Year effect on blooming and harvesting time and fruit weight in two peach varieties grown under Sais valley climatic conditions

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Abstract. Morocco is country concerned by climate warming, phenomenon affecting fruit tree phenology and yield. The present study aims at evaluating blooming and maturity date, fruit weight and yield of two peach varieties grown under Sais Valley conditions during three consecutive years (2017 to 2019). The results showed that, for both varieties, the flowering time was 7 days earlier in 2017 than in 2018. Temperatures were highest in 2017 than in other years of study. For both varieties, the maturity date was earliest in 2017 and 2019, compared to that recorded in 2018. During fruit growth period, the temperatures were higher in 2017 and 2019 compared to those recorded in 2018. The fruit weight was significantly low during the warmest years. From year to year, the fluctuation of flowering and maturity date of the peach in Sais Valley might be related to the variability of temperatures. The warmest years were characterized by early flowering and fruit maturity and low fruit weight.

1 Introduction

Use Peach, *Prunus precica*, is an important commercial fruit species well adapted to Mediterranean climate. In Morocco, during the last decades, new orchards were planted in Sais Valley based on new varieties introduced from different countries mainly from Spain, France and United State. This increase is due to the national market demand for this fruit. However, the studies focusing on the agronomical behaviour of these varieties under climatic conditions of Sais Valley region in Morocco are scarce. The Inter-governmental Panel on Climate Change (IPCC) has provided evidence of accelerated global warming and climate change [1], situation affecting especially Morocco [2,3]. Deciduous fruit trees require specific temperature for breaking dormancy, flowering and fruit maturity. Peach is considered a susceptible to temperature and has a relatively strict chilling requirement [4]. Indeed, several studies have shown that the chilling accumulation variability during dormancy could affect negatively blooming time and fruit set [5,6]. As well the temperature, inconsistencies during fruit growth affect negatively the yield and fruit weight

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[7,8]. It has been also reported that pre-blossom temperatures had a clear effect on the yield [6,9,10].

The irregularity of yield is one of the main problems in fruit production [11]. Thus, in fruit tree, the durability and regularity of orchard production is essential to ensure its economic viability during several decades. The current study focused on the evaluation of climatic conditions effects on flowering, harvest date and fruit weight of two new commercial peach cultivars grown under Sais Valley conditions in Morocco.

2 Materials and methods

2.1 Experimental site and plant material

The present study was carried out at the Agriculture Field Louata of the Providence Verte company in the region of Sefrou, Sais area, situated in north-western Morocco (33.54°N, -4.41°W, 649 m above the sea level). This region is characterised by Mediterranean climate characterized by a hot summer and winters particularly mild and cold. Seventeen-year-old peach trees of *Red Robin* and *Alexandra*, respectively, early and mid-season ripening cultivars were studied. Trees grafted on GF677 (*Prunus persica* x *Prunus dulcis*) and were planted on a loamy-clay soil at 3 x 5 m spacing, drip irrigated and trained according to open-vase system. The nitrogen mixed with potassium sulphate and P were applied by ferti-rrigation during the period from Mars to September ate rates of 100, 60 and 120 unites per hectare, respectively. Four trees per cultivar were chosen for observations of the phenological stages and to determine the average fruit weight. The trees were chosen based on trunk diameter to ensure homogeneity among them. The experiment was carried out during three consecutive seasons (2017-2019).

2.2 Climatic data and chilling accumulation

The weather data collected from meteorological stations located near to the field were used to characterize climatic conditions. Temperature data were considered between October 1st and February 28th during the corresponding observation periods (2017, 2018 and 2019). Chilling availability was determined using Crossa-Raynaud method (CH_{CR})[12]. The chilling hours less than 7.2 ◦C per day (N) were calculated by Crossa-Raynaud model as: $N = [(7.2 - m)/(M - m)] \times 24$, for $m < 7.2$ ◦C and $N = 0$, for $m \geq 7.2$; where M and m are, respectively, maximal and minimal temperature (◦C)[12]. The mean temperatures were calculated using maximum and minimum temperatures.

2.3 Flowering and harvest date

Blooming time was determined during three growing seasons (2017-2019) by identification of the stages of: beginning of flowering (up to 10% open flowers), full bloom (50% open flowers) and end of flowering (less than 5% of flowers to open). Flowering date is considered as the date when 50% of flowers are open indicating period of full flowering (F_{50}). The maturity of the fruit was determined considering the background colour changing from green to light yellow or white-cream of each cultivar.

2.4 Fruit weight

At the maturity, sample of 15 fruits per tree per cultivar were harvested randomly around the canopy and were immediately brought back to the laboratory. The fruits were collected at commercial harvest time, when the colour of the skin was changed. The fruits were weighted using a precision balance.

2.5 Statistical analysis

Statistical analyses were performed by the SAS software (SAS Institute Inc., 1988), using analysis of variance (ANOVA). Significant differences of means were analysed using the Duncan's multiple range test.

3 Results and Discussion

3.1 Temperature and chilling hours availability

The temperatures variation from October to February is considered the main factor affecting the physiological process of floral buds in the mid-season flowering period of species [9,13]. The analysis of the average temperature recorded during this period showed basically similar values for the three years of study (Table 1). The average mean temperatures recorded were13.8 °C, 13.73 °C and 13.45 °C during 2017, 2018 and 2019 respectively. The average mean of minimum temperature was 7.11 °C in 2019 lower than those recorded in 2018 (7.72 °C) and 2017 (8.21 °C). These results showed clearly that the coldest year was 2019 flowed by 2018 and finally by 2017.

Table 1. Average, maximum and minimum daily temperatures (°C) and chilling hours at Louata (Morocco) for three years.

Annual period	Dialy temperature	Mean dialy temperature (°C)		
		2016-2017	2017-2018	2018-2019
October	Average	21.70	23.41	18.55
	Maximum	28.02	29.66	23.29
	Minimum	15.38	17.16	13.82
	Chilling hours[a]	-	-	9.38
November	Average	13.85	16.40	13.15
	Maximum	18.70	23.03	18.80
	Minimum	9.00	9.77	7.60
	Chilling hours	19	1.71	24.63
December	Average	11.63	9.90	13.64
	Maximum	16.57	15.30	21.29
	Minimum	6.69	4.50	6.00
	Chilling hours	100	177.53	77.32
January	Average	9.53	9.71	10.10
	Maximum	15.91	15.71	16.84
	Minimum	3.16	3.70	3.37
	Chilling hours	245	208.39	204.55
February	Average	12.28	9.21	11.83
	Maximum	17.74	14.98	18.90
	Minimum	6.83	3.45	4.75
	Chilling hours	46	242.30	107.87

[a]The chilling hours were calculated using the method described by Crossa-Reynaud

When comparing the average mean temperature from October to the end December (autumn), the results showed that the mean value observed in 2018 (16.57 °C) was higher than those observed in 2017 and 2019 with values of 15.73 and 15.11 °C, respectively. However, during the winter (period from the end of December to October), the average of the mean temperature was higher in 2019 and 2017 (10.97 °C) than in 2018 (9.46 °C). These results indicate that the temperatures were warmer during autumn (fall) than during the winter for the three years of study. This variability of temperature during the winter and spring among the three years affects the chilling hour's availability and flowering time.

Concerning the chilling hour availability (CHA), the results showed that the values were varied between 409 and 629.95 CH by the Crossa-Raynaud model (Table 1). The highest value of CHA was recorded in 2018 (629 CH), followed by 2019 (423 CH) and 2017 (409 CH). During the autumn (from October to the end December), the chilling hours accumulated during 2017, 2018 and 2019 were119 CH, 179 CH and 111CH, respectively. However, during the winter (from January to February) the chilling hours accumulated during 2017, 2018 and 2019 were 290 CH, 450 CH, and 311 CH, respectively. Thus, the chilling accumulation under the Sais Valley conditions was probably realised effectively during the winter than fall.

3.2 hilling hours availability and Flowering date

The results of full bloom date of the peach cultivars studied during the three years (2017–2019) are given in Table 2. The flowering date of *Red Robin* variety was later than that of *Alexandra* cultivar during the three years of study (Table 2). For both varieties, the earliest full bloom date was registered in 2017, followed by that of 2019 and finally that observed in 2018.

Table 2. Harvest date observed during warm (2017) and normal (2018-2019) springs for peach cultivars early-maturing RedRobin and mid-season maturing Alexandra in Valley Sais, Morocco.

Year	Flowering date		Harvest date		FDP (days)	
	Red Robin	Alexandra	Red Robin	Alexandra	Red Robin	Alexandra
2017	04-march	01-march	24-May	28-June	81	119
2018	13-march	09-march	10-June	18-July	89	131
2019	09-march	03-march	27-May	11-July	79	130

These findings could be due to the low chilling recorded in 2017 and 2019 (409 and 423 CH, respectively) leading to a full bloom-advancing for both cultivars (Fig. 1). The latest flowering date observed in 2018 might be due to the highest chilling hours (629 CH) recorded in this year. Correlations analysis showed good relationship between flowering date and the accumulated chill hours for both cultivars among the three years (Fig. 1).

The high temperature observed in 2017 and 2019 during the winter was translated by an early flowering dates in comparison with the results obtained in 2018. These results are in accordance with those reported by El Yaacoubi *et al.* [13], which claimed that in warmer conditions during winter, the fruit tree species flowered earlier than in cooler conditions.

It has been reported that insufficient winter chill may delay or prevent flowering, lead to staggered bloom, and cause various forms of anomalous growth [6,14,15]. However, in the present study, the lower chill hours recorded in winter during the three years of study did not delay the full bloom date of both varieties. Chilling requirement for Red Robin and Alexandra varieties is unknown, but it seems that Red Robin has low chilling requirements than Alexandra because of the flowering date. Cultivars with low chilling requirements always bloom earlier, whereas those with high chilling requirements bloom later [16]. Regardless the chilling requirements of these varieties, the results indicate that under Sais Valley climatic conditions these varieties are not affected by the low chill winter accumulation.

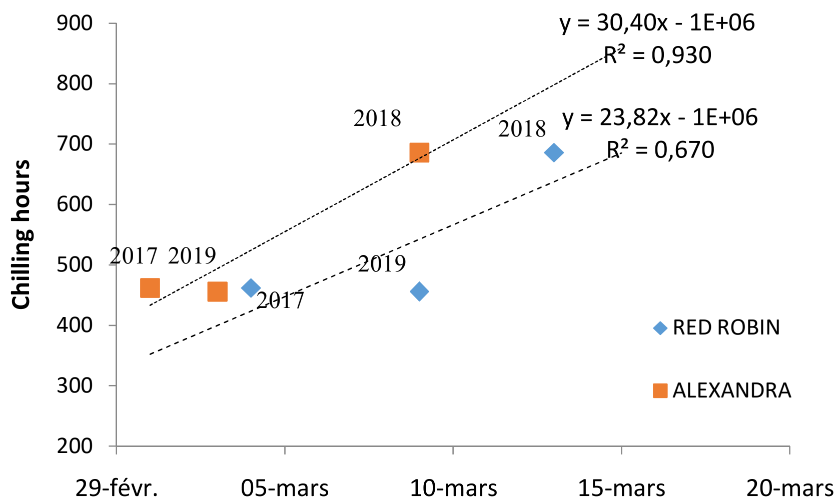

Fig. 1. Relationship between date of full bloom and chilling accumulations expressed as chilling hours (CH) Crossa-Raynaud, for two peach cultivars *Red Robin* and *Alexandra*, observed in valley Sais, during three years (2017-2019).

3.3 Harvest date and chilling hours

The results of harvest date of Red Robin and Alexandra cultivars, during the three years (2017–2019) are given in Table 2. During the three years of study, the fruits of Red Robin reached the maturity stage and harvested earlier than those of Alexandra (Table 2).

The fruit development period (expressed as Julian days from full bloom to the harvest) varied among years between 79 and 89 days for Red Robin; and between 119 and 131 days for Alexandra (Table 2). Shorter fruit development (FDP) day was registered in 2019 and 2017 for Red Robin, and in 2017 for Alexandra. These results could be attributed to delayed bloom that occurred that year as a result of lack of chilling and the resulting warmer temperatures recorded during early fruit growth, as reported in others peach varieties [7].

In the present study, a high positive correlation was found between pre-blossom chill hours accumulation and FDP for Red Robin ($r^2=0,96$) and for Alexandra ($r^2=0,66$). This finding indicates that lack of winter chill affects clearly the FDP of the earliest varieties (Red Robin) and at less level of the mid-season varieties (Alexandra). Temperatures during the early stages of fruit development have been shown to affect the FDP in peach[7]. The monitoring of mean temperature from Full bloom to harvest days showed that during early fruit development the temperatures were higher in 2017 and 2019 in comparison to those recorded in 2018 (Fig. 2). The present results show clearly that the effect of the lack winter chill and temperature during early fruit growth depends on the variety.

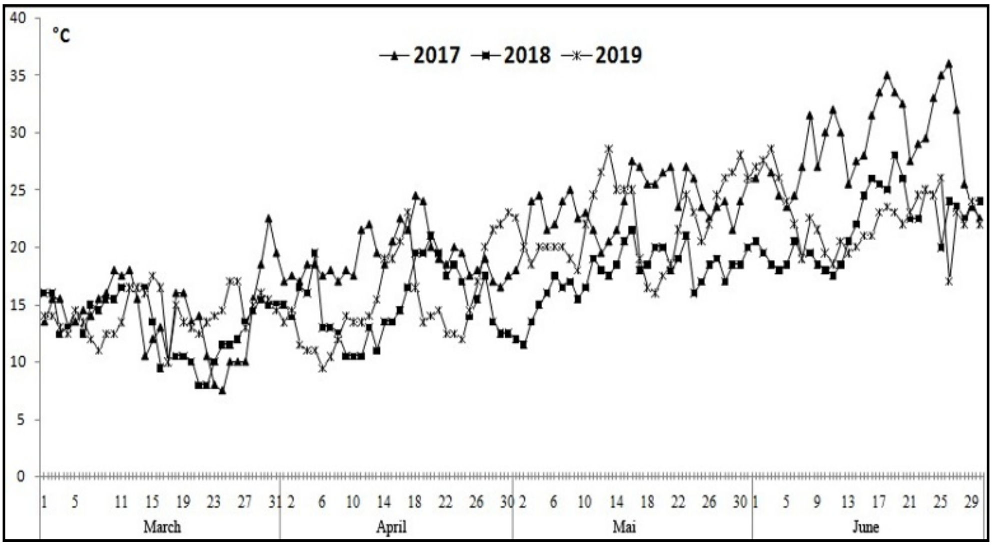

Fig. 2. Monthly mean temperature at valley Sais from March to July (2017 to 2019).

3.4 Fruit weight and temperatures

The statistical analysis revealed significant effect of variety and year on the fruit weight (Table 3). Average fruit weight varied from 142.17 to 160.68 g for Red Robin and from 166.87 to 183.52 g for Alexandra cultivars (Table 3). The lowest value of fruit weight was obtained in 2017 for both cultivars, followed by those obtained in 2018 and finally 2019 (Table 3). This could be due to the negative effect of high temperature during earlier stages of fruit development recorded in 2017 (Fig 2). Similar results were reported in other peach varieties during warmer years [17]. The early cultivar Red Robin and the mid-season Alexandra cultivar showed a slight increase of fruit weight during 2018, with high chill accumulation and delayed fruit ripening (Table 2). In the present study, during warmer year (2017) the fruit development period was short (Table 2) and fruit weight (highly correlated with fruit size) was low (Table 3). Several studies pointed out that during warmer conditions during the spring (corresponding to earlier stage of fruit development) the fruit growth rates was high (short fruit development period) and the trees probably were not able to ensure quickly enough supply resources to support the potential fruit growth rates that apparently accompanied the higher temperatures [17].

Table 3. Effect of variety and year on the fruit weight at harvest during 2017–2019 on peach cultivars in valley Sais, Morocco.

Cultivar	Fruit weight (g)		
	2017	**2018**	**2019**
RedRobin	142.17 c	151.79 b	160.68 a
Alexandra	166.86 b	173.09 b	183.52 a

Average with the same letters in the same column are not significantly different at (p=0,05)

4 Conclusion

The results revealed that the high temperatures affected flowering and harvesting date, and fruit weight of "Red Robin" and "Alexandra" peach cultivars under valley Sais conditions in Morocco. The full bloom and harvesting date were earlier during warmest year, and the fruit weight was reduced. In the context of climate change more attention is needed when planting new orchards in order to reduce anomalies resulting from warmer climatic conditions expected to be more frequent in Morocco in the near future. Selecting precocious and low chilling cultivars may help producers in the warm production region. Additional studies should be carried out in the future, including other varieties, to establish fruit growth models that could allow producers to predict the ripening period of the fruit according to the evolution of temperatures during the fruit growth period.

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