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Calculating Heat Requirements and Flowering Generation of some Pomegranate Cultivars Grown in Egypt

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ABSTRACT

The present investigation was carried out in a private farm located at Alexandria Desert Road (km 64), Giza Governorate, Egypt to calculating heat requirements and generation flowering of some pomegranate cultivars (H 116, Wonderful and Manfalouty) grown in Giza Governorate during 2017 and 2018 seasons.Results showed that under Giza Governorate conditions, average of effective heat summation requirement from red tip to harvest stage for H 116, Wonderful and Manfalouty are (1789, 2403), (2982, 3569) and (3036, 3602) growing degree days (GDD) during the two season of the study, respectively. Also, found that the first generation of flowering gave the highest value of fruit length and diameter (cm), fruit weight (g) and acidity (%).While, the second generation of flowering gave the highest value of fruit weight (g), number of fruit/tree, yield (kg/tree) and total soluble solids (%).Generally, it can be concluded that the effective heat summation requirement of Giza Governorate is suitable for commercial growing for (H 116, Wonderful and Manfalouty) cultivars. The first generation of flowering is good for production big fruit, while the second generation of flowering is suitable for production quantity and quality of fruits pomegranate.

***Keywords**: Calculating Heat Requirements, H 116, Wonderful and Manfalouty.*

INTRODUCTION

Temperate fruits are grown in many different environmental conditions and studies concerning chilling and heat requirements of different cultivars are valuable tools to avoid incomplete breaking of dormancy or abnormal flowering. Pomegranate (*Punica granatum* L.) is a temperate species grown in the Mediterranean region and requires high summer to ripen properly (Melgarejo and Martinez 1989). However, warming during the forcing period could increase the rate of heat accumulation, which compensates for only phenology delaying effects of reduced chilling (Rutz *et al.*, 2007). Therefore, specific knowledge of the influence of climatic conditions and thermal flowering of cultivated temperate trees allows farmers to obtain adequate productivity (Erez, 2000). Knowing that the pomegranate fruit requires temperature to reach the stage of full bloom and also the stage of full maturity, once the chilling requirements have been satisfied (Guo *et al.*, 2014).

Although the pomegranate is one of the fruit trees, which have contributed remarkably to increase of crop areas and a rise in flowering income. The total cultivated area of pomegranate in Egypt reached about 106690 feddans, its production were 405763 metric tons of fruits according to the recent statistics of the Ministry of Agriculture (2019). Therefore, this investigation was designed to see the best generation of flowers.

The aim of this study was to determine heat requirements and fruit stages fruit of three commercial pomegranate cultivars ('Wonderful', 'Manfalouty' and 'H 116') grown in Giza region.

MATERIALS AND METHODS

The present study was carried out during 2017 and 2018 seasons on pomegranate cultivar trees (*Punica granatum* L.) . The experimental trees were uniform as possible, five years old growing in sandy soil under a drip irrigation system in a private farm located at Alexandria Desert Road, km 64, Giza Governorate, Egypt. Trees were planted at a distance of 5 x3 meters apart and subjected to the same agriculture practices. The most important commercial cultivars Wonderful', 'Manfalouty' and 'H 116' were selected. Wonderful cultivar (originated in Florida) has a sweet-tart taste, deep purple-red fruits with soft seeds and delicious vinous flavor. H 116 (Israel cultivar: H116) has sour taste fruits with red skin and hard seeds. Manfalouty cultivar (originated in Egypt) has sweet-tart taste, deep purple-red fruits. The study was of the third generations of fruits pomegranate.

Field observations and laboratory measurements were carried out as follows:

1. Fruit physical characteristics:

A sample of ten fruits was randomly harvested a replicate for each treatment to determine the following:

1. Average fruit length and fruit diameter (cm)
2. Percentage of grain weight (edible part) and peel weight (non-edible part) of total fruit weight.
3. Total yield/tree (kg), total fruits number /tree and fruit weight (g).

2. Fruit juice chemical composition:

1. Total soluble solids percentage (TSS %) was determined using hand refractometer.
2. Total acidity percentage was determined by titrating 5 ml juice against 0.1 NaOH using phenolphthalein as an

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indicator. The values of total acidity were expressed in grams of citric acid per 100 ml juice as described in AOAC, 1985, then, T.S.S/acid ratio was calculated.

- **Determination of Heat Requirements:** Two years (2017 and 2018), the main phenological stages of pomegranate trees were identified from bud swelling to dormancy following the BBCH General Scale (Melgarejo *et al.*1997 and Meier, 2001).

Table 1.Climatic data for Giza (N; E). The values are the long-term averages obtained from the local meteorological station during the years

Date	T MAX	T MIN	T Mean	RH	WIND	RAIN
	°C	°C	°C	%	m /s	mm
			2017			
Jan	19.1	7.7	12.5	68.3	2.8	29.8
Feb	22.8	10.1	15.6	57.0	2.0	5.2
Mar	28.7	11.7	19.4	42.3	2.4	1.1
Apr	30.9	14.2	21.9	41.0	2.6	28.5
May	35.6	19.2	27.0	38.0	3.1	0.2
Jun	37.8	21.2	29.3	36.1	3.1	0.0
Jul	39.0	22.4	30.3	40.8	3.0	5.5
Aug	38.4	22.6	30.0	45.1	2.9	0.0
Sep	36.3	21.0	28.1	47.1	2.7	0.0
Oct	31.7	18.1	24.1	50.8	2.7	4.8
Nov	26.5	14.2	19.5	55.9	2.1	6.2
Dec	20.5	9.7	14.3	63.3	2.6	9.2
			2018			
Jan	18.8	6.2	11.7	50.1	2.9	2.2
Feb	21.0	7.5	13.4	53.1	2.5	5.5
Mar	23.7	9.0	15.7	51.5	2.9	11.0
Apr	28.2	12.4	19.8	43.0	3.1	1.9
May	36.8	17.8	26.9	29.2	3.3	0.0
Jun	38.3	21.6	29.7	38.0	3.3	0.0
Jul	39.3	22.4	30.5	38.7	2.9	0.0
Aug	39.0	22.7	30.5	39.8	2.6	0.0
Sep	36.0	20.7	27.6	47.6	2.8	0.0
Oct	32.5	18.7	24.8	53.5	2.7	16.8
Nov	28.5	14.9	20.7	51.8	2.4	0.1
Dec	21.0	9.6	14.4	63.7	2.9	15.0

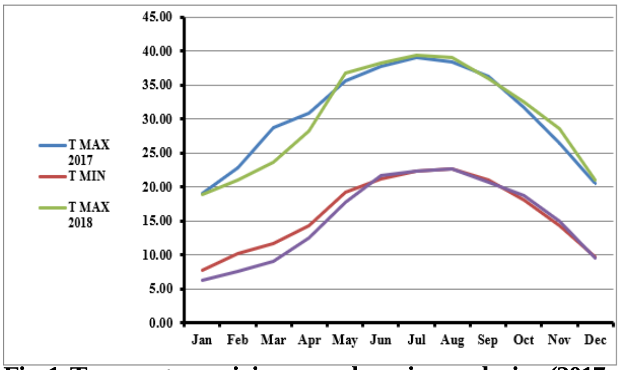

Fig. 1. Temperature minimum and maximum during (2017 and 2018 seasons)

Growing Degree Days (GDD):

The main phenological stages of pomegranate trees were identified from red tip to leaf fall to calculate Growing Degree Days (GDD). the determination of effective heat summations, thresh temperature is subtracted from the mean daily temperature, daily and based on the number of days between each phenological phase the sum of effective temperature (°C-day) "day-degree" were calculated. Temperatures below the threshold temperature have not been taken into account. Pomegranate phenological stages of determining the values for the day-degree, phenological development threshold is taken as 10 °C (Jackson, 1999).

The following equation was used for the calculation of GDD:

$$GDD= T_{max} + T_{min}/2 - T_{Base} \quad (T_{max} = \text{maximum daily temperature})$$

$$T_{min} = \text{minimum daily temperature}$$

$$T\ base = 10\ °C$$

Statistical analysis:

All parameters studied data were analyzed as Randomized Complete Blocks Design in factorial arrangement with three replications. All data were subjected to statistical analysis as described by Snedecor and Cochran (1990). Mean separation was carried out using Duncan's multiple range test (Duncan, 1955).

RESULTS AND DISCUSSION

Table (2) shows the phonological stages and dates of three pomegranate cultivars (H 116, Wonderful and Manfalouty) during the two season of the study. While, Table (3) shows the effect of the heat requirements (GDD) of three pomegranate cultivars as first generation, second generation and third generation on blooming characteristic (Phonological stages). Concerning the red tip of Phonological stages, the results revealed that Manfalouty and Wonderful had a pronounced increase of red tip in the first season, while in the second one the highest values for Manfalouty. As for appearance of the flower buds, the highest value was obtained for Wonderful during both seasons. In regard to open the flower, the obtained results indicated that wonderful gave the highest values in both seasons. As for number of petals fall, it is obvious that the highest number of petals fall came from Manfalouty during both seasons. Regarding the fruit set, the Manfalouty trees had the highest values in the first season, while in the second one the highest values for Manfalouty and Wonderful. The highest fruit ripening obtained for Manfalouty in both seasons.

Concerning leaf fall, Table (3) shows that the highest values were obtained for Manfalouty and Wonderful in the first season, while in the second season the highest values for Manfalouty. From the previous results, it is clear that the Wonderful variety achieved the best results, which means that the environmental and climatic conditions are suitable for the conditions of its cultivation.

These results are in accordance with those obtained by Ikinci (2014), who mentioned that the heat requirement of pomegranate cultivars is affected by climate and environmental condition.

These results are in accordance with those obtained by Luedeling *et al.*, (2009), who mentioned that deciduous fruit species require a certain amount of winter chilling to overcome their dormancy. Once the chilling requirements have been satisfied, heat is also required to reach full bloom stage. Insufficient chilling can lead to uneven leafing and bloom and can cause varying fruit sizes and maturity times, both of which can reduce the quantity.

Table (4) and Fig (2) shows the dates of opening flowers of three pomegranate cultivars (H 116, Wonderful and Manfalouty) during the two season of the study. The cultivar H 116 was early in opening flowers compared with other cultivars.

Table 2. Phenoclimatology of H 116, Wonderful and Manfalouty pomegranate cultivars (2017–2018).

Phonological stages	H 116	Wonderful	Manfalouty
2017			
Red tip	5 February	17 February	16 February
Appearance of the flower buds	2 March	16 March	15 March
Open the flower	17 March	1 April	30 March
Petals fall	13 April	27 April	28 April
Fruit setting	2 May	11 May	13 May
Fruit ripening	10 July	10 September	12 September
Leaf fall	27 November	11 December	11 December
2018			
Red tip	6 February	19 February	18 February
Appearance of the flower buds	5 March	20 March	18 March
Open the flower	25 March	4 April	2 April
Petals fall	17 April	1 May	1 May
Fruit setting	5 May	23 May	23 May
Fruit ripening	25 July	25 September	27 September
Leaf fall	28 November	13 December	12 December

Table 3. GDD of H 116, Wonderful and Manfalouty pomegranate cultivars (2017–2018)

Phonological stages	H 116	Wonderful	Manfalouty
2017			
Red tip	36	61	61
Appearance of the flower buds	111	184	180
Open the flower	188	299	284
Petals fall	403	541	552
Fruit setting	600	725	754
Fruit ripening	1789	2982	3036
Leaf fall	3926	3997	3997
2018			
Red tip	98	164	158
Appearance of the flower buds	266	386	367
Open the flower	436	525	507
Petals fall	676	849	849
Fruit setting	917	1206	1206
Fruit ripening	2403	3569	3602
Leaf fall	3454	4430	4426

Table 4. Dates of opening flowers pomegranate during 2017and 2018 seasons

	H 116	Wonderful	Manfalouty
2017			
First generation of flowering	17 March	1 April	30 March
Second generation of flowering	27 March	14 April	12 April
Third generation of flowering	9 April	29 April	28 April
2018			
First generation of flowering	25 March	4 April	2 April
Second generation of flowering	6 April	15 April	13April
Third generation of flowering	16 April	30 April	29 April

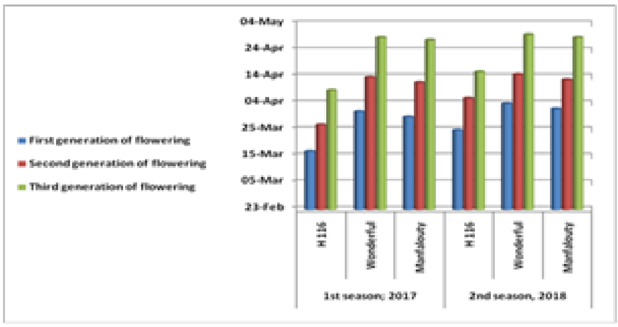

Fig. 2. Dates of opening flowers pomegranate during 2017and 2018 seasons

1. Fruit physical characteristics:

- Fruit length (cm):

Data in Table (5) shows a significant effect of fruit length (cm) in the first generation with Wonderful during both seasons. As for cultivar, in the first and second seasons, the uppermost two values of fruit length came from Wonderful and Manfalouty. Luedeling *et al*., (2009) found that insufficient chilling can cause varying fruit sizes.

Table 5. Fruit length (cm).

	H 116		Wonderful		Manfalouty		Mean	
2017								
First generation of flowering	8.25	e	13.50	a	12.80	b	11.52	A
Second generation of flowering	7.15	f	11.00	c	10.80	c	9.65	B
Third generation of flowering	6.10	g	8.50	de	9.16	d	7.92	C
Mean	7.16	B	11.00	A	10.92	A		
2018								
First generation of flowering	8.30	c	13.30	a	13.12	a	11.57	A
Second generation of flowering	7.10	d	11.87	b	11.25	b	10.07	B
Third generation of flowering	6.00	e	8.50	c	8.87	c	7.79	C
Mean	7.13	B	11.22	A	11.08	A		

Values that have the same letter are not significantly different at 5% level using Duncan's Test.

- Fruit diameter (cm):

Table (6) shows significant fruit diameter (cm) with the first generation of flowering in both seasons, concerning the cultivar, Wonderful gave the highest fruit diameter (cm) during both seasons. This may be reflected in the synchronization between the development stages and climate (Dietrichson, 1964).

Table 6. Fruit diameter (cm):

	H 116		Wonderful		Manfalouty		Mean	
2017								
First generation of flowering	9.15	c	13.00	a	10.50	b	10.88	A
Second generation of flowering	8.20	de	10.30	b	10.00	b	9.50	B
Third generation of flowering	7.15	f	8.00	e	8.80	cd	7.98	C
Mean	8.16	B	10.43	A	9.76	A		
2018								
First generation of flowering	9.10	d	13.16	a	12.25	b	11.50	A
Second generation of flowering	8.00	e	11.50	bc	11.16	c	10.22	A
Third generation of flowering	7.00	f	8.12	e	8.00	e	7.70	B
Mean	8.03	B	10.92	A	10.47	A		

Values that have the same letter are not significantly different at 5% level using Duncan's Test.

- **Fruit edible part (%)**

Data in Table (7) reveal the highest fruit edible part (%) with the third generation in both seasons. Regarding cultivar, H 116 and Manfalouty exhibited the highest significant with the third generation during the two growing seasons.

It appears that the heat requirement of pomegranate cultivars is affected by climate, altitude, cultivar; age of the tree, and the year that the experiment is carried out (Ikinci *et al*., 2014).

Table 7. Fruit edible part (%):

	H 116		Wonderful		Manfalouty		Mean	
2017								
First generation of flowering	53.0	b	48.0	d	51.0	c	50.67	C
Second generation of flowering	54.0	ab	51.0	c	53.0	b	52.67	B
Third generation of flowering	55.0	a	54.0	ab	55.0	a	54.67	A
Mean	54.0	A	51.0	B	53.0	A		
2018								
First generation of flowering	54.0	bc	45.0	f	54.5	bc	51.17	B
Second generation of flowering	55.0	b	47.0	e	53.5	c	51.83	B
Third generation of flowering	56.0	a	50.0	d	56.5	a	54.17	A
Mean	55.0	A	47.3	B	54.8	A		

Values have the same letter are not significantly different at 5% level using Duncan's Test.

- **Fruit non-edible part (%)**

Table (8) shows a significant effect in fruit non-edible with the first generation in the first season. As for second season, the first and the second generation gave the highest fruit non-edible pare (%).Wonderful recorded the highest fruit non-edible part (%) during both seasons. Once the chilling requirements have been satisfied, heat is also required to reach full bloom stage. Insufficient chilling can lead to uneven leafing and bloom, and can cause varying fruit sizes and maturity times, both of them can reduce the quantity and quality of fruits (Luedeling *et al*. 2009; Guo *et al.,* 2014).

Table 8. Fruit non-edible part (%):

	H 116		Wonderful		Manfalouty		Mean	
2017								
First generation of flowering	47.0	c	52.0	a	49.0	b	49.3	A
Second generation of flowering	46.0	cd	49.0	b	47.0	c	47.3	B
Third generation of flowering	45.0	d	46.0	cd	45.0	d	45.3	C
Mean	46.0	B	49.0	A	47.0	B		
2018								
First generation of flowering	46.0	de	55.0	a	45.5	de	48.8	A
Second generation of flowering	45.0	e	53.0	b	46.5	d	48.1	A
Third generation of flowering	44.0	f	50.0	c	43.5	f	45.8	B
Mean	45.0	B	52.6	A	45.1	B		

Values that have the same letter are not significantly different at 5% level using Duncan's Test.

- **Fruit weight (g)**

Table (9) indicates that fruit weight exhibited the highest values of the first and second generation in both seasons. Wonderful cultivar gave the highest fruit weight in both seasons.

The suitable correlation was observed between chilling requirement and geographical/climatic parameters including wind speed and altitude, as well as with tree and fruit characteristics (Legave *et al*., 2008).

Table 9. Fruit weight (g):

	H 116		Wonderful		Manfalouty		Mean	
2017								
First generation of flowering	400.0	d	665.29	a	568.50	b	544.6	A
Second generation of flowering	325.0	e	425.00	c	424.5	c	391.5	B
Third generation of flowering	170.0	g	223.50	f	218.4	f	204.0	C
Mean	298.3	C	437.9	A	403.8	B		
2018								
First generation of flowering	390.0	e	650.0	a	597.1	b	545.7	A
Second generation of flowering	300.0	f	519.8	c	454.0	d	424.6	B
Third generation of flowering	160.0	i	231.8	g	192.1	h	194.6	C
Mean	283.3	C	467.2	A	414.4	B		

Values that have the same letter are not significantly different at 5% level using Duncan's Test.

- **Number of fruits/tree**

Results in Table (10) show the highest significant values of number of fruits/tree with the third generation of flowering in the first season. In contrast, the second generation of flowering achieved the highest values in the second season.

It was confirmed by many studies carried out on apricot, almond, pistachio and sweet cherry fruit species that determining the heat requirements, which also play a role in fruit cultivation (Egea *et al*. (2003), Ruiz *et al.* (2007); Alburquerque *et al.* (2008); Rahemi and Pakkish (2009) and Campoy *et al.,* (2012).

Table 10. Number of fruits/tree:

	H 116		Wonderful		Manfalouty		Mean	
2017								
First generation of flowering	31.0	c	18.3	g	15.0	h	21.4	C
Second generation of flowering	20.0	f	31.3	c	26.0	d	25.7	B
Third generation of flowering	24.0	e	44.6	a	35.0	b	34.5	A
Mean	25.0	B	31.4	A	25.3	B		
2018								
First generation of flowering	43.3	b	24.0	f	14.0	h	27.1	B
Second generation of flowering	21.0	g	45.0	a	32.0	c	32.6	A
Third generation of flowering	25.0	f	29.0	d	27.0	e	27.0	B
Mean	29.7	B	32.6	A	24.3	C		

Values that have the same letter are not significantly different at 5% level using Duncan's Test.

- **Fruit yield (kg/tree)**

Table (11) demonstrates that the highest values of fruit yield (kg/tree) came from the first and the second generation of flowering in both seasons. As for cultivar, Wonderful was significant with the second generation of flowering in both seasons. Erez (2000) and Aslamarz *et al.* (2009) reported the risk of yield losses if high chill cultivars are grown in warm regions; this means that the climate is suitable for trees that have given a great harvest.

Table 11. Fruit yield (kg/tree):

	H 116		Wonderful		Manfalouty		Mean	
2017								
First generation of flowering	12.40	b	12.17	b	8.53	e	11.03	A
Second generation of flowering	6.50	g	13.30	a	11.04	c	10.28	A
Third generation of flowering	4.08	h	9.97	d	7.64	f	7.23	B
Mean	7.66	C	11.81	A	9.07	B		
2018								
First generation of flowering	16.89	b	15.60	c	8.36	e	13.62	A
Second generation of flowering	6.30	f	23.39	a	14.53	d	14.74	A
Third generation of flowering	4.00	h	6.72	f	5.19	g	5.30	B
Mean	9.06	B	15.24	A	9.36	B		

Values that have the same letter are not significantly different at 5% level using Duncan's Test.

2. Fruit juice chemical composition:

- **Total soluble solids (%)**

Table (12) clarifies that the second generation of flowering achieved significantly highest TSS values in the first season. On the other hand, TSS showed the highest values with the first, second and third generation of flowering in the second season. Referring to the cultivar, wonderful was the most significant values in both seasons. Westwood (1999) suggested that knowledge on heat sum in the growing season is a requirement for fruit quality.

Table 12. Total soluble solids (%):

	H 116		Wonderful		Manfalouty		Mean	
2017								
First generation of flowering	13.5	f	17.0	c	16.0	d	15.5	B
Second generation of flowering	14.5	e	18.0	b	17.0	c	16.5	AB
Third generation of flowering	15.0	e	19.0	a	17.5	bc	17.17	B
Mean	14.3	C	18.0	A	16.8	B		
2018								
First generation of flowering	14.0	e	17.0	c	17.0	c	16.0	A
Second generation of flowering	15.0	d	18.0	ab	17.0	c	16.6	A
Third generation of flowering	15.5	d	18.5	a	17.5	bc	17.1	A
Mean	14.8	B	17.8	A	17.1	A		

Values that have the same letter are not significantly different at 5% level using Duncan's Test.

- **Acidity (%)**

Table (13) illustrated that the highest values of acidity were recorded with the first generation of flowering in both seasons. In regard to cultivar, Manfalouty showed the highest significant values of acidity during both seasons.

It was confirmed by many studies carried out on apricot, almond, pistachio and sweet cherry fruit species that determining the heat requirements, which plays a very important role in fruit cultivation (Campoy *et al*., 2012).

Table 13. Acidity (%):

	H 116		Wonderful		Manfalouty		Mean	
2017								
First generation of flowering	1.40	a	1.10	f	1.31	b	1.27	A
Second generation of flowering	1.16	e	1.11	f	1.25	c	1.17	B
Third generation of flowering	1.13	ef	1.12	f	1.20	d	1.15	B
Mean	1.23	A	1.11	B	1.25	A		
2018								
First generation of flowering	1.49	a	1.13	d	1.38	b	1.33	A
Second generation of flowering	1.26	c	1.15	d	1.26	c	1.22	B
Third generation of flowering	1.15	d	1.15	d	1.15	d	1.15	C
Mean	1.30	A	1.14	B	1.26	A		

Values that have the same letter are not significantly different at 5% level using Duncan's Test.

CONCLUSION

From the above results, it could be concluded that, average of effective heat summation requirement from red tip to harvest stage for H 116, Wonderful and Manfalouty are (1789, 2403), (2982, 3569) and (3036, 3602) GDD) during the two season of the study, respectively, respectively.

Generally, it can be concluded that the effective heat summation requirement of Giza Governorate is suitable for commercial growing for H 116, Wonderful and Manfalouty cultivars. The first generation of flowering is good for production big fruit, while the second generation of flowering is suitable for production good quantity and quality of fruits pomegranate.

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حساب الاحتياجات الحرارية واجيال التزهير لبعض اصناف الرمان النامية فى مصر

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تم اجراء هذة الدراسة فى مزرعة خاصة بطريق مصر اسكندرية الصحراوى (الكيلو 64) فى محافظة الجيزة – مصر وذلك لحساب الاحتياجات الحراريه واجيال التزهير لبعض اصناف الرمان (اتش 116 – وندرفول – المنفلو طى) النامية فى محافظة الجيزة خلال موسمى الدراسة 2017 و 2018.أظهرت النتائج انه تحت ظروف محافظة الجيزة ، متوسط مجموع المتطلبات الحرارة من مرحلة البرعم الاحمر الى مرحلة الحصاد للاصناف (اتش 116وندرفول و المنفلو طى) حوالى (1789-2403) و (2982 – 3569) و (3036- 3602) مقدرة بدرجة الحرارة اليومية فى الموسمين على التوالى.وتشير النتائج الى ان الجيل الاول من التزهير اعطى اعلى قيمه من حيث طول وقطر الثمار (سم) ووزن الثمرة (جم) والحموضه (%) بينما الجيل الثانى من التزهير اعطى اعلى قيمه لوزن الثمرة (جم) وعدد الثمار/شجرة والمحصول (كجم/شجرة) و المواد الصلبه الذائبة (%). عموما يمكن تلخيص ذلك ان مجموع تراكم المتطلبات الحرارية تحت ظروف محافظة الجيزة مناسب لنمو الاصناف التجارية (اتش 116 – وندرفول – المنفلو طى). وان الجيل الاول من التزهير مناسب لانتاج ثمار كبيرة الحجم بينما الجيل الثانى من التزهير يكون مناسب لانتاج ثمار ذات كم وجوده عالية.