EFFECTS OF DIFFERENT GRAFTING METHODS AND TIMES ON GRAFTING SUCCESS AND PLANT DEVELOPMENT IN SARI ALIÇ HAWTHORN GENOTYPE (*Crataegus azarolus* L.)

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Abstract

The study was carried out to determine the different grafting methods and times on the grafting success and plant development in 'Sarı Alıç' hawthorn genotype (*Crataegus azarolus* L.) on *Crataegus monogyna* L. rootstock in Hatay province, eastern Mediterranean region of Turkey. T and chip budding and whip grafting methods were conducted on February 15, March 01, March 15, April 01, April 15, May 01 and May 15 dates in 2016. The grafting take and bud sprout percentages, graft shoot development and shoot diameter were also investigated. The results of the study showed that graft success and plant development were affected by grafting times and methods. The mean highest bud sprout percentage (71.91%) was found in whip grafting whereas mean graft shoot development (55.18 cm) and diameter (5.57 mm) were detected in T budding. The bud sprout ratio was the highest on April 01 and April 15 (84.44% and 77.77%, respectively). The results showed that whip grafting method applied within March and April months was very successful for growing of 'Sarı Alıç' hawthorn genotype in Hatay, Turkey ecological conditions.

Keywords: Hawthorn, budding, grafting, plant development.

Introduction

Crataegus species form genus known as hawthorns that belongs to subfamily Maloideae of the Rosacea (Evans and Campbell 2002). The genus is closely related to the genera *Pyracantha* M. Roem, *Mespilus* L. and *Hesperomeles* Lindl. (Hummer and Janick 2009). Several hawthorn species are grown for their eatable fruit in Asia, America, and the Mediterranean countries. In Europe, the fruit, leaves, and flowers of the hawthorn are traditionally employed in the treatment of heart problems due to their antispasmodic, cardiotonic, hypotensive, and antiatherosclerotic effects, as well as being ingredients in wine, conserve and sweets (Ljubuncic et al. 2005, Caliskan 2015).

Turkey have different climatic conditions for the hawthorn species in the diverse regions. The regions have at least one characteristic species and other secondary or common species with domestic genotypes. *C. monogyna* Jacq is widespread in Turkey. Hawthorn species are mainly distributed in temperate zone areas of Turkey. Some hawthorn species are also growing in low altitudes such as 300 and 500 m areas of subtropical ecology such as Hatay in Turkey (Caliskan et al. 2016). Caliskan et al (2012) reported some genotypes of the *C. azarolus* are grown for large and delicious fruits in Belen, Hatay province, eastern Mediterranean region of Turkey. The promising genotypes are found in the region because of its fruit size (fruit weight >10 g), as well as high total soluble solids, total phenolic, antioxidant activity and antioxidant capacity contents. The genotypes of this species are commonly grown in Belen County and the fresh fruits have been sold with the higher prices in local markets.

A most important limiting factor for the hawthorn growing is propagation. Vegetative propagation of hawthorn species is not a usefully method because of their rooting percentage is very lower. At the present time, rootstock production is curried out with seeds, and then grafting and budding methods are used for new plants. However, there is no detail studies for the grafting methods and times on the grafting success and plant development in hawthorn. This study was designed to determine optimal grafting methods and times for hawthorn grown in Hatay, Turkey ecological conditions.

Material and methods

The study was conducted at Fidanlı located Samandağ, Hatay province (Turkey). The scions of 'Sarı Alıç' hawthorn genotype was taken from main plants which were selected Belen, Hatay in February and stored at 4°C in a refrigerator. In the study, *Crataegus monogyna* L. seedling produced with seed propagation was used as rootstock.

T and chip budding and whip grafting methods were conducted on February 15, March 01, March 15, April 01, April 15, May 01 and May 15 dates in 2016. The budding and grafting methods on rootstock were applied from soil surface at a height 15-20 cm. Cultural applications such as removal of suckers below graft point, weeding, irrigation and fertilization were fulfilled at regular intervals. A mini data logger (Testo 174T Temp/RH, Germany) was used for the daily mean temperature and relative humidity measurements (eight hours intervals).

The grafting take and bud sprout percentage (%), graft shoot length (cm) and diameter (mm) were investigated. The bud sprout percentage was observed within 30 days following grafting. The shoot length and diameter were measured at the end of vegetation period (December 15). The shoot length was measured by meter from the graft point and the shoot diameter was evaluated by digital caliper at a height 5 cm above the graft point.

Data were analyzed using SAS software and procedures (SAS 2005). Variance analysis was formed with Tukey's Honestly Significant Difference (HSD) method at $p<0.05$. The two-factorial arrangement on a completely randomized design was constructed with three replications. Each replication included 15 plants. The data expressed as percentage were transformed using the to the arc-sin√x transformation.

Results and discussion

Climatic data included daily mean temperature (°C) and relative humidity (%) were recorded during February 10 to December 31, 2016 year (Figure 1). In the experimental area, daily mean temperature ranged between 2.8 and 38.5 (°C) and daily mean relative humidity varied between 22.8 and 99.9%. Generally, mean temperature and relative humidity varied throughout the year except for June, July and August. Hartmann et al. (2011) indicated that temperature and relative humidity values are very critical pending the 30 days following grafting methods. The period is important for formation of callus cells and wound closure. In addition, Yilmaz (1992) showed that the temperature at the grafting times should be 26 and 28°C for optimum development of callus cells. The maximum mean temperature (38.5°C) was recorded in June whereas the mean temperatures were ranged between 10 and 20°C in February and March, ranged between 12 and 25°C in April and ranged between 15 and 29°C in May at the grafting application times. The relative humidity values changed from 30 to 70% at the same times.

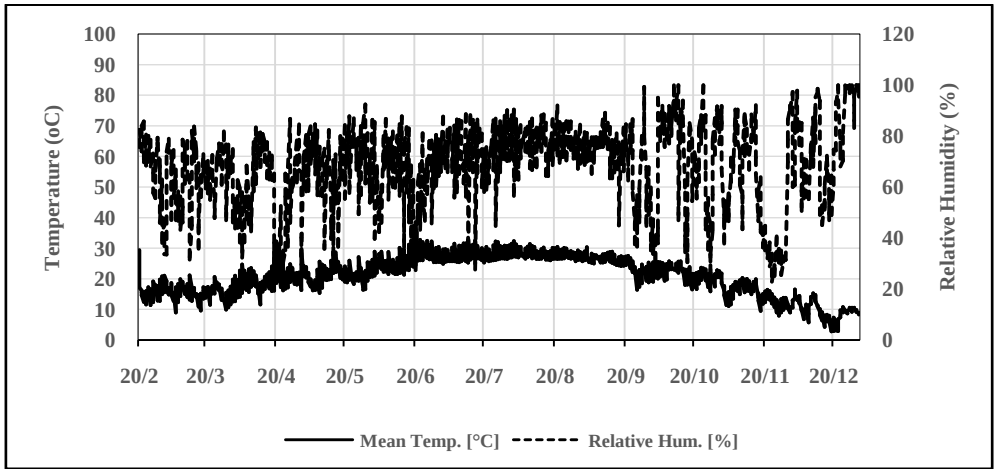

Figure 1. Variation of mean temperature (°C) and relative humidity (%) during the days after grafting in 2016.

The influence of T and chip budding and whip grafting on the grafting take and bud sprout percentages, graft shoot length and diameter values were shown in Table 1. The data showed that grafting success and plant development in 'Sarı Alıç' hawthorn genotype were statistically significant ($p<0.05$) depend on grafting method and time. Grafting success was not obtained from T budding method on February 15. The result may be due to the application date was not enough for activity of plant sap in phloem cells. However, the highest bud sprout ratio (86.67%), graft shoot length (94.33 cm) and shoot diameter (8.40 mm) were found in T budding application on April 15. Grafting take and bud sprout ratios were showed differences in chip budding. The highest grafting ratio was detected for chip budding on March 01 and March 15 whereas the highest bud sprout ratio for chip budding was observed on April 01. Bud sprout ratio for chip budding was the lowest on May 01. The highest graft shoot length and shoot diameter values were measured for chip budding on April 01 while it was lowest on February 15 (50.67 cm and 3.15 mm, respectively) and May 15 (41.33 cm and 3.75 mm, respectively). Grafting take ratio for whip grafting was ranged between 26.66 (May15) and 100.00% (March01 and April 15) and bud sprout ratio was ranged between 23.33 (May 01) and 93.66% (April 15). The longest graft shoot length was detected for whip grafting on February 15 (72.08 cm) whereas it was the lowest on May 15 (26.44 cm). Graft shoot diameter values for whip grafting based on various grafting times did not found statistically important.

Table 1. The influence of T, chip and whip grafting based on grafting times on grafting success and plant development in 'Sarı Alıç' hawthorn genotype

Grafting Method	Grafting Time	Grafting take ratio (%)	Bud sprout ratio (%)	Graft Shoot length (cm)	Graft Shoot diameter (mm)
T budding	15 February	0.00 b	0.00 c	0.00 d	0.00 d
	01 March	80.00 a	60.00 ab	50.33 c	6.66 ab
	15 March	86.67 a	26.67 bc	46.78 c	4.83 b
	01 April	100.00 a	86.68 a	61.50 bc	2.74 c
	15 April	93.33 a	86.67 a	94.33 a	8.40 a
	01 May	100.00 a	53.33 ab	70.43 b	8.36 a
	15 May	86.70 a	66.67 ab	62.89 bc	8.00 a
Chip budding	15 February	91.67 ab	46.67 abc	50.67 c	3.15 e
	01 March	100.00 a	60.00 ab	32.44 e	4.04 cd
	15 March	100.00 a	40.00 bc	56.04 b	4.21 bc
	01 April	93.33 ab	80.00 a	63.00 a	5.64 a
	15 April	86.67 ab	53.33 abc	54.00 bc	4.50 b
	01 May	80.00 ab	20.00 c	53.44 bc	3.97 cd
	15 May	73.33 b	53.33 abc	41.33 d	3.75 d
Whip Grafting	15 February	46.68 b	43.22 b	72.08 a	5.46
	01 March	100.00 a	80.00 a	56.22 b	5.47
	15 March	80.00 a	80.00 a	49.22 c	5.17
	01 April	86.67 a	86.67 a	53.33 bc	5.04
	15 April	100.00 a	93.33 a	53.67 bc	4.72
	01 May	86.66 a	66.67 a	37.11 d	4.64
	15 May	26.66 b	23.33 b	26.44 e	4.61
HSD_T		29.81	40.35	20.28	1.85
HSD_{Chip}		25.99	36.51	4.75	0.41
HSD_{Whip}		32.19	41.71	5.24	ns

Different letters within columns indicate significant differences by Tukey's at $p<0.05$; ns: not significant

The mean grafting take and bud sprout ratios, graft shoot length and diameter values were presented in Table 2. The mean grafting take ratio was the highest for chip budding (89.29%). The lowest grafting take ratio was observed in whip grafting (75.24%). However, the mean bud sprout ratio was the highest for whip grafting (71.91%). Actually, some researchers indicated that whip

grafting is one of the successfully methods than others due to the callus formation and graft union are better in whip grafting (Miller and Crocker 1994, Bellini 2002).

The highest mean grafting take ratios were found between March 01 and May 01 (from 88.80 to 93.50%). The lowest grafting take and bud sprout ratios for all grafting methods were detected in February 15 (46.11 and 40.00%, respectively). The mean bud sprout ratio was the highest in April 01 (84.44%) and April 15 (77.77%). The climatic data showed that daily mean temperatures between 15 and 25°C at the grafting application time (April) were very successfully for hawthorns. Grafting take and bud sprout ratios were adversely affected by low temperatures in February and March. Similar to our results, low temperatures at the March were showed negative results on grafting success in persimmon (Zenginbal 2015) and kiwi (Öztürk et al. 2012). In addition, April is the stage of speed shoot development on hawthorns in Hatay, Turkey ecological conditions. This time can be perfect time for grafting because of growth hormones are concentrated in the buds and these may be induce differentiation of vascular tissues in the graft union point (Hartmann et al. 2011).

Grafting methods and times had significant effect ($p<0.05$) on the mean graft shoot length and diameter values (Table 2). The highest mean graft shoot length were found in T budding (55.18 cm), followed by chip budding (50.13 cm) and whip grafting (4.73 cm). The-mean graft shoot length was the highest for April 15 and April 01 (67.33 and 59.28 cm, respectively) whereas the lowest mean graft shoot length was found in February 15 (40.92 cm) and May 15 (43.56 cm). T budding had the highest mean graft shoot diameter with 5.57 mm. The lowest mean graft shoot diameter was measured in chip budding (4.18 mm). The mean graft shoot diameter was effected by grafting time. The highest shoot diameter was obtained in April 15, May01 and May 15 (5.88, 5.65 and 5.45, respectively).

Table 2. The effects of various grafting methods and times on mean grafting take, bud sprout ratio, graft shoot length and shoot diameter in 'Sarı Alıç' hawthorn genotype

Variable	Grafting take ratio (%)	Bud sprout ratio (%)	Graft Shoot length (cm)	Graft Shoot diameter (mm)
Grafting method				
T budding	78.10 b	54.29 b	55.18 a	5.57 a
Chip budding	89.29 a	50.48 b	50.13 b	4.18 c
Whip Grafting	75.24 c	71.91 a	49.73 b	5.02 b
Grafting time				
15 February	46.11 c	40.00 c	40.92 e	2.87 d
01 March	93.33 a	66.67 ab	46.33 de	5.39 ab
15 March	88.89 a	48.89 bc	50.68 cd	4.74 bc
01 April	93.35 a	84.44 a	59.28 b	4.47 c
15 April	93.50 a	77.77 a	67.33 a	5.88 a
01 May	88.80 a	46.67 bc	53.66 bc	5.65 a
15 May	62.22 bc	47.78 bc	43.56 e	5.45 a
HSD_{method}	7.91	10.64	3.33	0.36
HSD_{time}	15.40	20.71	6.49	0.69

Different letters within columns indicate significant differences by Tukey's at $p<0.05$.

Conclusions

This study provided the first data indicating the grafting methods and times in hawthorn culture. The results showed that considerable variation in bud sprout percentage, graft shoot length and diameter values based on grafting methods and times. According the results, we can say that whip grafting can be used successfully from March 01 to April 15 for hawthorn nursery production in Hatay, Turkey ecological conditions. Chip budding may be preferred if there are not enough graft shoots on February 15, March 01 and March 15. T budding can be suggested for high budding success and plant development on April 01 and April 15.

Acknowledgments
This study was supported by the Mustafa Kemal University Scientific Research Foundation (Project Number 14820).

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