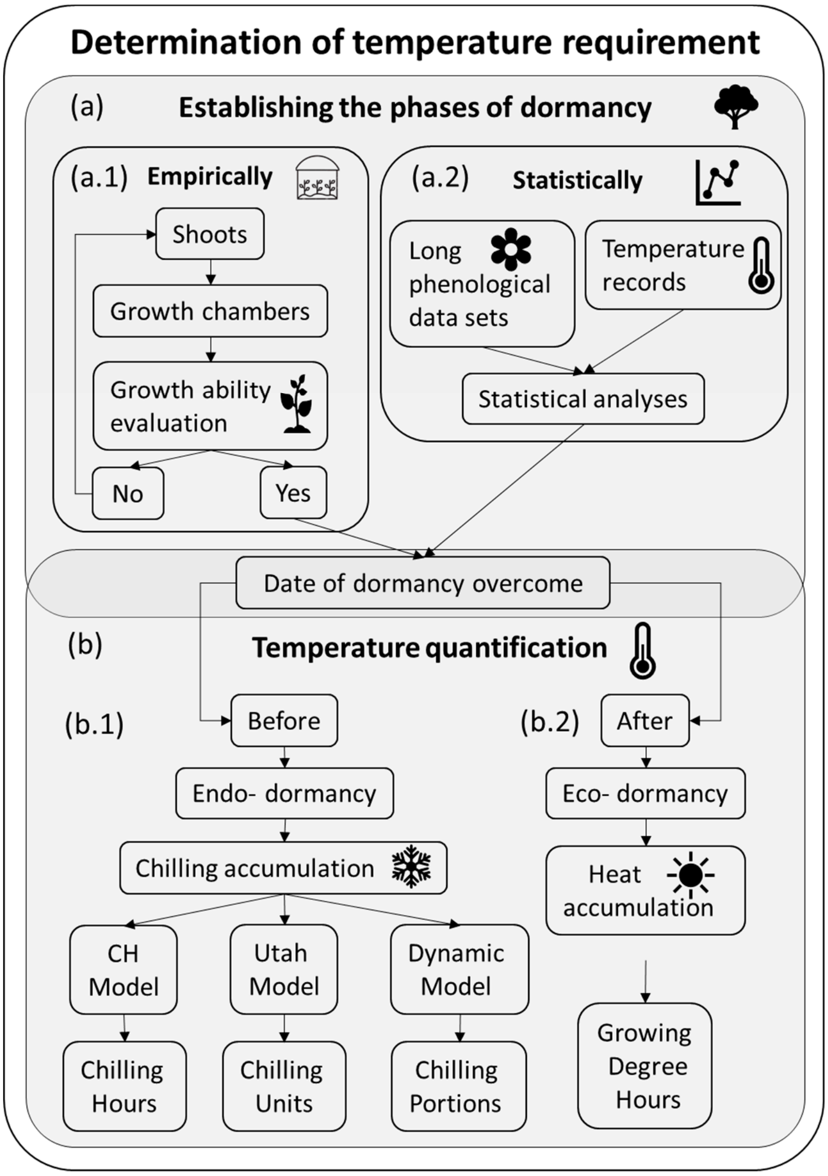

Figure 1. Determination of the temperature (chill and heat) requirements in temperate fruit trees: a workflow. (**a**) Determination of the phases of dormancy: (**a.1**) empirically or (**a.2**) statistically. (**b**) Temperature quantification: (**b.1**) chilling quantification during endo-dormancy and (**b.2**) heat quantification over eco-dormancy.

The experimental determination of dormancy consists of evaluating when the buds recover the capacity to grow (Figure 1a.1). This is usually performed by transferring shoots into a growth chamber sequentially during winter, thus after different chilling exposures. Shoots remain a certain period in the warm conditions, and then bud growth is evaluated. This approach has been widely used from early [24] to recent studies [31] that determine the chilling requirements of the cultivars. Furthermore, these experiments serve as a base for physiological studies on dormancy [6].

The statistical approach estimates the date of chilling fulfillment based on a long series of phenological observations (flowering dates) and relating them with the previous temperature records (Figure 1a.2). Tabuenca et al. established a statistical methodology by calculating the correlation coefficients between the maximum, minimum and mean temperatures of certain time periods and flowering dates in apple, apricot, cherry, peach, pear, plum [32], and almonds [33]. Then, Alonso et al. determined the temperature requirements correlations between the flowering dates of almond cultivars and daily minimum, mean and maximum temperatures calculated as the mean of the surrounding 5, 10, 15 . . . until 30 days, with a set of data from 7 years. The endo-dormancy to eco-dormancy transition was considered to be when the significant correlation coefficients change from being mainly positive to be mainly negative [26]. Ashcroft et al. firstly estimated chilling and heat accumulation of peaches [29] based on when the chilling and heat accumulation presented the least squared residuals methods [25]. A new approach has been recently developed based on the statistical analysis of long-term phenological records and temperature series. The application of partial least squares (PLS) regression leads to the estimation of the agroclimatic requirements. PLS regression is especially applicable when the number of independent variables (daily temperatures, 365 data per year) substantially exceeds the number of dependent variables (one flowering date per cultivar and year). The results of these analyses include the model coefficients and variable-importance-in-the-projection. Significant positive model coefficients correspond with the chilling accumulation, endo- dormancy, while negative coefficients correspond with the heat accumulation, eco- dormancy [34]. It was initially applied in sweet cherry [34] and later in other fruit trees as almond [35,36], pistachio [19], apricot [27] or apple [36].

4. Temperature Based Models for Phenology Prediction

Three main models are currently used in agriculture to quantify chilling over the dormancy period [37]. They were developed in peach: the Chilling Hours model [28], the Utah model [29], and the Dynamic model [30] (Figure 1b.1). The Chilling Hours model was developed in the early fifties of the 20th century, and it has been widely used up to now due to its simplicity and easy comprehension and calculation. This model establishes that a Chilling Hour (CH) corresponds to an hour at temperature between 0 and 7.2 °C (45 °F), since this range of temperatures is considered to affect dormancy completion. While temperatures below 0 °C are assumed not contributing due to at such low temperatures biological processes were considered slowed or not occurring, temperatures over 7.2 °C (45 F) were considered not low enough to affect dormancy completion [28].

The Utah model bases on the quantification of Chilling Units (CU) and establishes different ranges of temperatures with a different contribution to dormancy completion. A chilling unit corresponds to one hour under temperatures between 2.5–9.1 °C, a range that is considered the most effective temperatures on dormancy completion. Other ranges of temperatures are considered to have half (1.5–2.4 °C and 9.2–12.4°C), null (<1.4 °C and 12.5–15.9 °C) or negative (>16 °C) contribution to dormancy [29].

The Dynamic model, dated back from the 1980s [30], is based on a series of experiments that evaluated the effect of different series of temperatures on dormancy release [38–40]. This model proposed the accumulation of an intermediate product promoted by cold temperatures that can be reversed by warm temperatures (first step). Once this intermediate product has reached a certain level, the chill portions are permanently fixed and are considered not affected by warm temperatures [30]. The model is based on a possible biological process in which a thermally unstable precursor would lead to the accumulation of a factor in the buds. This process would follow the Arrhenius law that fits the mathematical relationship between temperature and the rate of a chemical reaction.

Once dormancy is predicted allowing the quantification of chilling, it is also needed to quantified warm temperatures after dormancy for flowering to occur (Figure 1b.2). The modelization of warm temperatures was early developed in agriculture to predict the different phenological stages of crops [41].

The combination of a chilling model with a heat model to predict flowering was firstly described with the combination of the Utah model with the Growing Degree Hours (GDH) quantification [25], and then this combination was also applied with the other chilling models. A GDH is defined as one hour at 1 °C above the base temperature (4.5 °C), this linearly progresses until the upper limit (25° C) [13]. One of the main drawbacks of using these models is the necessity of hourly temperature data records, whose availability is limited. Thus, equivalent models have been developed based on maximum and minimum temperatures [42].

5. Chilling and Heat Requirements

5.1. Almond (*P. dulcis*)

Although North America is the main area for almond production (over 1 million t/year) [2], temperature requirements have been calculated in the Mediterranean area, in Spain [26,33,36,43], the second world producer (0.6 million t/year) [2] and Tunisia [35]. Temperature requirements (chilling and heat) are available for a total of 106 almond cultivars [26,33,35,36,43] (Table 1). The chilling requirements varies between 'Achaak' (8 CH/ -297CU/ 3.4CP) [35] and 'R1000' (996 CU) [43]. The heat requirements range from 2894 GDH for 'Pizzuta' to 10201 GDH for 'Primorskiy' [36].

In this species, the most data (96 out of 106 cultivars) were calculated with statistical approaches, which contrast with the other *Prunus* sp. reported in this work. Almond data were obtained according to three different statistical methodologies [26,33,34]. The initial phenological data set also differed between works: the PLS analysis was performed over the date of flowering initiation (BBCH phenological stage 61, 10% flowers open) during 30 years [34,35], while the other approaches based on the dates of full bloom (BBCH phenological stage 65, 50% flowers open) over 7 [26] and 4-10 years [33].

A comparison between experimental (E) [43] and statistical (S) [26] approaches reveals similar results of chilling requirements and heat requirements for 'Ferragnès' (558 and 444 CU, 7309 and 8051 GDH), 'Marcona' (435 and 428 CU, 6681 and 6603 GDH) and 'Ramillete' (326 and 444 CU, 6538 and 5947 GDH) in Spain. Unfortunately, it is not possible to make more comparisons due to the different models used to quantify chilling and the different cultivars used in each study.

Table 1. Chilling and heat requirements of almond cultivars.

Cultivar	Chilling requirements			Heat requirements	Method	Loc.	Ref.
	CH	CU	CP	GDH			
A-258	-	-	17 ± 4.5	8725 ± 1712	S	Spain	[36]
Abiodh de Sfax	12	−284	4.6	6206	S	Tunisia	[35]
Abiodh Ras Djebel	59	−53	15.5	7324	S	Tunisia	[35]
Achaak	-	266	-	6444	E	Spain	[43]
	8	−297	3.4	8703	S	Tunisia	[35]
Aï	-	444	-	8051	S	Spain	[26]
	169	-	-	Very high	S	Spain	[33]
Alicante	-	-	21.7 ± 4.7	6940 ± 1400	S	Spain	[36]
Alzina	-	463	-	6757	S	Spain	[26]
	408	-	-	Very low	S	Spain	[33]
Amargo	169	-	-	Low	S	Spain	[33]
Andreu	151	-	-	High	S	Spain	[33]
Antoñeta	-	514	-	7512	E	Spain	[43]
Ardechoise	-	-	21.8 ± 4.5	6994 ± 1546	S	Spain	[36]

Table 1. *Cont.*

Cultivar	Chilling requirements CH	CU	CP	Heat requirements GDH	Method	Loc.	Ref.
Avola	50	46	13.6	6673	S	Tunisia	[35]
Aylés	-	481	-	7909	S	Spain	[26]
Bertina	-	463	-	8536	S	Spain	[26]
Blanquerna	-	463	-	6906	S	Spain	[26]
Bonifacio	61	101	15.8	7559	S	Tunisia	[35]
Bruantine	34	−219	10.4	8548	S	Tunisia	[35]
Cambra	-	463	-	7697	S	Spain	[26]
Cavaliera	34	−219	10.4	7042	S	Tunisia	[35]
	-	-	11.6 ± 4.0	7452±1601	S	Spain	[36]
Chellastone	-	463	-	6168	S	Spain	[26]
Chine	151	-	-	Low	S	Spain	[33]
Constantini	-	444	-	5345	S	Spain	[26]
Cristomorto	83	−29	22.6	5872	S	Tunisia	[35]
	-	428	-	8027	S	Spain	[26]
	-	-	20.7 ± 4.7	8236 ± 1482	S	Spain	[36]
Desmayo	-	309	-	5942	E	Spain	[43]
	169	-	-	Medium	S	Spain	[33]
Desmayo Largueta	-	428	-	5458	S	Spain	[26]
	-	-	8.4 ± 3.7	8552±1741	S	Spain	[36]
Desmayo Rojo	-	463	-	6418	S	Spain	[26]
	169	-	-	High	S	Spain	[33]
Dorée	46	−174	12.7	8867	S	Tunisia	[35]
Drake	169	-	-	Very high	S	Spain	[33]
Durán	151	-	-	Medium	S	Spain	[33]
Faggoussi	54	−148	14.5	3962	S	Tunisia	[35]
Fakhfekh	33	−219	10.4	5979	S	Tunisia	[35]
Fasciuneddu	34	−219	10.4	7027	S	Tunisia	[35]
Felisia	-	428	-	9352	S	Spain	[26]
Ferraduel	54	59	14.4	9272	S	Tunisia	[35]
	-	-	52.9 ± 6.0	7285 ± 1362	S	Spain	[36]
Ferragnès	-	558	-	7309	E	Spain	[43]
	54	59	14.4	9215	S	Tunisia	[35]
	-	444	-	8051	S	Spain	[26]
	-	-	20.7 ± 4.7	8696 ± 1543	S	Spain	[36]
Filippo Ceo	-	463	-	7558	S	Spain	[26]
	483	-	-	Low	S	Spain	[33]
Fourcouronne	169	-	-	High	S	Spain	[33]
Fournat de Brézenaud	169	-	-	Very high	S	Spain	[33]
	-	416	-	7367	S	Spain	[26]
	79	−50	21.1	5368	S	Tunisia	[35]
Gabaix	-	-	13.4 ± 4.4	6824 ± 1421	S	Spain	[36]
Garbí	-	-	52.9 ± 6	7040 ± 1312	S	Spain	[36]
Garnghzel	12	−284	4.6	8703	S	Tunisia	[35]

Table 1. *Cont.*

Cultivar	Chilling requirements CH	CU	CP	Heat requirements GDH	Method	Loc.	Ref.
Garrigues	-	-	22.0 ± 4.7	8054 ± 1811	S	Spain	[36]
Genco Taronto	80	194	21.4	6148	S	Tunisia	[35]
	-	-	28.7 ± 4.9	5971 ± 1189	S	Spain	[36]
Glorieta	-	-	51.6 ± 5.9	5654 ± 1177	S	Spain	[36]
Guara	-	463	-	7978	S	Spain	[26]
Jordi	-	428	-	6488	S	Spain	[26]
	151	-	-	Medium	S	Spain	[33]
Khoukhi	31	−227	9.9	8873	S	Tunisia	[35]
Ksontini	21	−258	7.3	7071	S	Tunisia	[35]
Languedoc	23	−174	7.7	9097	S	Tunisia	[35]
Lauranne	-	428	-	8569	S	Spain	[26]
LeGrand	-	428	-	8027	S	Spain	[26]
Lluch		-		Very high	S	Spain	[33]
Malagueña	23	−82	7.6	9224	S	Tunisia	[35]
Marcona	169	-	-	High	S	Spain	[33]
	-	435	-	6681	E	Spain	[43]
	-	428	-	6603	S	Spain	[26]
	-	-	22.0 ± 4.7	6378 ± 1341	S	Spain	[36]
Marta	-	478	-	7577	E	Spain	[43]
Masbovera	-	463	-	7841	S	Spain	[26]
	-	-	28.6 ± 4.9	6232 ± 1221	S	Spain	[36]
Mazzetto	54	-68	14.5	9507	S	Tunisia	[35]
Miagkoskorlupij	-	463	-	7439	S	Spain	[26]
	631	-	-	Very low	S	Spain	[33]
Mollar de Tarragona	-	-	20.0 ± 4.7	6718 ± 1378	S	Spain	[36]
Moncayo	-	463	-	8696	S	Spain	[26]
Montrone	31	-227	9.9	9694	S	Tunisia	[35]
Morskoi	233	-	-	Very high	S	Spain	[33]
Ne Plus Ultra	169	-	-	Medium	S	Spain	[33]
	50	11	13.6	6847	S	Tunisia	[35]
	-	463	-	6635	S	Spain	[26]
Nonpareil	83	-29	22.6	6045	S	Tunisia	[35]
	-	403	-	7758	S	Spain	[26]
	169	-	-	High	S	Spain	[33]
	-	-	21.7 ± 4.7	7062 ± 1399	S	Spain	[36]
Picantilli	-	428	-	7386	S	Spain	[26]
	561	-	-	Very low	S	Spain	[33]
Pizzuta	83	-29	22.6	2894	S	Tunisia	[35]
Ponç	-	428	-	6210	S	Spain	[26]
	101	-	-	High	S	Spain	[33]
Poleta	151	-	-	High	S	Spain	[33]
Pou de Felanitz	-	392	-	5419	S	Spain	[26]
	101	-	-	Medium	S	Spain	[33]

Table 1. *Cont.*

Cultivar	Chilling requirements CH	CU	CP	Heat requirements GDH	Method	Loc.	Ref.
Princesa	169	-	-	High	S	Spain	[33]
Primorskij	-	428	-	8434	S	Spain	[26]
	-	-	52.85 ± 5.95	10201 ± 1834	S	Spain	[36]
R1000	-	996	-	7438	E	Spain	[43]
Rachele	233	-	-	Very high	S	Spain	[33]
	-	376	-	8302	S	Spain	[26]
	47	-167	13.3	6374	S	Tunisia	[35]
Ramillete	-	444	-	5947	S	Spain	[26]
	-	326	-	6538	E	Spain	[43]
	-	-	20.7 ± 4.7	6998 ± 1540	S	Spain	[36]
Ramlet R249	33	18	10.3	6812	S	Tunisia	[35]
Ramlet R250	19	-266	6.7	6812	S	Tunisia	[35]
Rana	-	-	20.0 ± 4.7	6518 ± 1292	S	Spain	[36]
Rof	-	463	-	6418	S	Spain	[26]
	169	-	-	High	S	Spain	[33]
	-	-	20.8 ± 4.7	6965 ± 1355	S	Spain	[36]
Rotjet	151	-	-	Low	S	Spain	[33]
S2332	-	417	-	6481	E	Spain	[43]
S5133	-	973	-	7003	E	Spain	[43]
Sicilia	151	-	-	High	S	Spain	[33]
Soukaret	77	-57	20.6	5960	S	Tunisia	[35]
Tardive de la Verdière	-	358	-	8814	S	Spain	[26]
Tardy Nonpareil	-	-	55.4 ± 5.9	9444 ± 1658	S	Spain	[36]
Tarragona	83	-29	22.6	5830	S	Tunisia	[35]
Tarragones	-	-	51.6 ± 5.9	6370 ± 1238	S	Spain	[36]
Tamarite 2	169	-	-	High	S	Spain	[33]
Texas	-	463	-	7697	S	Spain	[26]
	233	-	-	High	S	Spain	[33]
	-	-	51.6 ± 5.9	6280 ± 1225	S	Spain	[36]
Thompson	-	463	-	7697	S	Spain	[26]
Titan	-	444	-	8457	S	Spain	[26]
Tokyo	-	463	-	7558	S	Spain	[26]
Totsol	-	428	-	6943	S	Spain	[26]
	101	-	-	High	S	Spain	[33]
Tozeur 1	12	-284	4.6	8124	S	Tunisia	[35]
Tozeur 2	33	-219	10.4	6309	S	Tunisia	[35]
Tozeur 4	12	-284	4.6	6698	S	Tunisia	[35]
Trell	77	-57	20.6	6003	S	Tunisia	[35]
	233	-	-	Medium	S	Spain	[33]
Tuono Taronto	-	463	-	7978	S	Spain	[26]
	50	46	13.6	6148	S	Tunisia	[35]
	-	-	52.9 ± 6.0	6870 ± 1319	S	Spain	[36]

Table 1. *Cont.*

Cultivar	Chilling requirements CH	CU	CP	Heat requirements GDH	Method	Loc.	Ref.
Verdereta	-	416	-	6606	S	Spain	[26]
	101	-	-	High	S	Spain	[33]
Verdiere	169	-	-	Very high	S	Spain	[33]
Vinagrilla	408	-	-	Very low	S	Spain	[33]
Vivot	-	428	-	6603	S	Spain	[26]
	151	-	-	High	S	Spain	[33]
Xina	-	403	-	5815	S	Spain	[26]
Yaltano	713	-	-	Very low	S	Spain	[33]
Yaltinskij	-	463	-	8536	S	Spain	[26]
Zahaf	31	-227	9.9	6279	S	Tunisia	[35]
	-	392	-	5611	S	Spain	[26]

5.2. European and Japanese Apricot (P. armeniaca and P. mume)

European apricot is one of the most economically important fruit crops in temperate regions worldwide [44]. It is mainly produced in the Mediterranean area and the Middle East, being the higher producers Turkey, Uzbekistan, Italy, Algeria, and Iran [2]. A total of 15 works have experimentally evaluated the chilling requirements of 68 apricot cultivars all around the world (Iran, Italy, Serbia, South Africa, Spain, and the USA) (Table 2). The range of chilling requirements is between 274 CU in 'Palsteyn' [45] to 1450–1600 CU in 'Orangered' [46]. This crop is cultivated mainly in Mediterranean regions and it has traditionally been considered that most cultivars had low chilling requirements. However, some traditional cultivars showed high chilling requirements as 'Búlida' (1048 CU), 'Canino' (806 CU), 'Currot' (642 CU) or 'Moniqui' (1139 CU) [42,43] (Table 2).

In the last decades, an important renewal is taking place due to sharka, a disease caused by the Plum Pox Virus (PPV). High chilling PPV-resistant cultivars from North America, such as 'Goldrich' (950–108 CU / 65-59 CP), 'Harcot' (920–1665 CP), 'Orangered' (568–1481 CH / 902–1600CU / 55–69 CP), and 'Stark Early Orange' (1411 CU / 79 CP) (Table 2), have been used as parentals in different breeding programs with the aim of introducing a source of the resistance to the disease. The release of a high number of new cultivars is resulting in a lack of information about the chilling and heat requirements of the majority of the new commercial cultivars [44,47].

Some cultivars such as 'Aurora', 'Bergeron', 'Currot', 'Dorada', 'Goldrich', 'Laycot', 'Luizet', 'Moniqui', 'Murciana', 'Paviot', 'Rojo Pasión', 'Royal', 'San Castrese', and 'Selene' show homogeneous results in the different studies (Table 2). However, highly variable results have been reported in other cultivars as 'Cafona', 'Canino', 'Harcot', 'Orangered', 'Palsteyn', 'Polonais', 'Precoz de Colomber', and 'Tonda di Costiglione', showing heterogeneity among the different approaches (Table 2). Likewise, high differences have been reported when the experiments were carried out in different locations [45,48,49] or years [48,50,51]. Even when the same cultivars ('Canino', 'Orangered' and 'Palsteyn') were evaluated using the same approach in two environments with different climatic conditions, the results obtained showed high differences, with higher values in Spain (806/1172/631 CU) than in South Africa (304/957/274 CU) [45] (Table 2). Heat requirements ranged from 485 GDH in 'Goldrich' [49] to values above 6000 GDH in 'Canino' [48], 'Dorada', 'Palsteyn', and 'Rojo Pasión' [45]. Some cultivars showed high differences between seasons, as 'Cafona' (2499–5800 GDH), 'Canino' (2547–6729 GDH), and 'Precoz de Colomber' (2320-5304 GDH) [48].

Japanese apricot originated in China and has been widely cultivated for about 3000 years in Asian countries as China, Japan, and Korea. However, this crop is hardly known in other countries probably due to its poor adaptation to other areas of different climatic conditions, since it requires warmer and more humid conditions than European apricot [44].

Chilling requirements range from 26 ± 7 CP for 'Shuangshuidaroumei' [52] to 78.5 CP for 'Sichuangqingmei' and 'Tengwulang' [53] (Table 3). Heat requirements vary from 822 GDH for 'Dayu' to 2378 GDH for 'Jietianmei', 'Sichuangqingmei', and 'Tengwulang' (Table 3) [53]. Japanese apricot shows high chilling requirements and extremely low heat requirements when compared with the other *Prunus* sp. reported in this study.

Some cultivars with a wide range of chilling requirements, such as 'Nanko', a high-chilling cultivar from Japan, and 'Ellching', a low-chilling cultivar from the subtropical region in Taiwan, have been used in studies on dormancy physiology [54] and genetic regulation [55–59].

Table 2. Chilling and heat requirements of European apricot cultivars.

Cultivar	Chilling requirements			Heat requirements	Method	Loc.	Ref.
	CH	CU	CP	GDH			
Abricot Pêche 1708 A.D.	1015–1105	-	-	-	E	Spain	[60]
Alessandrino	-	1000–1140	-	3825	E	Italy	[46]
Amabile Vecchioni	-	1140	-	2950	E	Italy	[46]
Amoscatelado	711–806	-	-	-	E	Spain	[60]
Asgarabad	710	652	-	3465	E	Iran	[61]
Aurora	-	1140	-	2750	E	Italy	[46]
	1237	1296	-	2490–2812	E	Italy	[62]
Baracca	-	1000–1140	-	4680	E	Italy	[46]
Bebeco	-	1030–1125	-	3775	E	Italy	[46]
Bergeron	-	1225	-	4300	E	Italy	[46]
	699	1176	64.8	4526	E	Spain	[50]
	762	1134	61.7	5150	E	Spain	[45]
	-	1122–1224	-	-	E	Serbia	[51]
Blanc Rose	1105–1185	-	-	-	E	Spain	[60]
Búlida	1050	-	-	-	E	Spain	[63]
	950–983	-	-	-	E	Spain	[60]
	976–1015	-	-	-	E	Spain	[60]
	830–926	-	-	-	E	Spain	[60]
	1133 ± 170	1296 ± 145	-	-	E	Spain	[64]
	560	968	53.8	5146	E	Spain	[50]
	708	1048	56.4	5294	E	Spain	[45]
Cafona	-	1200 ± 35	-	3433	E	Italy	[48]
	-	824–1515	-	2499–5800	E	Spain	[48]
Canino	≤750	-	-	-	E	Spain	[63]
	787–878	-	-	-	E	Spain	[60]
	<779	-	-	-	E	Spain	[60]
	771–779	-	-	-	E	Spain	[60]
	-	964–1370	-	2477 - 3087	E	Italy	[48]
	-	725–1350	-	2547 - 6729	E	Spain	[48]
	-	1030	-	3275	E	Italy	[46]
	532	806	45	5724	E	Spain	[45]
	488	304	29.8	-	E	South Africa	[45]

Table 2. *Cont.*

Cultivar	Chilling requirements CH	CU	CP	Heat requirements GDH	Method	Loc.	Ref.
Cegledy arany	-	1122–1310	-	-	E	Serbia	[51]
Charisma	188	290	31.7	-	E	South Africa	[45]
Comice de Toulon	806-878	-	-	-	E	Spain	[60]
Corbato	≤750	-	-	-	E	Spain	[63]
Currot	≤750	-	-	-	E	Spain	[63]
	354 - 507	-	-	-	E	Spain	[60]
	267	596	34.3	5879	E	Spain	[50]
	-	621	40.4	1611–2083	E	Italy	[49]
	-	634	38.8	2114–3168	E	Spain	[49]
	-	726–669	-	-	E	Italy	[65]
	409	642	37.8	5774	E	Spain	[45]
D'Alessandria	-	1000–1140	-	4150	E	Italy	[46]
Doctor Mascle	592 - 711	-	-	-	E	Spain	[60]
Dorada	594	1007	56.2	5079	E	Spain	[50]
	720	1069	57.7	6189	E	Spain	[45]
Early Blush	1407	-	-	2969	E	Italy	[66]
Galta Rocha	372–592	-	-	-	E	Spain	[60]
Giletano	771–806	-	-	-	E	Spain	[60]
Goldrich	-	950–1030	-	3950	E	Italy	[46]
	-	1084	65.2	485–913	E	Italy	[49]
		992	58.6	2067–3431	E	Spain	[49]
	-	834–846	-	-	E	Serbia	[51]
Harcot	-	1275–1530	-	2267–2988	E	Italy	[48]
	-	920–1665	-	3731–5355	E	Spain	[48]
Hatif de Sig	902–976	-	-	-	E	Spain	[60]
Hoja de Parra	668–787	-	-	-	E	Spain	[60]
Koiska	1050	-	-	-	E	Spain	[63]
Laycot	1214	-	-	3533	E	Italy	[66]
	1045	1157	-	3252–3481	E	Italy	[62]
Luicet	1150	-	-	-	E	Spain	[63]
	1074–1140	-	-	-	E	Spain	[60]
	1058–1116	-	-	-	E	Spain	[60]
Magyar kajski	-	1122– 1310	-	-	E	Serbia	[51]
Moniqui	850	-	-	-	E	Spain	[63]
	779–926	-	-	-	E	Spain	[60]
	954 ± 103	1139 ± 96	-	-	E	Spain	[64]
	-	930–1140	-	3250	E	Italy	[46]
Moongold	-	910	-	2712	E	USA	[67]
Moonpark	1074–1105	-	-	-	E	Spain	[60]

Table 2. *Cont.*

Cultivar	Chilling requirements CH	CU	CP	Heat requirements GDH	Method	Loc.	Ref.
Murciana	585	1009	55.9	4440	E	Spain	[50]
	690	1030	55.6	5392	E	Spain	[45]
Ninfa	-	834–846	-	-	E	Serbia	[51]
Orangered	1587	-	-	3448	E	Italy	[66]
	-	1450–1600	-	2700	E	Italy	[46]
	1481	1467	-	2654–3136	E	Italy	[62]
	738	1266	69.1	4362	E	Spain	[50]
	-	902	55.5	2421–3398	E	Italy	[49]
	-	1146	67.2	1443–1505	E	Spain	[49]
	777	1172	64.3	4916	E	Spain	[45]
	568	957	55.4	-	E	South Africa	[45]
Palsteyn	171	274	31.6	-	E	South Africa	[45]
	413	631	37.1	6247	E	Spain	[45]
Patriarca de Hueso Dulce	664–729	-	-	-	E	Spain	[60]
Paviot	1050	-	-	-	E	Spain	[63]
	995–1075	-	-	-	E	Spain	[60]
	1148 ± 148	1318 ± 145	-	-	E	Spain	[64]
Perfection	-	844	-	2593	E	USA	[67]
Perla	1074–1105	-	-	-	E	Spain	[60]
Phelps	-	857	-	2206	E	USA	[67]
Pike	-	895	-	2753	E	USA	[67]
Pisana	-	1113–1122	-	-	E	Serbia	[51]
Polonais	1058–1116	-	-	-	E	Spain	[60]
	-	1175–1450	-	2611 - 2823	E	Italy	[48]
	-	920–1665	-	4047 - 5753	E	Spain	[48]
	-	1300	-	2850	E	Italy	[46]
Precoz de Colomer	950	-	-	-	E	Spain	[63]
	< 779	-	-	-	E	Spain	[60]
	-	1175–1250	-	2503–2563	E	Italy	[48]
	-	690–1190	-	2320–5304	E	Spain	[48]
Priana	-	926 ± 26	-	2189	E	Spain	[48]
Rapareddu	-	1250	-	2850	E	Italy	[46]
Re Umberto	-	1126–1442	-	-	E	Serbia	[51]
Rojo Pasión	531	917	51.2	4670	E	Spain	[50]
	566	874	48.2	6078	E	Spain	[45]
Rouge de Rousillon	950 - 1005	-	-	-	E	Spain	[60]
Royal	875	-	-	-	E	USA	[23]
	850	-	-	-	E	Spain	[63]
	779 - 950	-	-	-	E	Spain	[60]

Table 2. *Cont.*

Cultivar	Chilling requirements CH	CU	CP	Heat requirements GDH	Method	Loc.	Ref.
San Castrese	-	964–1100	-	1410–3289	E	Italy	[48]
	-	725 ± 23	-	4134	E	Spain	[48]
	1044	-	-	3558	E	Italy	[66]
	-	870–930	-	3425	E	Italy	[46]
	788	894	-	2705–3874	E	Italy	[62]
	-	880	54	1615–3326	E	Italy	[49]
	-	981	56.5	2116–2967	E	Spain	[49]
S. Nicola Grosso	-	1140	-	3350	E	Italy	[46]
Sarritzu I°	-	950–1140	-	3950	E	Italy	[46]
Selene	590	1018	57.4	4078	E	Spain	[50]
	705	1057	56.9	4605	E	Spain	[45]
Shakarpare	862	746	-	3171	E	Iran	[61]
Shamlo	1130	826	-	2987	E	Iran	[61]
Stark Early Orange	-	1411	78.9		E	Italy	[49]
Sundrop	-	964–967	-	-	E	Serbia	[51]
Sylred	-	967–1019	-	-	E	Serbia	[51]
Tabarze ghermez	1130	826	-	2987	E	Iran	[61]
Tilton	1000	-	-	-	E	USA	[23]
Tirynthos		935–1000	-	1898–3289	E	Italy	[48]
Tom Cot	-	834–846	-	-	E	Serbia	[51]
Tonda di Costiglione	1812	-	-	3643	E	Italy	[66]
	1586	1561	-	3402–3696	E	Italy	[62]

Table 3. Chilling and heat requirements of Japanese apricot cultivars.

Cultivar	Chilling requirements CH	CU	CP	Heat req. GDH	Method	Loc.	Ref.
67	-	-	69	994	E	China	[53]
Baijiahe	-	-	59	1316	E	China	[53]
Changnong17	-	-	69	994	E	China	[53]
Dabaimei	-	-	56	1669	E	China	[53]
Dali	-	-	40	1192	E	China	[53]
Danfenghou	-	-	73	2054	E	China	[53]
Daqiandi	-	-	66.5	1096	E	China	[53]
Daroumei	-	-	38.5	1100	E	China	[53]
Dayezhugan	-	-	73	1651	E	China	[53]
Dayu	-	-	69	822	E	China	[53]
Dongqing	875 ± 147	1054 ± 256	58±9	1018±174	E	China	[52]
Dongshanlimei	-	-	50	1250	E	China	[53]
Ellching	300	-	-	-	E	Japan	[54]
Fenghou	1148 ± 162	1323 ± 247	73±8	1697±1697	E	China	[52]
Fenghualimei	-	-	56	1533	E	China	[53]

Table 3. *Cont.*

Cultivar	Chilling requirements CH	CU	CP	Heat req. GDH	Method	Loc.	Ref.
Gaotianfenghou	-	-	73	2054	E	China	[53]
Gaotiangmei	-	-	64.5	1099	E	China	[53]
Guangdonghuangpi	-	-	40	1192	E	China	[53]
Gucheng	-	-	59	1383	E	China	[53]
Hangzhoubaimei	-	-	60	1231	E	China	[53]
Henghe	-	-	34	1287	E	China	[53]
Hongding	-	-	69	860	E	China	[53]
Hongmei	-	-	73	1835	E	China	[53]
Hongnong	-	-	75	1675	E	China	[53]
Huangxiaoda	-	-	56	1533	E	China	[53]
Huaxiangshi	-	-	33.5	1072	E	China	[53]
Jiazhouxiaomei	-	-	69	1733	E	China	[53]
Jiazhouzuixiao	-	-	62	1116	E	China	[53]
Jietianmei	-	-	77	2378	E	China	[53]
Jiuzhongmei	-	-	66.5	1096	E	China	[53]
Lizimei	-	-	69	977	E	China	[53]
Longyan	-	-	73	1835	E	China	[53]
Lve	-	-	29	1268	E	China	[53]
Nanhong	-	-	50	1583	E	China	[53]
Nanko	500	-	-	-	E	Japan	[54]
Pinzhimei	-	-	73	1835	E	China	[53]
Qijiangxingmei	-	-	56	1533	E	China	[53]
Qingjia2	-	-	75	1675	E	China	[53]
Qixingmei	-	-	60	1232	E	China	[53]
Ruantiaohongmei	-	-	73	1835	E	China	[53]
Shuangshuidaroumei	239 ± 84	479 ± 180	26±7	1235±77	E	China	[52]
Shuangtaomei	-	-	36.5	1079	E	China	[53]
Sichuangbaimei	-	-	60	1231	E	China	[53]
Sichuanghuangmei	-	-	60	1231	E	China	[53]
Sichuangqingmei	-	-	78.5	2378	E	China	[53]
Siyuemei	-	-	60	1231	E	China	[53]
Taihu1	-	-	69	977	E	China	[53]
Taihu3	-	-	50	1575	E	China	[53]
Taoxingmei	332 ± 110	567 ± 198	32 ± 8	110 ± 199	E	China	[52]
Tengwulang	-	-	78.5	2378	E	China	[53]
Tonglv	-	-	73	1835	E	China	[53]
Touguhong	-	-	62	986	E	China	[53]
Wanhong	-	-	73	1835	E	China	[53]
Weishanzhong	-	-	50	1574	E	China	[53]
Xianmimei	-	-	40	1205	E	China	[53]
Xiaomei	-	-	50	1369	E	China	[53]
Xiaoougongfen	-	-	42.5	1037	E	China	[53]

Table 3. *Cont.*

Cultivar	Chilling requirements CH	CU	CP	Heat req. GDH	Method	Loc.	Ref.
Xiaoqing	-	-	73	1432	E	China	[53]
Xiaoyezhugan	-	-	56	1533	E	China	[53]
Xingnongxiaomei	-	-	62	1116	E	China	[53]
Xiyeqing	828 ± 139	1040 ± 231	64 ± 9	1179 ± 230	E	China	[52]
Xuemei	-	-	69	1405	E	China	[53]
Yanglao1	-	-	59	1530	E	China	[53]
Yanglao2	-	-	34	1297	E	China	[53]
Yanglao3	-	-	56	1669	E	China	[53]
Yanhua	1141 ± 253	1321 ± 328	76 ± 6	1250 ± 213	E	China	[52]
Yanzhimei	-	-	69	977	E	China	[53]
Yeliqing	-	-	69	994	E	China	[53]
Yingsu	-	-	59	1463	E	China	[53]
Yinnafenghou	-	-	73	2054	E	China	[53]
Yueshijie	-	-	62	1116	E	China	[53]
Yunnanxingmei	-	-	73	1835	E	China	[53]
Yuying	-	-	62	1116	E	China	[53]
Zaohong	-	-	50	1583	E	China	[53]
Zaohua	-	-	56	1403	E	China	[53]
Zhizhimei	-	-	69	1069	E	China	[53]
Zhonghong	-	-	53	1542	E	China	[53]

5.3. Peach (P. persica)

Peach is the stone fruit crop with higher economic importance. It has been confined traditionally to latitudes between 30° and 50° North and South [68], but in the last years, there is an increasing interest to expand it to warmer areas, including tropical and subtropical regions [68–70]. In recent decades, intense breeding has led to the release of an enormous number of cultivars of different types of fruit, including pubescent (peaches) or glabrous skin (nectarines), round or flat shape, white or yellow flesh, and freestone o clingstone [70] (Table 4). Several peach cultivars have been used to develop models in dormancy studies, both in experimental approaches to determine the date of breaking of endodormancy [23,38,71] and in models to quantify chilling and forcing temperatures [13,28,29,72]. The *DORMANCY-ASSOCIATED MAD-BOX* (*DAM*) genes that regulate dormancy were first reported in an 'evergreen' peach mutant [73,74].

This work compiles the chilling requirements of 216 cultivars, including seven flat peach cultivars, 25 nectarine cultivars and 172 peach cultivars, showing high differences in the range 239-536 CH, 354-861 CU and 22.3-48.5 CP for flat peaches, 90-426 CH/ 45-1050CU/9-47CP for nectarines and 71-1390 CH/ 5-1220 CU/ 1-1221.8 CP for peaches. The heat requirements of 44 cultivars have been compiled, ranging from 5853 to 9338 GDH for nectarine and between 3476 and 16493 GDH for peach.

Table 4. Chilling and heat requirements of peach cultivars.

	Cultivar	Chilling requirements CH	CU	CP	Heat requirements GDH	Method	Loc.	Ref.
Flat peach	**Carioca**	**368**	**582**	35.5	-	E	Spain	[75]
	Siroco 10	305	480	28.9	-	E	Spain	[75]
	Siroco 5	239	355	22.3	-	E	Spain	[75]
	Sweet Cap	536	86	47.6	-	E	Spain	[75]
	UFO 2	432	681	40.2	-	E	Spain	[75]
	UFO 3	451	741	43.8	-	E	Spain	[75]
	UFO 4	484	803	48.5	-	E	Spain	[75]
Nectarine	**Caldessi 2000**	316	210	33	9002	S	Argentina	[76]
	Carolina	326	-	-	-	S	Argentina	[77]
	Cheonhong	-	800	-	-	S	Korea	[78]
	Collins	-	950	-	-	S	Korea	[78]
	Cortez	-	750	-	-	S	Korea	[78]
	Derby	-	750	-	-	S	Korea	[78]
	Earliscarlet	-	800	-	-	S	Korea	[78]
	Early Giant	342	249	46	8677	S	Argentina	[76]
	Fantasia	-	750	-	-	S	Korea	[78]
	Firebrite	308	198	34	7498	S	Argentina	[76]
	Flavortop	-	750	-	-	S	Korea	[78]
	Garden State	-	1050	-	-	S	Korea	[78]
	Hahong	-	700	-	-	S	Korea	[78]
	Hardired	-	950	-	-	S	Korea	[78]
	Lara	350	-	-	-	S	Argentina	[77]
		93	47	9	9338	S	Argentina	[76]
	María Anna	426	392	46	5853	S	Argentina	[76]
	María Lucía	413	244	47	6777	S	Argentina	[76]
	May Glo	98	84	12	8242	S	Argentina	[76]
	May Grand	-	800	-	-	S	Korea	[78]
	Redgold	-	850	-	-	S	Korea	[78]
	Roseprincess	313	207	33	9000	S	Argentina	[76]
	Suhong	-	700	-	-	S	Korea	[78]
	Sunfre	-	500	-	-	S	Korea	[78]
	Sungem	-	425	-	-	S	Korea	[78]
	Sunraycer	90	45	10	9086	S	Argentina	[76]
Peach	**Afterglow**	750	-	-	-	S	USA	[28]
	Akatsuki	1176	1074	-	5675	E	Japan	[79]
	Anjiry Asali	862	746	-	4232	E	Iran	[61]
	Anjiry Zafarany	973	805	-	4099	E	Iran	[61]
	Armking	-	600	-	-	S	Korea	[78]
	Autumnglo	-	950	-	-	S	Korea	[78]
	Babygold 5	498	364	53	8505	S	Argentina	[76]

Table 4. *Cont.*

	Cultivar	Chilling requirements CH	CU	CP	Heat requirements GDH	Method	Loc.	Ref.
Peach	**Belle**	850	-	-	-	S	USA	[28]
	Best May	850	-	-	-	S	USA	[28]
	Big top	363	716	45.2	-	E	Spain	[80]
	Bonão	142.3	46.6	532	-	S	Brazil	[81]
	BR-1	<300	-	-	-	E	Brazil	[82]
	BR-3	305	265	982.6	-	S	Brazil	[81]
	Cambará do sul	371	295	1221.8	-	S	Brazil	[81]
	Camdem	-	750	-	-	S	Korea	[78]
	Canadian	-	750	-	-	S	Korea	[78]
	Candoka	850	-	-	-	S	USA	[28]
	Catherina	793	1220	62.4	-	E	Spain	[80]
	Changbangjosaeng	232	-	-	-	S	China	[83]
	Changhowon Hwangdo	-	850	-	-	S	Korea	[78]
	Cheonghong	146 - 261	-	-	-	S	China	[83]
	Cheonjoongdo	137	-	-	-	S	China	[83]
	Chinese cling	850	-	-	-	S	China	[84]
	Chiyohime	820	-	-	-	E	Japan	[85]
	Colora	1050	-	-	-	S	USA	[28]
	Coral	354	32	1137.8	-	S	Brazil	[81]
	Cresthaven	-	950	-	-	E	USA	[86]
	Cumberland	850	-	-	-	S	USA	[28]
	Delicioso	200	-	-	-	E	Brazil	[82]
	Della Nona	400	-	-	-	E	Brazil	[82]
	Diamante	294	228	875.6	-	S	Brazil	[81]
	Dixigem	850	-	-	-	S	USA	[28]
	Dixigold	850	-	-	-	S	USA	[28]
	Dixired	950	-	-	-	S	USA	[28]
	Duke of York	1150	-	-	-	S	USA	[28]
	Early Elberta	-	850	-	-	S	Korea	[78]
		850	-	-	-	S	USA	[28]
	Early Halegaven	850	-	-	-	S	USA	[28]
	Early Hiley	750	-	-	-	S	USA	[28]
	Early Jubilee	850	-	-	-	S	USA	[28]
	Early May Crest	300	600	40	-	E	Tunisia	[87]
	Early Rose	1150	-	-	-	S	USA	[28]
	Early Vedette	950	-	-	-	S	USA	[28]
	Early Wheeler	950	-	-	-	S	USA	[28]
	Eclipse	950	-	-	-	S	USA	[28]
	Elberta	850	-	-	-	S	USA	[28]
		790	-	-	5110	E	USA	[27]

Table 4. *Cont.*

	Cultivar	Chilling requirements CH	Chilling requirements CU	Chilling requirements CP	Heat requirements GDH	Method	Loc.	Ref.
Peach	Eldorado	300	-	-	-	E	Brazil	[82]
	Elegant Lady	806	-	-	4692	E	Italy	[66]
	Erly-Red-Fre	850	-	-	-	S	USA	[28]
	Fairhaven	-	850	-	-	S	Korea	[78]
	Fairprince	-	850	-	-	S	Korea	[78]
	Fairs Beauty	1050	-	-	-	S	USA	[28]
	Fay Elberta	750	-	-	-	S	USA	[28]
	Feicheng Bai Li 10	1100	-	-	-	S	China	[84]
	Fergold	921	861	52.8	-	E	Spain	[80]
	Fireglow	750	-	-	-	S	USA	[28]
	Fireprince	341	226	36	8488	S	Argentina	[76]
	Fisher	-	950	-	-	S	Korea	[78]
		950	-	-	-	S	USA	[28]
	Fla. 91-8c	100	-	-	-	S	Argentina	[77]
	Flaming Gold	750	-	-	-	S	USA	[28]
	Flavorcrest	-	750	-	-	S	Korea	[78]
	Flordaglo	79	11	1	8394	S	Argentina	[76]
	Flordastar	-	225	-	3476 ± 57	E	Spain	[88]
	Franca	818	-	-	4887	E	Italy	[66]
	Fuzzless Berta	1150	-	-	-	S	USA	[28]
	Gage	750	-	-	-	S	USA	[28]
	GaLa	306	206	30	7415	S	Argentina	[76]
	Gemmers Elberta	750	-	-	-	S	USA	[28]
	Golden Jubilee	-	850	-	-	S	Korea	[78]
		850	-	-	-	S	USA	[28]
	Goldeneast	1050	-	-	-	S	USA	[28]
	Guglielmina	488	381	51	8543	S	Argentina	[76]
	Haj kamzemi	1390	868	-	4543	E	Iran	[61]
	Halberta Giant	850	-	-	-	S	USA	[28]
	Halegold	850	-	-	-	S	USA	[28]
	Halehaven	850	-	-	-	S	USA	[28]
	Halford	-	900	-	-	S	Korea	[78]
	Harbrite	-	850	-	-	S	Korea	[78]
	Harken	-	750	-	-	S	Korea	[78]
	Harland	-	850	-	-	S	Korea	[78]
	Harrow Beauty	-	775	-	-	S	Korea	[78]
	Herbhale	850	-	-	-	S	USA	[28]
	Hikawahakuhou	1173	1079	-	5505	E	Japan	[79]
	Hiley	750	-	-	-	S	USA	[28]
	Ideal	850	-	-	-	S	USA	[28]
	J.H. Hale	850	-	-	-	S	USA	[28]

Table 4. *Cont.*

	Cultivar	Chilling requirements CH	CU	CP	Heat requirements GDH	Method	Loc.	Ref.
Peach	**Janghowon**	134	-	-	-	S	China	[83]
	Jerseyglo	-	750	-	-	S	Korea	[78]
	Jerseyland	-	850	-	-	S	Korea	[78]
	Jinmi	-	850	-	-	S	Korea	[78]
	July Elberta	750	-	-	-	S	USA	[28]
	Juneprince	-	650	-	-	E	USA	[86]
		-	625	-	-	S	Korea	[78]
	Kalhaven	950	-	-	-	S	USA	[28]
	Kosary	1390	868	-	4543	E	Iran	[61]
	Late Dwarf	71	5	6	16493	S	Argentina	[76]
	Levante 30	321	523	31.7	4592	S	Spain	[89]
	Levante 40	341	536	33.0	6824	S	Spain	[89]
	Lizzie	950	-	-	-	S	USA	[28]
	Loring	-	800	-	-	S	Korea	[78]
	Lovell	-	850	-	-	S	Korea	[78]
	Majestic	-	750	-	-	S	Korea	[78]
	Maravilha	203	124	692.4	-	S	Brazil	[81]
	Marfim	313	287	1018.2	-	S	Brazil	[81]
	María Delizia	338	223	47	11504	S	Argentina	[76]
	María Marta	327	212	34	9252	S	Argentina	[76]
	Maruja	572	809	51.8	-	E	Spain	[80]
	Maxine	1050	-	-	-	S	USA	[28]
	Mayflower	1150	-	-	-	S	USA	[28]
	Mibaekdo	-	850	-	-	S	Korea	[78]
	Michelini	884	-	-	5333	E	Italy	[66]
	Midway	850	-	-	-	S	USA	[28]
	Mihong	-	850	-	-	S	Korea	[78]
	Misshong	-	850	-	-	S	Korea	[78]
	Mistral 30	402	659	40.5	7103	S	Spain	[89]
	Momo tsukuba 127	555	652	-	5259	E	Japan	[79]
	Nectaross	925	-	-	5218	E	Italy	[66]
	New Yorker	-	850	-	-	S	Korea	[78]
	Newday	750	-	-	-	S	USA	[28]
	Okinawa 1	319	443	-	4691	E	Japan	[79]
	Pacemaker	750	-	-	-	S	USA	[28]
	Pepita	204	118	687.3	-	S	Brazil	[81]
	Planalto	400 - 500	-	-	-	E	Brazil	[82]
	Precocinho	216	139	720.4	-	S	Brazil	[81]
		150	-	-	-	E	Brazil	[72]

Table 4. *Cont.*

	Cultivar	Chilling requirements CH	CU	CP	Heat requirements GDH	Method	Loc.	Ref.
Peach	Qingzhou Bai Pi Mi Tao	1100	-	-	-	S	China	[84]
	Raritan Rose	-	1050	-	-	S	Korea	[78]
		950	-	-	-	S	USA	[28]
	Red Globed	-	850	-	-	E	USA	[86]
		-	850	-	-	S	Korea	[78]
	Redelberta	750	-	-	-	S	USA	[28]
	Redhaven	850	-	-	-	S	USA	[28]
		870	-	-	4922	E	USA	[27]
	Redheaven	-	950	-	-	S	Korea	[78]
	Redrose	850	-	-	-	S	USA	[28]
	Reliance	-	1050	-	-	S	Korea	[78]
	Rich Lady	73	6	11	14086	S	Argentina	[76]
	Richhaven	-	950	-	-	S	Korea	[78]
	Rio Oso Gem	850	-	-	-	S	USA	[28]
	Riograndense	300	-	-	-	E	Brazil	[82]
	Rosa del West	434	378	51	9879	S	Argentina	[76]
	Ruiguang 03	-	777	-	-	S	Korea	[78]
	Salberta	850	-	-	-	S	USA	[28]
	Salwy	1050	-	-	-	S	USA	[28]
	Sentry	-	875	-	-	S	Korea	[78]
	Shipper Late Red	850	-	-	-	S	USA	[28]
	Siroco 5	246	427	25.8	7025	S	Spain	[89]
	Siroco 20	344	561	35.8	7384	S	Spain	[89]
	Siroco 30	308	539	31.2	6815	S	Spain	[89]
	Siroco 40	310	509	30.3	7463	S	Spain	[89]
	Siroco 43	370	593	36.4	6552	S	Spain	[89]
	Southland	750	-	-	-	S	USA	[28]
	Spring Belle	650	-	-	-	S	Spain	[90]
	Spring Lady	331	625	40.8	-	E	Spain	[80]
	Springtime	-	650	-	-	S	Korea	[78]
	Stark Red Gold	898	-	-	5188	E	Italy	[66]
	Starking Delicious	-	750	-	-	S	Korea	[78]
	Sullivan	850	-	-	-	S	USA	[28]
	Summercrest	950	-	-	-	S	USA	[28]
	Sunglo	-	850	-	-	S	Korea	[78]
	Sunhigh	750	-	-	-	S	USA	[28]
	Sunland	-	750	-	-	E	USA	[86]
		-	750	-	-	S	Korea	[78]
	Triogem	850	-	-	-	S	USA	[28]

Table 4. *Cont.*

	Cultivar	Chilling requirements CH	CU	CP	Heat requirements GDH	Method	Loc.	Ref.
Peach	**Tropic Beauty**	-	150	-	-	S	Korea	[78]
	Tropic Snow	-	200	-	-	S	Korea	[78]
	Turmalina	250	184	801.8	-	S	Brazil	[81]
	Up-to-date	850	-	-	-	S	USA	[28]
	Valiant	850	-	-	-	S	USA	[28]
	Vedette	1050	-	-	-	S	USA	[28]
	Veeglo	-	950	-	-	S	Korea	[78]
	Veteran	1050	-	-	-	S	USA	[28]
	Vivid	-	950	-	-	S	Korea	[78]
	Worlds Earliest	750	-	-	-	S	USA	[28]
	Yanguang	-	780	-	-	S	Korea	[78]
	Youmyeong	150 - 277	-	-	-	S	China	[83]
	Yu Hua Lu	800	-	-	-	S	China	[84]
	Yumi	-	800	-	-	S	Korea	[78]
	Yumyeong	-	850	-	-	S	Korea	[78]
	Zoud Ras	1130	826	-	4384	E	Iran	[61]

5.4. European and Japanese plum (P. domestica and P. salicina).

World production of plums increased by almost 20% in the last 10 years (from 9.5 million tons in 2007 to 12 million tons in 2017) [2]. These data include European plums, Japanese plums and hybrids between different *Prunus* sp. In spite of the economic importance of this crop, temperature requirements are little studied, with data available for only nine cultivars of European plum (Table 5) [91] and 16 cultivars of Japanese plum (Table 6) from two studies performed in Spain [31,91]. The experimental procedure used was slightly different between studies, with variation in the temperature of the growing chamber and in the growth evaluation procedure.

European plums are cultivated in colder climates [92], showing higher chilling requirements (579-1323 CH) than Japanese plums (118–685 CH) (Tables 5 and 6). The chilling requirements of European plum ranged from 579–678 CH for 'Reine Claude d'Oullins' to 1116-1323 CH for 'Reine Claude Noir' [93]. There is no data available on heat requirements in this species.

The Japanese plum cultivars with lower chilling requirements are 'Methley' (118–239 CH [91] and 'Pioneer' (181-231 CH / 297–358 CU / 18.4-27.6 CP), which also showed the lower values of heat requirements (5261-6720 GDH) [31]. 'Songold' showed higher values both for chilling (561–630 CH/ 974–1001 CU / 60.4–61.1 CP) and heat requirements (8588-10034 GDH). There are only data from different reports for 'Golden Japan' and 'Santa Rosa', showing high differences between them (Table 6).

Table 5. Chilling and heat requirements of European plum cultivars.

Cultivar	Chilling requirements CH	CU	CP	Heat req. GDH	Method	Loc.	Ref.
Beauty Plum of Catalogne	**678–819**	-	-	-	E	Spain	[91]
Coe´s Golden Drop	984–1157	-	-	-	E	Spain	[91]
Real de Calahorra	976–1029	-	-	-	E	Spain	[91]
Reine Claude de Bavay	984–1157	-	-	-	E	Spain	[91]
Reine Claudie Noir	1116–1323	-	-	-	E	Spain	[91]
Reine Claude d´Oullins	579–678	-	-	-	E	Spain	[91]
Reine Claude Verte	976–1275	-	-	-	E	Spain	[91]
Reine Claude Violetta d´Agen	819–984	-	-	-	E	Spain	[91]
Reine Claude Washington	976–1275	-	-	-	E	Spain	[91]

Table 6. Chilling and heat requirements of Japanese plum cultivars.

Cultivar	Chilling requirements CH	CU	CP	Heat req. GDH	Method	Loc.	Ref.
Angeleno	434–447	750–779	39.7–50.1	7300–8180	E	Spain	[31]
Apex	486–678	-	-	-	E	Spain	[91]
Black Diamond	389–432	630–750	38.7–47.1	6994–8068	E	Spain	[31]
Black Splendor	213–324	437–605	29.1–31.2	5744–6705	E	Spain	[31]
Burbank	486–678	-	-	-	E	Spain	[91]
Formosa	486–678	-	-	-	E	Spain	[91]
Fortune	436–447	750–769	39.7–46.7	6681–8506	E	Spain	[31]
Golden Globe	473–685	872–1053	44.8–63.5	7300–9151	E	Spain	[31]
Golden Japan	118–287	-	-	-	E	Spain	[91]
	384–454	701–829	35.4–52.1	6939–7855	E	Spain	[31]
Laetitia	436–454	750–829	39.7–52.1	7894–8020	E	Spain	[31]
Methley	118–239	-	-	-	E	Spain	[91]
Pioneer	181–231	297–358	18.4–27.6	5261–6720	E	Spain	[31]
Red Beauty	265–369	500–688	25.6–46	6727–7183	E	Spain	[31]
Santa Rosa	372–627	-	-	-	E	Spain	[91]
	436–459	750–829	41.8–52.1	6591–9099	E	Spain	[31]
Songold	561–630	974–1001	60.4–61.1	8588–10034	E	Spain	[31]
Wickson	345–627	-	-	-	E	Spain	[91]

5.5. Sweet and Sour Cherry (P. avium and P. cerasus)

Sweet cherries are mainly produced in Mediterranean countries as Turkey (0.63 million t/year), Italy (0.12 million t/year), Spain (0.11 million t/year) and Greece (0.90 million t/year), in Middle Eastern countries such as Iran (0.14 million t/year) and Uzbekistan (0.14 million t/year), in the United States (0.40 million t/year), and in Chile (0.13 million t/year) [2]. Chilling requirements are available for 53 cultivars [34,94–97], while the heat requirements were only calculated for 16 of them (Table 7) [34,96]. Chilling requirements are mainly quantified with CH in 48 cultivars [94,96] that range from 176 CH of 'Cristobalina' [96] to more than 1100 CH for 'Garrafal de Lérida', 'Hedelfinger', 'Lambert', 'Napoleón', and 'Vignola' [94]. Data available in CU in 21 cultivars range between 94 CU for 'Lapins' and 'Larian' [97] and 1559 ± 53 CU for 'Skeena' [95], and 8 cultivars in CP from to 30.4 CP for 'Cristobalina' to 57.6 CP for 'Marvin' [96]. Chilling requirements for 'Burlat' and 'Cristobalina' were experimentally analyzed in two studies, resulting in higher values in the north of Spain ('Burlat' 900-100 CH and 'Cristobalina' <800 CH) [94] than in the Mediterranean area ('Burlat' 618 CH and 'Cristobalina'

176 CH) [96]. Estimations of heat requirements showed high variation between cultivars and locations: 3473 ± 1236 GDH for 'Schneider' in Germany [34], and 15500–16000 GDH are for 'Lapins', 'Larian', and '0900 Ziraat' in Turkey [97].

The experimental methodology [94–97] showed slight differences among studies: the frequency of field sampling (every 2 [97] or 7 [94] days, or every 50-100 CU [96]), the temperature of the chamber (24 ± 1 °C [96,97] or 20 ± 1 °C [94]), the period in the chamber (7 [94,95], 10 [96] or 21 [97] days), and also in the bud growth evaluation (dry weight [94], fresh weight [95], or phenology [96,97]). A statistical methodology was developed based on 'Schneiders' in Germany [34].

Sour cherry requirements have been poorly studied. There is only data of cultivar Montmorency, which showed 954 CU and 6130 GDH [42] (Table 7).

Table 7. Chilling and heat requirements of sour and sweet cherry cultivars.

Cultivar	Chilling requirements CH	CU	CP	Heat requirements GDH	Method	Loc.	Ref.
Ambrunés	1000–1100	-	-	-	E	Spain	[94]
Bing	1000–1100	-	-	-	E	Spain	[94]
	-	1082 ± 27	-	-	E	Spain	[95]
Brooks	411.5	556	36.7	7863.2	E	Spain	[96]
Burlat	900–1000	-	-	-	E	Spain	[94]
	618	806	48	8750.2	E	Spain	[96]
	-	981 ± 83	-	-	E	Spain	[95]
	-	-	86	-	E	Spain	[98]
Cherovina	900–1000	-	-	-	E	Spain	[94]
Cristobalina	<800	-	-	-	E	Spain	[94]
	176	397	30.4	9195	E	Spain	[96]
	-	687 ± 83	-	-	E	Spain	[95]
	-	-	29	-	E	Spain	[98]
Daiber	1000–1100	-	-	-	E	Spain	[94]
Earlise	-	981 ± 83	-	-	E	Spain	[95]
Early Rivers	800–900	-	-	-	E	Spain	[94]
Fertard	-	-	101	-	E	Spain	[98]
Garrafal de Lérida	> 1100	-	-	-	E	Spain	[94]
Guillaume	1000–1100	-	-	-	E	Spain	[94]
Hedelfingen	> 1100	-	-	-	E	Spain	[94]
Jaboulay	1000–1100	-	-	-	E	Spain	[94]
Jarandilla	> 1100	-	-	-	E	Spain	[94]
Kordia	700–750	150	-	14000	E	Turkey	[97]
Lambert	> 1100	-	-	-	E	Spain	[94]
Lampé (Ramillete)	900–1000	-	-	-	E	Spain	[94]
Lapins	400–450	94		15500–16000	E	Turkey	[97]
Larian	450	94		15500–16000	E	Turkey	[97]
Marmotte	1000–1100	-	-	-	E	Spain	[94]
Marvin	788	1002	57.6	9450	E	Spain	[96]
Merton Glory	900–1000	-	-	-	E	Spain	[94]
Mollar de cáceres	900–1000	-	-	-	E	Spain	[94]
Moreau	1000–1100	-	-	-	E	Spain	[94]
Nafrina	500–550	120	-	15000–15500	E	Turkey	[97]
Napoleón	> 1100	-	-	-	E	Spain	[94]
New Star	709	909	53.5	8257	E	Spain	[96]

Table 7. *Cont.*

Cultivar	Chilling requirements			Heat requirements	Method	Loc.	Ref.
	CH	CU	CP	GDH			
Noir de Guben	600–650	110	-	14000–14500	E	Turkey	[97]
Pico Colorado	1000–1100	-	-	-	E	Spain	[94]
Producta	1000–1100	-	-	-	E	Spain	[94]
Ramón Oliva	900–1000	-	-	-	E	Spain	[94]
Regina	-	-	86	-	E	Spain	[98]
Reverchon	1000–1100	-	-	-	E	Spain	[94]
Ripolla	800–900	-	-	-	E	Spain	[94]
Ruby	618	806	48	7326	E	Spain	[96]
Somerset	618	806	48	8625.2	E	Spain	[96]
Schneiders	698 ± 151	794 ± 17	45.7 ± 5.4	3473 ± 1236	S	Germany	[34]
Skeena	–	1559 ± 63	-	-	E	Spain	[95]
Stark Hardy Giant	1000–1100	-	-	-	E	Spain	[94]
Summit	650	125	-	15000	E	Turkey	[97]
Sunburst	650–700	141	-	14000–14500	E	Turkey	[97]
Taleguera Brillante	1000–1100	-	-	-	E	Spain	[94]
Temprana de Sot	1000–1100	-	-	-	E	Spain	[94]
Tigré	900–1000	-	-	-	E	Spain	[94]
Van	1000–1100	-	-	-	E	Spain	[94]
Vernon	1000–1100	-	-	-	E	Spain	[94]
Vignola	> 1100	-	-	-	E	Spain	[94]
Villareta	900–1000	-	-	-	E	Spain	[94]
0900 Ziraat	600–650	134	-	15500–16000	E	Turkey	[97]
Montmorency(sour cherry)	–	954	-	6130	S	USA	[42]

6. Concluding Remarks and Perspectives

This study compiles the temperature requirements of a total of 530 cultivars of eight *Prunus* ssp. Most of the data correspond to peach (204 cultivars), almond (106 cultivars), Japanese apricot (77 cultivars), European apricot (68 cultivars), and sweet cherry (49 cultivars) since there is little information available for European plum (nine cultivars), Japanese plum (16 cultivars), and sour cherry (1 cultivar) (Table 8). These data represent a very small percentage of the existing commercial cultivars and, in addition, 84 out of 530 cultivars came from studies published more than 25 years ago (Table 8). Therefore, temperature requirements are only available for very current growing cultivars. To serve as a reference, more than 1500 stone fruit cultivars were registered in the European Union in the last 25 years, including 946 for peach, 320 for apricot, 132 for Japanese plum, and 130 for sweet cherry [99]. Two main methodologies, statistical and experimental, have been used to obtain the temperature requirements reported here. Chilling requirements were experimentally determined for all the cultivars of European and Japanese apricot and European and Japanese plum. In contrast, most of the data available for cultivars of almond (153 statistical data vs. 56 experimental data) and peach (173 statistical data vs. 42 experimental data) were statistically determined (Table 8).

Table 8. For each stone fruit crop, number of studies included in this work, number of cultivars with available data of chilling and/or heat requirements, and number of cultivars according to the methodology used.

Specie		Studies	Cultivars		Methodology	
			Total nº	> 25 years old	Statistical	Experimental
Almond		5	106	17	98	10
European apricot		15	68	23	0	69
Japanese apricot		3	77	0	0	77
Peach	Flat peach	1	7	0	1	0
	Nectarine	3	25	0	3	0
	Peach	18	172	1	7	11
European plum		1	9	9	0	9
Japanese plum		2	16	5	0	16
Sweet and Sour cherry		7	50	29	1	49

Chilling quantification was performed according to different temperature models: 382 data were calculated with CH, 342 with CP and 241 with CP. Heat requirements are available for 328 out of 530 cultivars (Table 9). Among the different stone fruit crops, peach cultivars presented a wider range of chilling requirements (71–1390 CH, 5-1220 CU, and 1–1222 CP), while flat peach cultivars showed the least narrow range (239–536 CH, 354–861 CU, and 22.3–48.8 CP). Some almond cultivars showed the lowest chilling requirements, while some cultivars of European apricot, European plum, peach, and sweet cherry showed the highest chilling requirements. Japanese apricot cultivars showed lower heat requirements, while some peach cultivars showed the highest values (16493 GDH) (Table 9).

Table 9. For each stone fruit crop, the number of cultivars and range of both chilling and heat requirements according to the model used.

Specie		Chilling requirements CH		CU		CP		Heat requirements GDH	
		Data	Range	Data	Range	Data	Range	Data	Range
Almond		73	8–713	91	284–996	62	3.4–55.4	107	2862–10201
Eur. apricot		78	171–1812	88	274–1665	31	29.8–78.9	74	485–6729
Jap. apricot		8	239–1148	6	479–1323	75	29–78.5	75	822-2378
Peach	Flat peach	7	239–536	7	354–861	7	22.3–48.5	0	-
	Nectarine	11	90–426	24	45–1050	9	9–47	9	5853–9338
	Peach	132	71–1390	93	5–1220	34	1–122	35	3476–16493
Eur. plum		9	579–1323	0	-	0	-	0	-
Jap. plum		16	118–685	11	297–1053	11	18–64	11	5261–10034
Sweet cherry		48	176–1100	22	94–1559	12	29–107	17	3473–16000

The empirical methodology to determine dormancy by monitoring shoots in forcing conditions is the unique currently available, although it was designed more than 60 years ago [23]. This method has been applied to determine chilling requirements in early [32] and recent studies [31], but it has also been used to infer the dormant stage in research aimed at studying the physiology of dormancy [6,54,59,100–102]. The variability on the experimental designs among studies had often resulted in inconsistencies in the data obtained. This variability is noted in the frequency of shoot sampling along winter (e.g., weekly, every 10 days or every certain amount of chilling accumulated), but also in the environmental conditions of the growth chamber: temperature (20 °C, 25 °C), temperature regime (constant or with day/night variation), and photoperiod. Subsequently, the evaluation of bud growth is performed after different periods in the growth chamber (a week, 10 days, 20 days), and it is based on analyzing vegetative [103] or flower buds [95]. Furthermore, several criteria are used to determine dormancy overcome. These can consist of significant increases in fresh [23] or dry weight [60], and/or phenological changes in bud phenology [24], which can result in an underestimation of the chilling requirements [98]. All these variations make this methodology easily adaptable to the characteristics of each fruit species and regional variations, but the results obtained under specific conditions should be taken with caution when applied to other regions or climates.

The statistical determination of dormancy is mainly based on two approaches. On one side, the correlation of winter temperatures with the flowering dates, which has been used to establish the chilling requirements of almond [26,33], apricot, peach, plum and sweet cherry [33] cultivars in Spain. On the other side, PLS analysis has been recently developed in a sweet cherry cultivar in Germany [34], and was subsequently applied to other temperate fruit crops as almond in Tunisia [35] and Spain [36], and apricot in China [27,104]. This methodology has reported interesting results on predicting phenology under future scenarios of global warming [19,104]. However, statistical analyses present low applicability on new cultivars released from breeding programs, since they are based on a long series of flowering dates records (more than 20 years).

Once the endo- and eco- dormancy periods have been established, specific temperature models are used to calculate the duration of each phase. Although these models were specially designed to quantify chilling or warm temperatures, they present numerous drawbacks. The Chilling Hours model is easy to understand and calculate and is commonly used by growers who often know the accumulated CH in their location, despite the lack of information about the requirements of their cultivars. This model does not fit perfectly with the behavior of trees, especially in mild and warm areas [105,106]. The Utah model attempts to be more accurate by weighting the temperature ranges. However, the fact that it establishes negative values for warm temperatures hampers its applicability in mild winter conditions. The different criteria for establishing the starting point to quantify temperatures, either an established date for dormancy starting (e.g., November 1st) [35] or the date with the maximum negative value [29], had resulted in high differences even for the same cultivar as occurs in almond [26,35,43] or European apricot [45,48,50], making the comparison between studies difficult. The Dynamic model has been proposed as the best model available but also presents limitations on fitting the plant responses to chill [37]. It was designed as a process-based model, however, the physiological process behind is still unknown [30,40,72]. Finally, the Growing Degree Hours model allows quantifying forcing temperatures in a wide range of biological processes, such as phenological stages of annual crops or even insect growth [107]. The results of GDH quantification are highly variable between species, especially at different locations [34]). This could be due to both the model and the interaction between chill and heat accumulation [108–110].

In spite of both the methodologies to determine dormancy periods and the temperature models have numerous pitfalls, the available data of temperature requirements are useful to predict the adaptability of a particular cultivar to a certain area. However, very few of the cultivars currently grown have known temperature requirements. This means that, in most cases, the flowering period is the unique information available to assess the adaptation of a cultivar. Flowering periods are usually related to a reference cultivar (e.g., 'Burlat' in sweet cherry) [5] and successfully used for spring frost risk assessment and for pollination purposes, to predict flowering overlap between pollinating and pollinated cultivars. However, assessing the possible adaptation to an area based on relative flowering dates has many limitations, and temperature requirements offer a more reliable approach [111]. However, this review shows that information is not available for the most important cultivars nowadays, and, when available, they are usually imprecise estimations based only on flowering dates. Furthermore, temperature requirements are scarcely evaluated in most breeding programs, which could lead to an increasing lack of information in the coming years.

In conclusion, numerous improvements may be needed to obtain an accurate determination of the temperature requirements of stone fruit cultivars. The standardization of the experimental conditions would allow obtaining more robust and comparable data. However, the increasing number of new cultivars in most Prunus species and the expected reduction of winter chill due to global warming emphasize the necessity of a proper biological marker for dormancy. This would allow the analysis of samples collected directly from the field, without depending on external factors such as forcing conditions in the experimental approach or the availability of a large set of phenological data. Recent reports have revealed several processes as promising candidates for dormancy markers such as the expression of the *DORMANCY-ASSOCIATED MAD-BOX* (*DAM*) genes in peach [112], starch accumulation within the ovary primordia cell in sweet cherry [113], anther meiosis in apricot [114,115], and hormone regulation in sweet cherry [116]. Establishing the relationship between temperature records and a biological dormancy marker would lead to a process-based model that would allow direct determination of dormancy and a more accurate estimation of the temperature requirements of particular cultivars.

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