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The Determination of The Chilling Requirements of Some Walnut (*Juglans regia* L.) Cultivars and Types

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Abstract

This study was conducted on 8 different walnut genotypes (Bilecik, Kaman-1, Maraş-18, Sütyemez-1, Şebin, Şen-1, Maraş-12 and Sütyemez-2) between 2013 and 2014 years. Chilling requirements of terminal buds, lateral buds and male flowers of walnut genotypes were determined based on separate standard and chill unit methods. The results suggest that chilling requirement of the walnut genotypes was the lowest for Sütyemez-2 (809 H - 644 CU) and highest for Bilecik (1570 H - 1755.5 CU). The chilling requirement of lateral buds was the lowest for Şebin (1016 H - 956 CU) and highest for Bilecik (1571 H - 1769.5 CU). When it comes to male flowers, the lowest chilling requirement was that of Sütyemez-2 (915 H - 770 CU) while the highest was for Bilecik (1407 H - 1416.5 CU). It was observed that terminal buds required the lowest chilling duration while lateral buds required the highest chilling duration. Additionally, accumulated chilling was calculated as 1645 H and 1753 CU in Kahramanmaraş province of Turkey where this study was conducted.

Key words: Chilling, chill unit, genotype, standard method, walnut

Bazı Ceviz (*Juglans regia* L.) Çeşit ve Tiplerinin Soğuklama İhtiyacının Belirlenmesi

Özet

Bu araştırma, 2013-2014 yılları arasında, SEKAMER'de bulunan 8 ceviz genotipi (Bilecik, Kaman-1, Maraş-18, Sütyemez-1, Şebin, Şen-1, Maraş-12 ve Sütyemez-2) üzerinde yürütülmüştür. Ceviz genotiplerinin tepe tomurcuğu, yan tomurcuk ve erkek çiçeklerinin soğuklama ihtiyaçları ayrı ayrı standart ve soğuk birimi yöntemlerine göre belirlenmiştir. Elde edilen bulgulara göre, ceviz genotiplerinin soğuklama ihtiyaçları; tepe tomurcukları için; (809 saat-644 sb) Sütyemez-2 tipinde en düşük ve (1570 saat-1755.5 sb) Bilecik çeşidinde en yüksek olarak belirlenmiştir. Yan tomurcuklarda soğuklama ihtiyacı; Şebin çeşidinde en düşük (1016 saat- 956 sb), Bilecik çeşidinde en yüksek (1571 saat-1769.5 sb) olduğu tespit edilmiştir. Erkek çiçeklerde ise, en düşük (915 saat ve 770 sb) soğuklama ihtiyacını Sütyemez-2 tipi gösterirken, en yüksek soğuklama süresinin (1407 saat-1416.5 sb) Bilecik çeşidinde olduğu belirlenmiştir. Soğuklama süreleri belirlenen bitkisel organlar arasında, tepe tomurcuklarının genelde en düşük, yan tomurcukların ise en yüksek soğuklama sürelerine ihtiyaç duydukları tespit edilmiştir. Ayrıca çalışmanın yürütüldüğü Kahramanmaraş ilinde meydana gelen soğuk birikimi 1645 saat ve 1753 sb olarak hesaplanmıştır.

Anahtar kelimeler: Soğuklama, soğuk birimi, standart yöntem, genotip, ceviz

Introduction

Walnut (*Juglans regia* L.) belongs to *Dicotiledoneae* class, *Juglandales* order, *Juglandaceae* family and *Juglans* species. Today, *Juglans* species cover 22 different walnut types. *Juglans regia* L., which is also called Anatolian and English walnut, is recognized as the most well-known walnut type among these types as it completely differ from the other walnut types. Therefore, it is grown for its fruit around the world

(Şen, 2011). The leading countries in walnut cultivation are China, USA, Iran and Turkey. The USA is the leading walnut exporter among countries. Turkey possesses an important potential of walnut production, as well.

When one plans to grow fruits in a region, it is essential that the most suitable cultivar and type for that region be identified. Natural flora in a region must be taken into account in order to identify the most suitable cultivar and type. Otherwise, various problems regarding productivity and quality losses cannot be avoided. Climatic and soil factors are of vital importance in order for a fruit tree to grow in any ecological zones, to yield high quality fruits and to ripen their products. Therefore, climate is the most decisive factor in the selection of a cultivar and type in a region. Temperature is the most critical one among various climate factors for fruit growing because plants need the combination of low and high temperature for a certain period during their vegetation period.

Total temperatures, needed for deciduous plants, are analyzed in three different periods: "from defoliation to efflorescence", "from efflorescence to fruit formation" and "from fruit formation to defoliation" (Özbek, 1975). The most important period of these is "from defoliation to efflorescence" period. Deciduous fruit types require some duration of lower temperature in this period, which is called "chilling requirement".

If chilling requirements of deciduous fruit types are not met, various problems, mainly in bud breaking, such as irregular/unbalanced blossoming, disorders in shoot development and productivity and quality loss may be encountered (Özbek, 1975). In addition, irregular leafing in these fruit types may lead to problems such as sunburn. The impact of these problems may be observed in the same year or in the following year. Therefore, completion of chilling requirements for the fruit cultivars and types based on the climatic conditions in a certain region bears utmost importance for high quality yield production and professional fruit growth (Bayazit et al., 2012).

Besides its genetic structure, temperature and chilling requirements are the two main decisive factors in early and late blossoming of a plant. Therefore, chilling requirement plays an important role in providing earliness and lateness during plant improvement (Alburquerque et al., 2008).

Although there are some studies on the dormancy conditions and chilling requirement of different fruit types, few researches studies on chilling requirements of walnut, has been conducted so far. In a study on 8 different walnut genotypes in Iran, the lowest chilling duration (under 7.2 ºC) was observed in Serr cultivar and Z30 types with 600 and 650 hours, respectively. Chilling requirements of the other genotypes (Lara, Z63, Z53, Pedro and Z67) were 900, 900, 800, 750 and 750 hours, respectively. The highest chilling requirement was seen in the Hartley cultivar with 1000 hours (Aslamarz et al., 2009). Also, Sibbett et al (1998) reported that most American walnut cultivars required approximately 800 hours temperature below 7 ºC in winter.

This study focuses on determining chilling requirements of some important walnut cultivars as Maraş-18, Şebin, Bilecik, Kaman-1, Sütyemez-1 and Şen-1 and types Maraş-12 and Sütyemez-2, with standard and chill unit methods.

Materials and Methods

Material

This study was conducted in the 2013 and 2014 winter. The materials used in the study are one and two year old shoots taken from Bilecik, Kaman-1, Maraş-18, Sütyemez-1, Şebin, Şen-1, Maraş-12 and Sütyemez-2 genotypes of 12 years old, available in Kahramanmaraş Sütçü İmam University Prof. Dr. Nurettin KAŞKA Hard Shell Fruits Application and Research Centre (SEKAMER). Each genotype used 250 cuttings of 20-25 cm length totaling up to 2000 pieces of cuttings in the study.

The properties of cultivars and genotypes:

Bilecik cultivar: The bunches of cultivar contained double or triple fruits and sub-branches displayed 30% productivity. The shell was smooth, the thickness of the shell was an average value and it had an oval-shaped fruit. Its shelled fruit weight is 13 grams. The inner fruit weight was 6.5 grams and its inner fruit rate was 50%. Its fat rate and protein rate were 68% and 18%, respectively. By the end of September, it was harvested. The efflorescence structure is protogyny. Şen (2011) reported that the pollinators can be Şebin, Yalova-3 and Yavuz-1 (KR-2).

Kaman-1 cultivar: Two to six fruits can be seen on the bunch of this cultivar. Its sub-branch productivity was 70-75%, with fruit weight of 11.5 to 13.5 grams, inner fruit weight of 6 to 6.7 grams, and its inner fruit rate is 51-55%. Bilecik, Yalova-3, Şebin, Şen-1, Şen-2 and Tokat-1 are recommended as pollinators (Şen, 2011).

Maraş-18 cultivar: It is a high quality cultivar in terms of productivity and taste. Its inner fruit rate, inner colour and fullness of inner fruit are superior and it is very resistant against weevil. It is harvested in the first half of September. Male flowers ripen earlier, and it needs pollinators. The Bilecik, Sütyemez-1, Chandler, Maraş-18 cultivars can be recommended as pollinators for regions suitable for walnut growing. Fruit weight: 14.5-16

grams, inner fruit rate: 52-57%, inner colour: light yellow, efflorescence: mid late, flower structure: protandry, harvest: between September 9-17 (Sütyemez, 2002).

Sütyemez-1 cultivar: Known as the largest walnut in the world, its shelled fruit weight, average inner weight, and inner fruit rate were 25-27 grams, 12-13.5 grams and 49-51%, respectively. Its inner colour is light yellow. Its efflorescence coincides with mid-season and the harvest is from September 10 to September 20. The productivity rate of its sub-branches is between 60 and 75%. The blossoming of Sütyemez-1 is protogyny. The Şebin, Maraş-18 and Yalova-4 cultivars are recommended as pollinators (Sütyemez, 2002).

Şebin cultivar: It is a productive cultivar with fruit weight of 9.4 grams, inner fruit weight of 6.6 grams, and inner fruit rate 63%. It can be easily peeled from its shell. Its efflorescence trend is protoandry and can be pollinated by the Bilecik and Yavuz-1 (KR-2) cultivars. The harvest is at the end of September. This cultivar is very vulnerable to weevil (Şen, 2011).

Şen-1 cultivar: It has a broad corolla structure and displays a strong growth with fruit weight of 17 grams, and inner fruit rate of 54%. It can be easily peeled from its shell and is harvested at the end of September. It is a productive cultivar, whose male and female flowers ripen in the same period (homogamy). Therefore, it does not necessarily need a pollinator. Şen, 2011 recommended the pollinators to be Şebin, Yalova-1 and Yavuz-1.

Maraş-12 genotype: The most distinctive property of this genotype is that its fruit grows on bunches. Each of which consists of 8-26 fruits with shelled weight of 8-10 grams, its inner fruit weight of 5.4-6.0 grams, and inner fruit rate of 65-70%. Its displays a homogamy structure in terms of efflorescence (Sütyemez, 2011).

Sütyemez-2 genotype: It is harvested very early in the seasons and its fruit is fairly large. Its shelled weight, inner fruit weight, and inner fruit rate were 15-16 grams, 8-8.7 grams, and 53-55%. This cultivar displays a protogyny structure in terms of efflorescence. Serr and Kaplan-86 cultivars can be used as pollinators (Sütyemez, 2002).

Method

Two different methods, namely "standard method" and "chill unit method" were used in order to calculate chilling requirements of walnut genotypes. Both methods were briefly mentioned below.

Standard method: The durations in which the temperature is under 7.2ºC in October, November, December, January, February, March and April in the experiment site are calculated as hours in this method. Hourly temperature values obtained from the temperature data logger in SEKAMER were used for this calculation.

Chill Unit Method (CU): Hourly temperature values obtained from the temperature data logger in SEKAMER were used for this calculation, also. Each hourly temperature value was recorded during the winter between October and April and converted to chill units based on "Richardson model". This mathematical model converts temperatures to effective chill units and thus accurately estimates the completion of dormancy as follows (Richardson et al., 1974):

Temperature (ºC)	Chill Unit Values (CU)
<1.4	0
1.5 – 2.4	0.5
2.5 – 9.1	1
9.2 – 12.4	0.5
12.5 – 15.9	0
16 – 18	-0.5
>18	-1

The most effective temperatures in chill unit range were between 2.5 ºC and 9.1 ºC, which correspond to "1" chill unit (Richardson et al., 1974).

Collection of cuttings started on December 30, 2013 and continued until March 22, 2014. One or two year old 25 cm long cuttings were collected every 72 hours under field conditions in the study. Three pieces of shoots were taken from three different trees belonging to walnut genotypes for 3 three times successively, corresponding to a total of 9 shoots each time.

The spots on the shoots were analyzed separately as terminal bud, lateral bud and male flower. The shoots, collected under field conditions were taken to a heated room (24±1 ºC) in the laboratory, department of Horticulture, Faculty of Agriculture, Kahramanmaraş Sütçü İmam University and the number of spots was recorded. Afterwards, they were placed in a water tank sized 120 × 130 cm in the heated room in accordance with the randomized block experimental design so as to dip last 5 cm of their end in the water. The water in the tanks always stirred. Observations and calculations were made daily always at the same time. The apparent green tissues observed at least in 50% of buds were considered as an indicator of completion of dormancy for each cultivar, which was defined as the "end of dormancy" (Bayazit et al., 2012).

Results

The chilling duration of the region where this study was conducted (Kahramanmaraş) was

determined based on standard and chill unit methods. The calculations demonstrate that the total low temperature in Kahramanmaraş province during 2013-2014 winter correspond to 1645 hours and 1753 CU (Table 1).

Table 1. Accumulated chilling in Kahramanmaraş province (2013-2014)

Months	Standard method (<7.2˚C) (hour)	Chill unit
October 2013	26.00	-125.50
November 2013	25.00	138.00
December 2013	607.00	465.00
January 2014	475.00	649.00
February 2014	327.00	373.50
March 2014	151.00	301.50
April 2014	34.00	-48.50
Total	1645.00	1753.00

Various studies on the calculation of regional chilling requirement indicate that standard method is used more compared to chill unit method. Therefore, the data in this study differ from some of the previous studies in this respect (Şahinoğlu and Küden, 2011; Bayazit et al., 2012; Küden et al., 2013). This may result from the fact that studies are usually conducted in subtropical regions such as Çukurova region of Turkey where winters are usually milder.

The most accumulated chilling in Kahramanmaraş province was recorded in December and January (Table 1). Therefore, it can be suggested that this duration can meet the chilling requirements of numerous fruit types.

Findings regarding chilling requirement of all walnut genotypes analyzed in this study are shown in Table 2, Table 3 and Table 4. The results indicate that the shortest and longest durations of chilling for terminal buds are between 809 hours-644 CU (Sütyemez-2) and 1570 hours-1755.5 CU (Bilecik) while the same durations for lateral buds were between 1016 hours-956 CU (Şebin) and 1571 hours-1769.5 CU (Bilecik). In addition, it was found that the chilling requirement of male flowers were between 915 hours-770 CU (Sütyemez-2) and 1407 hours-1416.5 CU (Bilecik). End of dormancy for terminal bud, lateral bud and male flowers of genotypes and their chilling requirements based on standard and chill unit methods are given in Table 2, Table 3 and Table 4.

According to these results, the chilling requirements of all genotypes are as follows:

Bilecik cultivar: 1570 hours and 1755.5 CU, 1571 hours and 1769.5 CU and 1407 hours and 1416.5 CU were calculated as chilling requirements of terminal bud, lateral bud and male flower, respectively. It was observed that the terminal buds and male flowers of this cultivar need the longest duration of chilling compared to other genotypes (Tables 2-3-4).

Kaman-1 cultivar: 1069 hours and 1025 CU, 1570 hours and 1755.5 CU and 1349 hours and 1313.5 CU were calculated as chilling requirements of terminal bud, lateral bud and male flower, respectively (Tables 2-3-4).

Maraş-18 cultivar: 966 hours and 837.5 CU, 1571 hours and 1758.5 CU and 1288 hours and 1215 CU were calculated as the chilling requirements of terminal bud, lateral bud and male flower, respectively. It was observed that the terminal buds and male flowers of this cultivar need an average duration of chilling compared to other genotypes (Tables 2-3-4).

It was observed that the chilling duration of lateral buds of Bilecik, Kaman-1 and Maraş-18 cultivars were very close to each other. Furthermore, the chilling durations of lateral buds of these cultivars are higher compared to other genotypes.

Sütyemez-1 cultivar: 856 hours and 705.5 CU, 1163 hours and 1114 CU and 1113 hours and 1095 CU were calculated as the chilling requirements of terminal bud, lateral bud and male flower, respectively (Tables 2-3-4).

Şebin cultivar: 856 hours and 705.5 CU, 1016 hours and 956 CU and 966 hours and 837.5 CU were calculated as the chilling requirements of terminal bud, lateral bud and male flower, respectively. It was observed that the lateral buds and male flowers of this cultivar need the shortest duration of chilling compared to other genotypes (Tables 2-3-4).

Şen-1 type: 856 hours and 705 CU, 1163 hours and 1114 CU and 1113 hours and 1095 CU were calculated as the chilling requirements of terminal bud, lateral bud and male flower, respectively (Tables 2-3-4).

It was observed that the chilling duration of terminal buds of Sütyemez-1, Şebin ve Şen-1 types were shorter compared to other genotypes.

Maraş-12 type: 915 hours and 770 CU, 1235 hours and 1170 CU and 992 hours and 893 CU were calculated as the chilling requirements of terminal bud, lateral bud and male flower, respectively (Tables 2-3-4).

Sütyemez-2: 809 hours and 644 CU, 1337 hours and 1275 CU and 915 hours and 770 CU were calculated as the chilling requirements of terminal bud, lateral bud and male flower, respectively. It was observed that the terminal buds of this cultivar need the shortest duration of chilling compared to other genotypes (Tables 2-3-4).

Table 2. The chilling requirement of terminal buds of walnut genotypes

Genotypes	Defoliation dates	End of dormancy	Total number of spots	Number of spots blossoming	Rate of spots blossoming	Standard method (s)	Chill unit method (CU)
Bilecik	17.11.2013	19.03.2014	18	12	66.7	1570	1755.5
Kaman-1	23.11.2013	27.01.2014	9	6	66.7	1069	1025
Maraş-18	08.11.2013	18.01.2014	9	6	66.7	966	837.5
Sütyemez-1	18.11.2013	12.01.2014	9	5	55.6	856	705.5
Şebin	29.11.2013	12.01.2014	9	6	66.7	856	705.5
Şen-1	10.11.2013	12.01.2014	9	5	55.6	856	705
Maraş-12	14.11.2013	15.01.2014	9	5	55.6	915	770
Sütyemez-2	14.11.2013	09.01.2014	8	4	50	809	644

Table 3. The chilling requirement of lateral buds of walnut genotypes

Genotypes	Defoliation dates	End of dormancy	Total number of spots	Number of spots blossoming	Rate of spots blossoming	Standard method (s)	Chill unit method (CU)
Bilecik	17.11.2013	22.03.2014	34	18	52.9	1571	1769.5
Kaman-1	23.11.2013	19.03.2914	30	18	60.0	1570	1755.5
Maraş-18	08.11.2013	26.03.2014	14	7	50.0	1571	1758.5
Sütyemez-1	18.11.2013	02.02.2014	30	17	56.7	1163	1144
Şebin	29.11.2013	24.01.2014	14	8	57.1	1016	956
Şen-1	10.11.2013	02.02.2014	12	7	58.3	1163	1144
Maraş-12	14.11.2013	05.02.2014	24	17	70.3	1235	1170
Sütyemez-2	14.11.2013	11.02.2014	11	8	72.7	1337	1275

Table 4. The chilling requirement of male flowers of walnut genotypes

Genotypes	Defoliation dates	End of dormancy	Total number of spots	Number of spots blossoming	Rate of spots blossoming	Standard method (s)	Chill unit method (CU)
Bilecik	17.11.2013	23.02.2014	124	62	50	1407	1416.5
Kaman-1	23.11.2013	14.02.2014	3	4	75.0	1349	1313.5
Maraş-18	08.11.2013	08.02.2014	72	49	68.6	1288	1215
Sütyemez-1	18.11.2013	30.01.2014	15	11	73.3	1113	1095
Şebin	29.11.2013	18.01.2014	62	32	51.6	966	837.5
Şen-1	10.11.2013	30.01.2014	86	49	57.0	1113	1095
Maraş-12	14.11.2013	21.01.2014	14	9	64.3	992	893
Sütyemez-2	14.11.2013	15.01.2014	10	8	80.0	915	770

No study on the chilling requirements of local walnut genotypes has been conducted so far in Turkey. However, Şen (2011) reported that the chilling requirements of Payne and Franquette, which are well-known walnut cultivars in the Europe, are 700 and 1500 hours under 7°C, respectively. In addition, he reported that the chilling requirement of Beykoz-8, which is a local cultivar, is around 1000-1200 hours. He also reported that the chilling requirement of walnut is around 400-1800 hours. Therefore, this study overlaps the values confirms by Şen (2011).

The chilling durations of the buds of walnut genotypes analyzed in this study are generally higher than those analyzed in a study by Aslamarz et al. (2009). Furthermore, Aslamarz et al. (2009) reported that the longest chilling duration among buds and male flowers belong to buds while the shortest chilling duration is needed by male flowers. In this study, it was observed that the chilling requirements of lateral buds were generally the longest while the lowest duration belonged to terminal buds.

Conclusion

This study attempted to determine the chilling requirements of some walnut genotypes which are popular and promising in Turkey. The findings suggest that all walnut genotypes analyzed in this study can be easily grown in Kahramanmaraş province. Nevertheless, it can be argued that some genotypes analyzed in this study is not suitable to be grown in the coast lines of Mediterranean and Aegean regions due to fairly short chilling durations. It is surprising that the lateral buds of all genotypes analyzed in this study need longer chilling durations compared to terminal buds. This may result from the fact that the lateral buds need longer chilling durations due to the apical dominancy of terminal buds. If the climatic conditions and chilling durations in a region where walnut is to be grown are taken into consideration, the impact of lacking chilling durations on the productivity can be eliminated. In addition, it is evident that this study may pioneer upcoming improvement studies.

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