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Research Article

Comparison of chilling and heat requirement in some peach and apricot cultivars

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Bud Dormancy in deciduous fruit trees of the temperate zones is a phase of development that occurs annually and enables trees to survive cold winters. Chilling and heat requirements for breaking dormancy and flowering were studied in five peach (Kosary, Haj Kazemi, Anjiry Asali, Anjiry Zafarany, and Zoud Ras) and four apricot (asgarabad, shamlo, shakarpare, tabarze ghermez) cultivars. Various models (two chilling hour models, the <7C and 0-7C models, and two chilling unit models, the Utah and Low Chill) were used to measure the accumulation of chilling requirement. The heat requirements were calculated as the growing degree hours (GDH) accumulated from breaking of dormancy to the F_{50} (50% of opened flowers). The cultivars studied showed a range of chilling requirements (chill units, CU), between 746 to 868 CU for peach and 652-826 CU for apricot. The heat requirements for peaches and apricots were between (4099 to 4543GDH) and (2987 to 3465GDH) respectively. Apricot cultivars with lower chilling and heat requirements showed earlier flowering dates. Thus apricot cultivars bloomed between 15 and 16 day before peach cultivars and Heat requirements were found to be more important for regulation of flowering time than were chilling requirement in our climatic condition.

Keywords: Chilling requirements; growing degree hours (GDH); Flowering, Utah model, peach, apricot

Dormancy in deciduous fruit trees and other woody perennials of the temperate zones is a phase of development that occurs annually and enables plants to survive cold winters. Because of relationship between winter frost hardiness and dormancy, it is very important for horticulturists (Saure, 1985). Short photoperiod is considered as a main factor regulating growth cessation and dormancy development in woody plants (Weiser, 1970; Fennell and Hoover, 1991). However, other factors such as temperature (Junttila, 1980; Svendsen *et al*.., 2007) and abiotic and biotic stresses (Chen and Li, 1978) have also been reported to affect timing and rate of dormancy induction.

To resume growth in plants, they need to be exposed to adequate chilling and heat (Couvillon and Erez, 1985). The chilling requirement varies from species to species and also within a species based on their adapted location (Mahmood, 2000). In the dormant state, the tree is able to resist low temperatures but once buds start to break in spring, resistance is lost (Martin, 1991).

Chilling and heat requirement plays a key role in the selection of cultivars for a given geographical region (Bassi *et al.*, 2006). In temperate zone, chilling requirements are generally largely satisfied before the end of the cold season. Therefore flowering happens too early and low temperature can induce an important loss of yield by frost (Faust *et al.*, 1997; Balandir *et al.*, 1993). For this reason, late blooming in stone fruit has been objectives of most breeding programs in order to have flowering take place when the risk of spring frost is low or non-existent (Kester and Gradziel, 1996). In subtropical areas, insufficient chilling has been known as an economic problem in the production of several temperate zone fruit species. Symptoms of insufficient chilling are many, but generally can be identified as a delay in flower and vegetative bud break, bud break spread over an extended period of time, or in severe cases a total lack of bud break. In areas that are commercial peach producing regions, insufficient chilling generally take placed an infrequent basis, but can result in severe economic loss following a warm winter (Couvillon, 1995). Nowadays fruit cultivation, especially for peach, is mainly developed in non-sloping areas that are more productive and easy to irrigate and mechanize. However these areas are more exposed to spring frosts, especially during flowering (Valentini *et al.*, 2004) and also Apricots are commercially cultivated in a relatively narrow climatic area in comparison to other deciduous species (Faust *et al.*, 1998) and determination of the end of dormancy is of considerable importance in apricot. Since the majority of apricot cultivars show poor adaptation to different environmental conditions, knowledge of flower bud chilling and heat requirements could allow the productive behavior of a given cultivar to be more accurately predicted (Guerriero *et al.*, 2006). Another application of the chilling and heat estimations for different fruit cultivars may be the planting design when cross-pollination is needed. Not only cross-compatible and simultaneously flowering cultivar must be selected, but also cultivars with similar chilling and heat requirement in order to obtain a highest overlapping of flowering period independently of the temperature regime before flowering, thus optimizing the possibilities of cross pollination (Alonso *et al.*, 2005). There are several methods for estimation of chilling requirement of trees such as using biological methods (Bassi *et al.*, 2006), anatomical method (Szabo *et al.*, 2002), biochemical method (Bartolini *et al.*, 2004), detached twigs (Aslani *et al.*, 2009), change in carbohydrate composition (Marquat *et al.*, 1999).

Little is known about the chilling requirements of apricot (Ruiz, 2007). Viti *et al.* (2010) calculated the chilling and heat requirement of different apricot cultivars, for breaking dormancy and flowering, as a Utah and dynamic models, in field conditions. Pawasut *et al.* (2004) studied the chilling and heat requirement of ornamental peaches in Japan, and Valentini *et al.* (2004) determined the chilling and heat requirement of peach and apricot with different temperature models in northwest Italy.

The objective of this study was to evaluate the chilling requirement for breaking the dormancy of five peach and four apricot cultivars, using different models and to evaluate the heat requirement for flowering in Iran.

Material and methods

Plant material was obtained from an experimental orchard of Tabriz University, situated in the North West Iran (altitude 1585 m, lat. 38 ° 15 N, long. 36 ° 45). The experiment was conducted with five commercial peach cultivars (Kosary, Haj Kazemi, Anjiry Asali, Anjiry Zafarany, and Zoud Ras), and four commercial apricot cultivars (asgarabad, shamlo, shakarpare, tabarze ghermez). The trees were 4 years old at the beginning of the study, and all trees received similar cultural practices such as irrigation and fertilization. The temperatures data used were the hourly records from thermo-hygrograph, located at height of 1.5 m in the field.

In our field condition, the start date of CU accumulation was fixed as the day in autumn when a consistent chilling accumulation occurred and the temperatures producing a negative effect were scarce (Richardson *et al.*., 1974). These dates were corresponded to 13 October. From the beginning of the chilling accumulation in the orchard, four branches (with lengths of around 40 cm and diameters of 8-10 mm taken from similar position on the tree) of each cultivar were picked randomly from four trees weekly. The branches were put in plastic bags and transferred to the laboratory. The branches were placed with their basal tip in 5% sucrose solution and forced in a growth chamber at 25±1 °C under photoperiod of 16 h light and 8 h of dark period, with a constant relative humidity of 65%. The basal ends of the branches were cut and the sucrose solution was replaced, after 5 days. After 10 days in the growth chamber, the phonological state of the flower buds was tested. Rest was considered as completed when 30% of floral buds reached the Baggiolini´s stage B – C within 10 day (Ruiz, 2007).

Various models (The Utah model (Richardson *et al.*., 1974), modified chill unit model (Gilreath and Buchanan, 1981), hours below 7.2°C (Weinberger, 1950) and hours between 0 and 7.2°C (Eggert, 1951)) were used to measure the accumulation of chilling requirement (Table, 1). Heat requirements were calculated as growing degree hours (GDH). The accumulation of GDH for flowering under natural conditions was considered to begin after the rest was fulfilled (Sparks, 1993).

Table 1. Chill units calculated by A) Richardson *et al.* (1974) in high chilling peach, B) Gilreath and Buchanan (1981), in low chilling nectarine

Chill unit value	A	B
0	1/4>	-1
./5	1/5-2/4	1/8
1	2/5-9/1	8
./5	9/2-12/4	14
0	12/5 -15/9	17
-./5	16 -18	19/5
-1	>18	21/5

Results and Discussion

Although there are many papers written on dormancy and its component periods, no universal models exist that accurately predict the release of dormancy for a broad range of plant species and environmental conditions (Cesaraccio *et al.*., 2004). Various models have been used to measure the accumulation of winter chilling in deciduous fruit-growing areas by different authors. It is difficult to compare results obtained by different authors. In order to resolve this issue, we evaluated CR based on two chilling hour models (the <7˚C and 0-7˚C models) and two chilling unit models (the Utah and Low Chill) (Table 2). The comparison of the four models to calculate chilling requirement was in agreement with the previous reports, and showed that <7.2°C method had the highest values of CU amounts, either for apricot and peach, while the 0-7.2°C method had the lowest (Valentini *et al.*, 2004). In our climatic conditions, the

Utah model is advisable because it was developed in a cooler area. In this model, the peach chilling requirements ranged from 746 to 868 CU for flower buds. Anjiry Asali (746 CU) had the lowest chilling requirement for flowering. The first cultivar to break dormancy finished the dormancy 49 days after the beginning of chilling accumulation. Anjiry Zafarany, Zoud Ras with 805, 826 CU respectively, showed intermediate chilling requirement. Finally, Kosary and Haj Kazemi with 868 CU were the peach cultivars with the highest chilling requirement in this study. Considerable variability has been observed in the chilling requirement for peach cultivars. Peach cultivars have chilling requirements of 100 –1200 CU, but most commercial cultivars ranging from 650 to 900 CU (Layne and Bassi, 2008). Pawasut *et al.* (2004) determined the chilling requirement for 11 ornamental peach cultivar and the calculated values were between 732-1433 CU. Chilling requirement of 5 peach cultivars in Italy were found to be about 806-925 CU by Valentini *et al.* (2004). Low chill peach cultivars adapted to subtropical conditions of south Florida, require from <100 to 200 chill units (Rouse and Sherman, 2003).

The date of dormancy breaking showed narrow variations among apricot cultivars (table 3). Asgarabad (652 CU) was the first cultivar to break dormancy followed by shakarpare (746 CU) with medium chilling requirement. But the highest chilling requirement observed for tabarze ghermez, shamlo with 826 CU. Ruiz *et al.* (2007) studied the chilling requirement of 10 apricot cultivars for 3 years in Spain and the results ranged between 596 and 1266 chill units. Valentini *et al.* (2004) showed that early flowering apricot cultivars required 1044 hours, whereas late flowering ones needed 1812 hours, according to the under 7/2 model that were similar to shamlo and tabarze ghermez(1130). Viti *et al.* (2010) reported that CU of apricot cultivars in Spain and Italy were between 634-1146 and 621-1084 respectivly. A chill unit of asgarabad (652 CU) was similar to currot with 634 CU in Italy (Viti *et al.* 2010).

The heat requirements for peaches and apricots were between (4099 to 4543GDH) and (2987 to 3465GDH) respectively. tabarze ghermez, shamlo (2987) had the lowest heat requirement. Shakarpare, asgarabad, Anjiry Zafarany, Anjiry Asali and Zoud Ras, showed intermediate heat requirement. Finally, Kosary and Haj Kazemi with 4543 GDH were the peach cultivars with the highest heat requirement. Citadin *et al.* (2001) conclude that peach cultivars differ in heat requirement for flowering and greater chilling exposures led to a reduction of the heat requirements. Our results of heat requirements for flowering in peach were similar to those found by Pawasut *et al.* (2004) and were lower than those found by Valentini *et al.* (2004). Our data show a narrow range of the heat requirement with a slight increase in the late flowering cultivars. Our data concerning heat requirement in apricot were in accordance with the suggestion of Valentini *et al.* (2004), which estimated the heat requirement of apricot cultivars between 2969 to 3643 GDH, and were lower than those found by Ruiz *et al.* (2007).

The time of flowering depend on the chilling and heat requirement. Couillon and erez (1985) reported that chilling and heat requirement is interdependent processes. The flowering dates of the evaluated cultivars showed in table (3). Apricot cultivars with lower chilling and heat requirements showed earlier flowering dates. Thus apricot cultivars bloomed between 15 and 16 day before peach cultivars. The earliest flowering cultivars were shakarpare and asgarabad that bloomed at 8 April. In the case of peach cultivars, Anjiry Zafarany was the first variety that reached full bloom (25 April) and followed by

Anjiry Asali (26 April) and Zoud Ras (27 April). The latest flowering cultivars were Kosary and Haj Kazemi that bloomed at 29 April. shakarpare and Anjiry Asali had similar chilling requirement, but their heat requirement were different, and flowering date were determined by heat requirement than chilling requirement. This result are in agreement with the finding of Alonso *et al.* (2005), who suggested that in cold conditions of Zaragoza, heat requirements were more important than chilling requirement to regulate the flowering date in almond due to early satisfaction of chilling. Nevertheless, these results are in disagreement with previous studies in other species (Ruiz *et al.* 2007, Egea *et al.* 2003, Alburquerque *et al.* 2008), stated that the flowering time was influenced more by chilling than by heat requirements.

Table 2. Chilling requirements for breaking of dormancy in the peach and apricot cultivars calculated by different model

Models / Cultivars	Utah model (CU)	Low Chill model (CU)	Hours <7/2˚C (H)	0-7/2˚C model (H)
Peachs				
Anjiry Asali	746	835	862	598
Anjiry Zafarany	805	907	973	648
Zoud Ras	826	943	1130	680
Kosary	868	991	1390	739
Haj Kazemi	868	991	1390	739
Apricots				
asgarabad	652	700	710	534
shakarpare	746	835	862	598
tabarze ghermez	826	943	1130	680
shamlo	826	943	1130	680

Table 3. Relationships between chill units (according to Utah model), growing degree hours and flowering time in five peach and four apricot cultivars.

Cultivars	Breaking endo-dormancy time	Utah model (CU)	Days[1]	GDH	Flowering (F50)	Days[2]
Peachs						
Anjiry Asali	1 December	746	49	4232	26 April	146
Anjiry Zafarany	8 December	805	56	4099	25 April	138
Zoud Ras	15 December	826	63	4384	27 April	133
Kosary	22 December	868	70	4543	29 April	128
Haj Kazemi	22 December	868	70	4543	29 April	128
Apricots						
asgarabad	24 November	652	41	3465	8 April	135
shakarpare	1 December	746	49	3171	8 April	128
tabarze ghermez	15 December	826	63	2987	9 April	115
shamlo	15 December	826	63	2987	9 April	115

1- Days after the start of the chilling accumulation (October 13th) until endodormancy breaking. 2 - Days after breaking dormancy until Flowering (F50).

Conclusions

We found that peach and apricot have close chilling requirement. But in the case of heat requirement, apricot cultivars (asgarabad, shamlo, shakarpare, tabarze ghermez) have low GDH, whereas peach cultivars (Kosary, Haj Kazemi, Anjiry Asali, Anjiry Zafarany, and Zoud Ras) have high GDH. Therefore, heat requirements were found to be more important for regulation of flowering time than were chilling requirement in our climatic condition. The lower heat requirements observed in apricot cultivars indicate the risk of growing this cultivar in cold areas, because flowering happens too early than peach and low temperatures can induce an important loss of yield by early spring frosts.

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