ISSN 1644-0692
www.acta.media.pl

ACTA SCIENTIARUM POLONORUM *Acta Sci. Pol. Hortorum Cultus, 14(4) 2015, 39-50*

THE EFFECTS OF GRAFTING METHODS (BY HAND AND WITH MANUAL GRAFTING UNIT) AND GRAFTING TIMES ON PERSIMMON (*Diospyros kaki* L.) PROPAGATION

Hamdi Zenginbal
Abant Izzet Baysal University, Bolu, Turkey

Abstract. This research was conducted to determine the effects of three different grafting periods (March 1, April 1 and May 1) and six grafting methods (tongue, splice, cleft grafting by hand and cleft, wedge, omega grafting by three different manual grafting tools) on graft success and plant growth in persimmon sapling production. The experiment was carried out in a randomized complete block design with three replications in Rize, Turkey during 2012–2013. The 'Hachiya' persimmon (*Diospyros kaki* L.) were used for grafting scions. Two-year old *Diospyros lotus* L. seedling were used for rootstocks. In conclusion, graft take percentages varied from 21.7 to 81.7% in 2012, from 10.0 to 73.3% in 2013. Sprouting percentages varied from 11.7 to 73.3% in 2012, from 5.0 to 68.3% in 2013. These parameters, tongue and wedge grafting (with tool) performed on April 1 gave the highest results in both years. Graft shoot lengths varied from 38.6 to 65.7 cm in 2012, from 38.3 to 61.5 cm in 2013. Graft shoot diameters varied from 5.3 to 8.3 mm in 2012, from 5.5 to 7.8 mm in 2013. These parameters, splice grafting performed on April 1 gave the highest results in both years. In generally among all parameters the best type of grafting was tongue and wedge (with tool) grafting. The omega grafting with manual grafting tool gave the lowest results in all parameters. Grafting period on April 1 gave the highest results, May 1 gave the lowest results in all parameters.

Key words: *Diospyros kaki*, hand and tool grafting, field conditions, graft success

INTRODUCTION

Persimmon (*Diospyros kaki* L.) is one of the most important fruits in the world. The fruits are consumed freshly or dried and also used in industry (dessert, ice cream, jam, cream, beverages, cosmetics etc.) and pharmacology. Besides, the persimmon tree is

Corresponding author: Hamdi Zenginbal, Abant Izzet Baysal University, Vocational High School of Bolu, 14100 Bolu, Turkey, e-mail: hzenginbal@gmail.com

used in forming landscapes and afforestation for preventing soil erosion [Özcan 2005, Zheng et al. 2013].

In recent years persimmon fruit production and consumption has increased noticeably in the world. According to FAO [2014], the world-wide persimmon production was 2417602 tons in 2000. The increased to 3263021 tons in 2005 and 44689955 tons in 2012. China is the world's biggest producer, followed by Korea, Japan, Brazil, Azerbaijan, and Italy.

Persimmon production in Turkey was 33232 tons on total area of 22642 acres in 2013 [TUİK 2014]. Persimmon in Turkey has been traditionally considered a minor fruit tree. Great persimmon orchards is situated in the Mediterranean area and regular orchards, the varieties grown have been of astringent fruits [Aksoy 1994]. But with increasing interest for developing the cultivation of persimmon, however there is not suitable technology and enough information about post-harvest behavior and storability of the fruit in developing countries. As a result, persimmon producers cannot offer the production out of season and are bound to sell it at low prices during a short period after ripening time [Khademi et al. 2013]. Currently in Turkey, the cultivation of persimmon has increased significantly in particularly the Black Sea Region. In order to meet the demand for the persimmon in the region, it is important to procure the sapling and present them to the farmers.

Persimmon can be propagated by seed, grafting, and micro propagation. Propagation from seed are employed for the production of rootstocks [Bellini 2002]. Grafting techniques are the most widely used persimmon propagation. Propagation in persimmon has been proved the difficulty as compared to other commercial fruit trees due to the problem of low success potential of grafting. The availability of good grafted plant material is a major factor in the commercial cultivation of persimmon.

The grafting is difficult and it needs too much time and effort. Grafting is made by experts and they are not always available. Because of these circumstances, new tools for simplifying the grafting process were invented in horticulture and floriculture [Çelik and Boz 2003]. Several new hand and bench top grafting tools or devices have been developed to prepare graft and bud union for such a purpose, but few are used extensively, mostly in propagating grapevines and fruit trees [Hartmann et al. 2011]. This new grafting tools should be tested for efficiency in the propagation of persimmon plants.

Grafting experts are also at premium persons and they are not easy to find in fruit tree production. Without question, finding skilled grafters is a severe production problem. Hence, the importance of developing mechanized and automated grafting systems is involved to use. Different companies manufactured grafting tools in different countries. About the suitability of these tools has not been studied in the world on persimmon propagation. In the present study, grafting methods by hand and manual grafting tools performed in different period were investigated for grafting success in persimmon propagation.

MATERIALS AND METHODS

Study site. The field experiment was conducted at Engindere neighborhood (North: 41°02', East: 40°34', Altitude: 4 m) in Rize, Turkey during 2012 and 2013. Rootstocks

were grown in nursery conditions. Soil properties studied on samples taken from 20 cm below the surface were as follow: organic matter 0.21–3.9%, total nitrogen content 0.17–0.25%, pH 6.0–6.4, exchangeable K_2O 100–370 mg kg^{-1}, available P_2O_5 15–30 mg kg^{-1}.

Plant materials. The two-year old *Diospyros lotus* L. seedlings having uniform diameter (between 8.0–10.0 mm) were used as rootstocks. According to Bellini's [2002] statement, *Diospyros lotus* currently the most commonly used rootstock in persimmon orchards. It has notable resistance to low temperatures and drought, and it is able to impart to the scion elevated vigor and uniformity of development. It has excellent affinity with cv. 'Hachiya'. Plants of *Diospyros kaki* L. 'Hachiya' cultivar were used for scions collection. 'Hachiya' is a common commercial cultivar in world. The origin is Japan. The tree is vigorous and upright. 'Hachiya' is a productive, very large, cone shaped, seedless persimmon [Miller and Crocker 1994, Özcan 2005]. The scions (one-year old shoots) were selected in previous winter from healthy donor persimmon trees in Rize. These shoots (25–30 cm long) were disease-free and lignified. The grafting scions were stored in a refrigerator at +4°C on damp paper in a plastic bag until used for grafting.

Grafting methods and grafting times. Tongue, splice, cleft grafting by hand, and cleft, wedge (saddle), omega grafting with three different manual grafting tools were investigated. The procedures for six grafting were as described by Hartmann et al. [2011]. In all six methods the following were standard procedures: (i) the scion and rootstock were washed with 10% sodium hypochlorite to remove the latex and sterilize, (ii) the scion and rootstock was matched in size, so that the cambial tissues are combined, (iii) after inserting the scions, the scion and rootstock were tied together by wrapping with white and soft plastic transparent plastic tapes. The grafting were done by expert researchers having extensive experience and researches about grafting [Çelik et al. 2006, Zenginbal et al. 2006 etc.]. Grafting operations were done on March 1, April 1, and May 1, 2012 and 2013.

Grafting tools. Wedge or saddle grafting tool is produced in Italy by Artı Tec Company (fig. 1). This device makes a type of wedge graft, cutting out a long V-notch in the rootstock and a corresponding long, tapered cut at the base of the scion. By reversing the position of the rootstock and scion, it could also make a saddle graft. Although the cuts fit together very well, the operation is slow because the graft union must be either tied with a budding rubber or poly tape or stapled together. This tool has been used successfully in propagating grapes and fruit trees. Various grafting tools for the omega graft are available, like the portable device made in Taiwan by Zenport Industries Company (fig. 2). It cuts through both the rootstock and scion, one laid on top of the other, making an omega-shaped (Ω) cut and leaving the two parts interlocked. Cleft manual grafting tool is produced in Italy by the Carlo A. Manaresi Company (fig. 3). This device makes a type of cleft graft, cutting out a long-narrow V-notch in the rootstock. This machine has been used in propagation ornamental and fruit bearing plants. In any case the branches to be grafted should not be thicker than 20 mm.

Investigation of criteria on grafting. At the end of growing season (December 1), the following parameters were examined to determine the effects of grafting methods and grafting periods on grafting success.

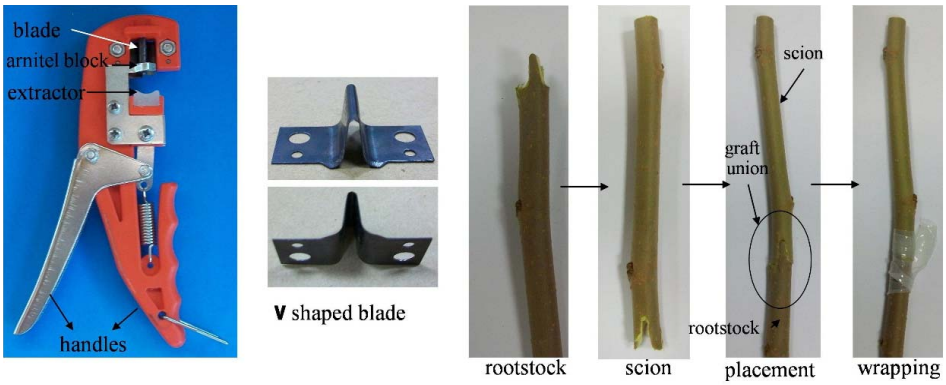

Fig. 1. Manual wedge grafting cut grafting, and grafting processes (Manuel Grafting 3T Art. AR-INN3T, made in Italy, by Artı Tec Company)

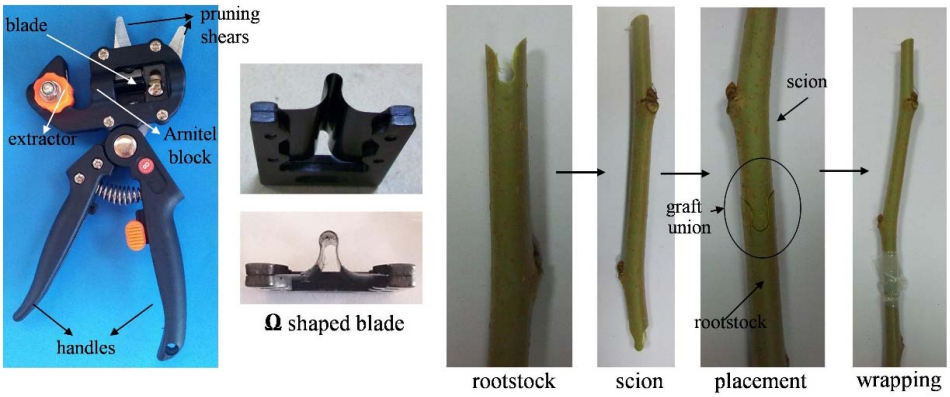

Fig. 2. Manual omega cut grafting, and grafting processes (Made in Taiwan, by Zenport Industries Company)

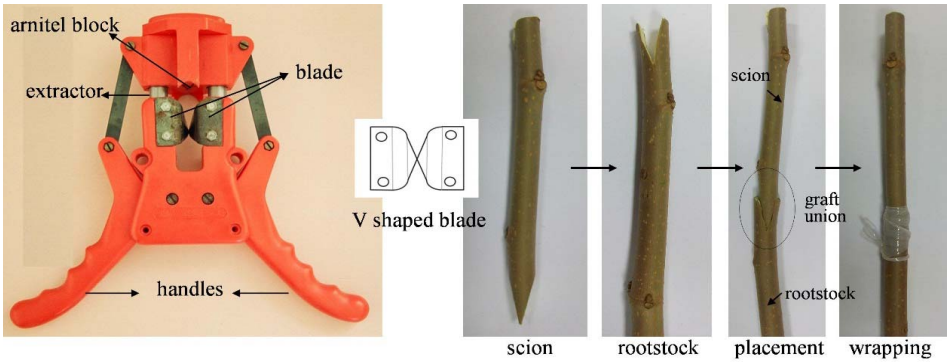

Fig. 3. Manual cleft cut grafting, and grafting processes (CEO Manuel Grafting Unit, made in Italy, by the Carlo A. Manaresi Company)

1. The daily mean temperature and relative humidity were scored (1 hour's intervals) by mechanical data logger (HOBO U10 Temp/RH).

2. Graft take rate (%): Percentage of grafted persimmons that have an adequate or all-around callus ring formation on the surface of the graft union. Sixty days after grafting the percentage of bud take was estimated as: Graft take rate (%) = Number of bud taken scion × 100 / Number of grafted rootstock.

3. Graft sprouting rate (%): Percentage of grafted persimmons that have an adequate shoot length and diameter flushed from scion bud. After grafting the graft sprouting rate was estimated as: Graft sprouting rate (%) = Number of sprouted scion × 100 / Number of grafted rootstock

4. Graft shoot length (cm): Observations on grafting shoot length was measured by meter at a point 5 cm above the graft union at the end of growing period (December 1).

5. Graft shoot diameter (mm): Observations on grafting shoot diameter was measured by digital compass at a point 5 cm above the graft union at the end of growing period (December 1).

Statistical analysis. The study was designed in two factor randomized complete blocks with three replications and 20 grafts per replications. The experiment was evaluated as 6 (grafting methods) × 3 (grafting periods) factorial design. Data calculated as percentage (graft take and sprouting) were transformed to the arc-sin$\sqrt{x}$ transformation method. The original data are given as percentages in the table. The transformed data are given in parentheses in the table. Data were analyzed using MSTAT pocket program. Duncan's Multiple Range Test was used to indicate the differences between the average data.

RESULTS AND DISCUSSION

Climatic data. Experiment carried out in Rize, Turkey where daily mean relative humidity (%) and maximum, minimum and mean temperature (°C) were recorded during March 1 to December 1, 2012 and 2013 (figs 4 and 5). As shown in Fig. 4, daily mean temperatures varied between 1.4°C–29.4°C. Daily mean relative humidity varied between 52.0–89.7%. As shown in Fig. 5, daily mean temperatures varied between 2.9°C–26.0°C. Daily mean relative humidity varied between 48.9–90.9%. In both years, temperature fluctuated after June 1 and reached the maximum in middle of August. After August, the average temperature decreased. The climatic data were in accordance with the long term average of Rize [TUMAS 2015], and indicating that 2012 and 2013 were average years. Thus, generalization from the study seemed possible.

Graft take. The graft take of persimmon grafting are summarized in Table 1. The interaction between grafting method and grafting time had insignificant effect in 2012 and significant effect (1%) in 2013 on graft take. The highest graft take rate (81.7%) was obtained from tongue and cleft grafting by hand performed on April 1 and wedge grafting performed on March 1 and April 1, 2012. In 2013, the highest result (73.3%) was obtained from tongue, cleft (with tool) and wedge (with tool) performed on April 1. Grafting methods had significant effect (1%) on graft take rate in both years. The best results were obtained from tongue and wedge grafting (no significant difference be-

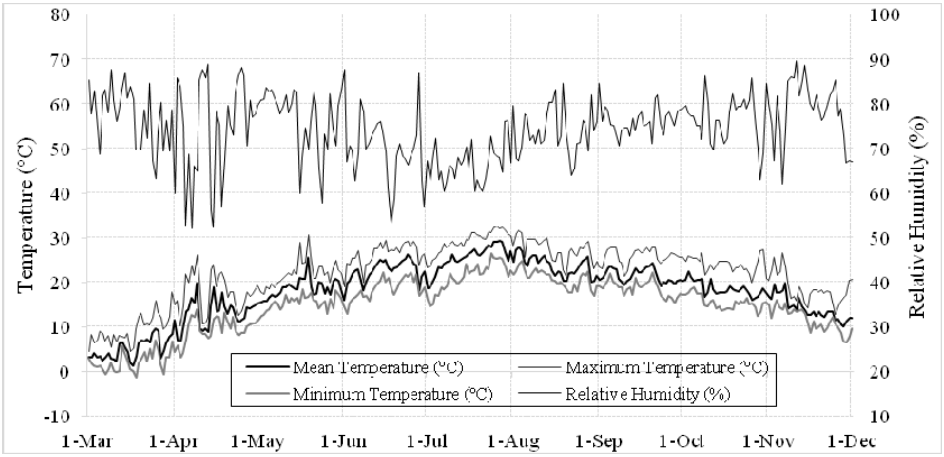

Fig. 4. Changing of mean, maximum and minimum temperatures and relative humidity during the days after grafting in 2012

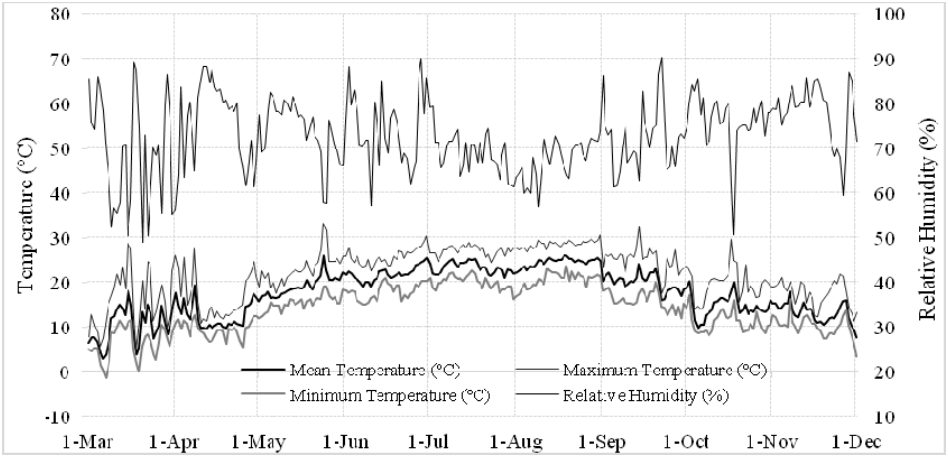

Fig. 5. Changing of mean, maximum and minimum temperatures and relative humidity during the days after grafting in 2013

tween tongue and wedge grafting). The lowest graft take rate (53.9 and 40.0% respectively to years) was recorded with omega grafting. Grafting times had significant effect (1%) on graft take, April 1 giving the best success in both years (78.9 and 71.1% respectively to years). The lowest results were obtained from all grafting methods performed on May 1 in both years. As a result of research, the best graft take was obtained from tongue and wedge (with tool) grafting, followed cleft (with tool and hand) and splice grafting. The lowest results were obtained omega grafting (with tool). Tongue (by

hand) and wedge (with tool) grafting superior to other grafting methods. The success of this grafting methods may be attributed to high level of callus formation around the grafting location. Several researchers [Mishra 1982, Miller and Crocker 1994, Bellini 2002, Chauhan et al. 2007, Yordanov and Tabakov 2009] reported that tongue grafting produced higher results in terms of graft take in persimmon. Grafting done on April 1 proved to be the optimum time for grafting in persimmon. Times of grafting on March 1 and May 1 produced the lowest bud take for grafting. Similar result was also reported by Yordanov and Tabakov [2009]. The higher success rate might be because of favorable temperature and relative humidity prevailing during the period following grafting and rapid sap flow in rootstock and scion which might have favored the healing process and established the continuity of cambial and vascular tissues for graft take. First 20 days after grafting were the most important period for the grafting success. Kongsakulvatanasuk [1987] reported that callus formation began 2–4 days and completed in 18–24 days after grafting in persimmon. It formed from both cells in scion and rootstock combination. Suriyapananont and Suriyapananont [1997], callus formation was found 2–10 days after grafting in persimmon. The new cambium initiation on scion side appeared and completely connected with stock cambium at 12 days after grafting. After 14 days of grafting, the new cambium layer differentiated into new vascular tissues. In this periods grafts should not be exposed to high and low temperatures. Hartmann et al. [2011], reported that temperature affected grafting integration significantly so that callus induction increased linearly between 4 and 32°C and stopped exactly under 0°C. As shown in Fig. 4–5, mean daily temperature varied with 1.4–9.6°C in March of 2012; 2.9–18.1°C in March of 2013 after grafting. Low temperatures prevailing just after grafting caused lower bud take in grafting performed on March 1 in both years. This temperature range did affect the grafting combination. The reason for low success rates of grafting performed on May 1 is excess bleeding in the rootstock. This situation was also reported by Hartmann et al. [2011].

Graft sprouting. The binary interaction (grafting method × grafting time) had insignificant effect in 2012, significant effect (1%) in 2013 on sprouting of scion (tab. 1). The highest sprouting rate (73.3%) was obtained from tongue grafting performed on April 1, 2012. In 2013, the highest rate (68.3%) was obtained from wedge grafting with manual tool performed on April 1. The lowest rate was obtained from omega grafting performed on May 1, 2012 and 2013. Grafting methods had significant effect (1%) on graft sprouting rate in both years. The best results were obtained from tongue and wedge grafting (no significant difference between tongue and wedge grafting). The lowest result was obtained omega grafting. Grafting times had significant effect (1%) on graft sprouting rate in both years. Grafting time on April 1, 2012 and 2013 gave the highest rate of sprouting (66.1 and 60.8% respectively to years). The lowest results were obtained from all grafting methods performed on May 1 in both years. The best sprouting rate was obtained from tongue and wedge grafting (with tool), followed cleft grafting (by hand), cleft grafting (tool) and splice grafting. The lowest results were obtained omega grafting (with tool). The callus induction and connection for tongue and wedge grafting were higher than other grafting methods. These findings are in conformity with those of Mishra [1982], Miller and Crocker [1994], Bellini [2002], Chauhan et al. [2007] and Yordanov and Tabakov [2009] reporting that tongue grafting gave higher

Table 1. Influence of different grafting methods and grafting times on the graft take and sprouting ratio in persimmon

Grafting methods	Grafting times	Graft take (%)		Graft sprouting (%)	
		in 2012	in 2013	in 2012	in 2013
Tongue graft	March 1	78.3[1] (62.3)[2]	46.7 (43.1) cd	61.7 (51.8)	38.3 (38.2) d
	April 1	81.7 (65.9)	73.3 (59.0) a	73.3 (58.9)	66.7 (54.7) a
	May 1	40.0 (39.2)	28.9 (32.1) e	26.7 (31.1)	15.0 (22.8) f
Splice graft	March 1	70.0 (56.8)	43.3 (41.2) d	50.0 (45.0)	31.7 (34.2) e
	April 1	76.7 (61.1)	70.0 (56.8) ab	61.7 (51.7)	60.0 (50.8) b
	May 1	33.3 (35.2)	20.0 (26.6) f	20.0 (26.6)	10.0 (18.4) gh
Cleft graft by hand	March 1	73.3 (58.9)	48.3 (44.0) cd	55.0 (47.9)	40.0 (39.2) d
	April 1	81.7 (64.7)	71.7 (57.9) ab	71.7 (57.9)	58.3 (49.8) b
	May 1	31.7 (34.2)	11.7 (19.9) g	16.7 (24.0)	6.7 (14.8) ıj
Cleft graft with tool	March 1	78.3 (62.3)	51.7 (46.0) c	56.7 (48.9)	38.3 (38.2) d
	April 1	78.3 (62.3)	73.3 (58.9) a	65.0 (53.8)	60.0 (50.8) b
	May 1	28.3 (32.0)	13.3 (21.3) g	15.0 (22.8)	8.3 (16.6) hı
Wedge graft with tool	March 1	81.7 (64.7)	48.3 (44.0) cd	65.0 (53.7)	40.0 (39.2) d
	April 1	81.7 (65.9)	73.3 (58.9) a	71.7 (57.9)	68.3 (55.8) a
	May 1	38.3 (38.2)	21.7 (27.7) f	23.3 (28.9)	13.3 (21.1) fg
Omega graft with tool	March 1	66.7 (54.7)	45.0 (42.1) cd	40.0 (39.2)	30.0 (33.2) e
	April 1	73.3 (58.9)	65.0 (53.7) b	53.3 (46.9)	51.7 (46.0) c
	May 1	21.7 (27.7)	10.0 (18.4) c	11.7 (19.9)	5.0 (12.9) j
	LSD volume	NS	1% : 4.2	NS	1%: 3.2
Overall mean (grafting method)	tongue graft	66.7 (55.8) a	49.6 (44.7) a	53.9 (47.2) a	40.0 (38.6) a
	splice graft	60.0 (51.0) b	44.4 (41.5) bc	43.9 (41.1) b	33.9 (34.5) b
	cleft graft by hand	62.2 (52.6) b	43.9 (40.6) c	47.8 (43.3) b	35.0 (34.6) b
	cleft graft with tool	61.7 (52.2) b	46.1 (42.1) bc	45.6 (41.8) b	35.5 (35.2) b
	wedge graft with tool	67.2 (56.3) a	47.8 (43.6) ab	53.3 (46.8) a	40.5 (38.7) a
	omega graft with tool	53.9 (47.1) c	40.0 (38.1) d	35.0 (35.3) c	28.9 (30.7) c
	LSD volume	1% : 3.1	1% : 2.4	1% : 3.1	1% : 2.5
Overall mean (grafting times)	March 1	74.7 (60.0) b	47.2 (43.4) b	54.7 (47.7) b	36.4 (37.1) b
	April 1	78.9 (63.2) a	71.1 (57.5) a	66.1 (54.5) a	60.8 (51.3) a
	May 1	32.2 (34.4) c	17.6 (24.3) c	18.9 (25.5) c	9.7 (17.8) c
	LSD volume	1% : 2.1	1% : 1.7	1% : 2.2	1% : 1.7

[1] – original data, [2] – transformed data, NS – non significant

results in terms of sprouting in persimmon. The lowest sprouting rates were obtained from omega grafting by tool performed on all grafting times. This is probably due to tissue damages by omega grafting with manual tool. Likewise, wood and bark tissue is

friable in persimmon. Therefore, cortex is separated from wood tissue by pressure of grafting tool resulting in enormous damage around grafting area. Our findings support the results of Zenginbal et al. [2006], Çelik [2000] and Hartmann et al. [2011]. Time of grafting on April 1 gave highest results for grafting. Similar result was reported by Yordanov and Tabakov [2009] in persimmon. Early April is the time when leaf buds on persimmon begin to burst [Şeker et al. 2004]. This is a good time for grafting as growth hormones are concentrated in the buds and these are effective enough in inducing differentiation of vascular elements in the tissues of the graft [Hartmann et al. 2011]. April is the time when the cold season ends and the rainy season begins (spring time). This transition from cold to rainy season is the best time for grafting because meristematic activity is starting and the scion-rootstock union is established quickly [Leakey and Newton 1994]. Time of grafting on March 1 and May 1 produced the lowest sprouting for grafting. The cause of the low sprouting rates in grafting performed on March 1 was the low temperature, while for grafting performed on May 1 it was the excess of bleeding in rootstock. Hartmann et al. [2011] also indicated that the amount of bleeding in the rootstocks affect the success of grafting. Şeker et al. [2004] in their study on phonology of persimmon varieties in Turkey reported that the bud sprouting occurred from March 27 to April 10, while the full flowering took place from May 6 to May 15. The full flowering stage of the persimmon at the beginning of May is the most intense period in terms of water content, so this finding supports our hypothesis.

Graft shoot length. The graft shoot lengths of persimmon grafting are summarized in Table 2. The interaction between grafting method and grafting time had significant effect (1%) in 2012 and insignificant effect in 2013 on shoot length. The highest shoot length (65.7 cm and 61.5 cm respectively) was recorded with splice graft performed on April 1 in both years. Considering the different times of the year when grafting took place, the relative annual shoot length of scions showed that splice and tongue grafting were significantly better than other grafting methods (no significant difference between tongue and splice grafting) in both years. Grafting times had significant effect (1%) on shoot length, April 1 giving the best success in both years (56.2 cm and 55.8 cm respectively to years). The lowest shoot lengths were obtained from all grafting methods performed on May 1 in two years. In general, splice and tongue grafting methods were found to be superior to other grafting methods. Similar result was reported by Zenginbal et al. [2006]. The higher growth of plants grafted on April 1 may be attributed to early union formation and greater duration of growing period as compared to grafting on May 1.

Graft shoot diameter. The binary interaction (grafting method × grafting time) had insignificant effect in 2012 and significant effect (1%) in 2013 on shoot diameter (tab. 2). The highest shoot diameter (8.3 mm) was recorded by splice grafting performed on April 1, 2012. In 2013, the highest shoot diameter (7.8 mm) was recorded by wedge grafting with manual tool performed on April 1. Grafting methods had significant effect (1%) in both years on shoot diameter. The best results were obtained from splice grafting (7.5 mm) in 2012 and splice (7.08 mm) and wedge grafting with manual tool (7.11 mm) in 2013. The lowest results were obtained cleft grafting by hand and manual grafting tools in two years. In both years, Grafting times had significant effect (1%) on the graft shoot diameter. Grafting time on April 1 gave the highest shoot diameter (7.7 and 7.4 mm respectively to years). The lowest shoot diameters were obtained from

Table 2. Influence of different grafting methods and grafting times on the graft soot length and graft shoot diameter in persimmon

Grafting methods	Grafting times	Graft shoot length (cm)		Graft shoot diameter (mm)	
		in 2012	in 2013	in 2012	in 2013
Tongue graft	March 1	56.8 bc	57.0	7.5	7.6 ab
	April 1	64.4 ab	60.0	8.0	7.6 ab
	May 1	44.4 e–h	39.7	6.7	5.5 j
Splice graft	March 1	57.4 bc	60.8	7.7	7.5 abc
	April 1	65.7 a	61.5	8.3	7.4 a–d
	May 1	40.0 gh	41.8	6.5	6.3 ghı
Cleft graft by hand	March 1	41.9 fgh	44.3	6.8	6.6 fgh
	April 1	49.4 c–f	53.3	7.2	7.2 b–f
	May 1	38.9 h	38.3	5.5	5.8 ıj
Cleft graft with tool	March 1	42.0 fgh	46.0	6.7	6.7 efg
	April 1	51.3 cde	52.9	7.7	6.9 c–f
	May 1	38.6 h	38.6	5.3	5.7 ıj
Wedge graft with tool	March 1	47.9 d–g	53.2	7.4	7.2 b–e
	April 1	54.7 cd	57.7	7.6	7.8 a
	May 1	39.0 h	41.9	5.7	6.3 ghı
Omega graft with tool	March 1	47.3 d–g	47.0	7.2	6.9 d–g
	April 1	52.0 cde	49.6	7.4	7.3 a–e
	May 1	39.3 h	39.5	6.2	6.1 hıj
	LSD volume	1% : 7.2	NS	NS	1% : 0.5
Overall Mean (grafting method)	tongue graft	55.2 a	52.2 a	7.4 ab	6.9 ab
	splice graft	54.4 a	54.7 a	7.5 a	7.1 a
	cleft graft by hand	43.4 b	45.3 b	6.5 c	6.5 c
	cleft graft with tool	44.0 b	45.8 b	6.6 c	6.5 c
	wedge graft with tool	47.2 b	50.9 ab	7.0 bc	7.1 a
	omega graft with tool	46.2 b	45.4 b	6.9 bc	6.8 bc
	LSD volume	1% : 4.2	1% : 5.5	1% : 0.5	1% : 0.3
Overall Mean (grafting times)	March 1	48.9 b	51.4 b	7.2 b	7.1 b
	April 1	56.2 a	55.8 a	7.7 a	7.4 a
	May 1	40.0 c	40.0 c	6.0 c	6.0 c
	LSD volume	1% : 3.0	1% : 3.9	1% : 0.3	1% : 0.2

NS – non significant

all grafting methods performed on May 1, 2012 and 2013. Splice and tongue grafting methods were found to be superior to other grafting methods. When comparing various methods of grafting we should note that Zenginbal et al. [2006] also obtained maximum

graft shoot diameter of the kiwifruit plants with tongue and splice grafting. The quick and strong union formation, greater uptake of water and nutrients and longer growing period may account for higher graft shoot diameter of tongue and splice grafted plants. All grafting methods performed in April 1 the growing bud evaluated the vegetation better and resulted in the highest graft shoot diameter.

CONCLUSION

According to the results of this study, tongue (by hand) and wedge (with tool) grafting and April 1 grafting time were found to be successful to persimmon nursery plant production. The omega grafting with manual tool produced the lowest results in all grafting times. Of all parameters the best type of grafting was tongue and wedge (with tool). The omega grafting with manual tool produced lowest results. The manual wedge grafting tool also produced good results.

REFERENCES

Aksoy, U. (1994). Present status and future prospects of underutilized fruit production in Turkey. CIHEAM Network on Underutilized Fruits, 7–10 November 1994, Zaragoza, Spain, 13, 97–107.

Bellini, E. (2002). Cultural practices for persimmon production. First Mediterranean Symposium on Persimmon. Zaragoza: CIHEAM. 23–24 November 2001, Faenza, Italy, 51, 39–52.

Chauhan, N., Ananda, S.A., Rana, A.S. (2007). Studies on propagation of persimmon (*Diospyros kaki* L.). Haryana J. Hortic. Sci., 36(3–4), 236–238.

Çelik, H. (2000). The Effects of different grafting methods applied by manual grafting units on grafting success in grapevines. Turkish J. Agric. For., 24, 499–504.

Çelik, H., Boz, Y. (2003). Hand manual grafting units for grapevine propagation. Centenary Jubilee of the IVE-Pleven, Celebration and Scientific Workshop, 13–14 June 2002, SPS Print, 150–159 p.

Çelik, H., Zenginbal, H., Özcan, M. (2006). Effect of budding performed by hand and with manual grafting unit on kiwifruit propagation in the field. Hort. Sci. (Prague), 33(2), 57–60.

FAO (2014). Food and Agriculture Organization of the United Nations, FAO database.

Hartmann, H.T., Kester, D.E., Davies Jr., F.T., Geneve, R.L. (2011). Plant Propagation: Principles and Practices. Eighth Edition. Regents/Prentice Hall International Editions, Englewood Cliffs, New Jersey, 915 p.

Khademi, O., Zamani, Z., Poor Ahmadi, E., Kalantari, S. (2013). Effect of UV-C radiation on postharvest physiology of persimmon fruit (*Diospyros kaki* Thunb.) cv. `Karaj´ during storage at cold temperature. Intl. F. Res. J., 20(1), 247–253.

Kongsakulvatanasuk, K. (1987). Graft union development of bud grafting in persimmon (*Diospyros sp.*). Master's Thesis, Kasetsart University, Bangkok (Thailand), 92 p.

Leakey, R.R.B., Newton, A.C. (1994). Domestication of tropical trees for timber and non-timber products. MAB Digest 17, UNESCO, Paris, France.

Miller, E.P., Crocker, T.E. (1994). Oriental Persimmons in Florida. Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. This document is SP 101, 1–16 p.

Mishra, K.A. (1982). The vegetative propagation of persimmon. Sci. Hortic. (Netherlands), 17(2), 125–127.

Özcan, M. (2005). Persimmon Cultivation. HASAT Publishing, İstanbul, Turkey, 77 p.

Suriyapananont, V., Suriyapananont, S. (1997). Bud-unıon behavıor of persımmon cultıvar 'Fuyu' on Kluaı Rusı stock. Acta Hort., 436, 321–329.
Şeker, M., Kaynaş, K., Aktaş, Z. (2004). The phenological characteristics of local persimmon types selected in Çanakkale district. First Persimmon Cultivation and Marketing Symposium, November 25–26, 2004, Ünye, Ordu, Turkey, 23–29.
TUMAS (2015). Turkey Meteorological Archive System, Climate Statistics. Ankara: Turkish State Meteorological Service Publications.
TUİK (2014). Prime Ministry Turkish Statistical Institute, Ankara.
Yordanov, A.I., Tabakov, S.G. (2009). Comparison of different methods of propagation of persimmon trees. Forth International Symposium on Persimmon, June 16, Firenze, Faenza, Caserta, Italy, 187–192.
Zheng, R., Zhang, Q., Luo, Z., Zhang, X., Wang, C. (2013). Application of *Diospyros* in Chinese landscape and study on its traditional culture. Fifth International Symposium on Persimmon, October 20, 2012, Wuhan, China, 55–59.
Zenginbal, H., Özcan, M., Demir, T. (2006). An investigation on the propagation of kiwifruit *(Actinidia deliciosa, A. Chev.)* by grafting under Turkey ecological conditions. Intl. J. Agri. Res., 1(6), 597–602.

WPŁYW METODY SZCZEPIENIA (RĘCZNEJ LUB ZA POMOCĄ RĘCZNEGO ZESTAWU DO SZCZEPIENIA) ORAZ CZASU SZCZEPIENIA NA ROZMNAŻANIE KAKI (*Diospyros kaki* L.)

Streszczenie. Badanie przeprowadzono w celu ustalenia efektów trzech różnych okresów szczepienia (1 marca, 1 kwietnia, 1 maja) oraz sześciu metod szczepienia na powodzenie szczepienia oraz wzrost roślin w produkcji owoców kaki. Eksperyment przeprowadzono w układzie bloków losowych w trzech powtórzeniach w Rize w Turcji w latach 2012–2013. Odmiana 'Hachiya' (*Diospyros kaki* L.) została użyta do szczepienia pędów. Sadzonek dwuletniego *Diospyros lotus* L. użyto do produkcji podkładek. Procent przyjętych szczepień wynosił 21,7–81,7% w 2012 i 10,0–73,3% w 2013. Procent kiełkowań wynosił 11,7–73,3% w 2012 oraz 5,0–68,3% w 2013. Parametry te dla szczepienia przez stosowanie i w klin (za pomocą narzędzia) przeprowadzonego 1 kwietnia miały największe wartości w obydwu latach. Długość pędu szczepionego wynosiła w 2012 38,6–65,7 cm i 38,3–61,5 cm w 2013. Średnica pędu szczepionego wahała się w 2012 w granicach 5,3–8,3 mm i 5,5–7,8 mm w 2013. Parametry szczepienia w klin przeprowadzonego 1 kwietnia miały największe wartości w obydwu latach. Ogólnie najlepszym typem szczepienia było w klin i przez stosowanie. Szczepienie urządzeniem omega dało najsłabsze rezultaty dla wszystkich parametrów. Szczepienie 1 kwietnia dało najlepsze wyniki, a 1 maja najsłabsze dla wszystkich parametrów.

Słowa kluczowe: *Diospyros kaki*, szczepienie ręczne i za pomocą urządzenia, warunki polowe, sukces szczepienia

Accepted for print: 20.04.2015

For citation: Zenginbal, H. (2015). The effects of grafting methods (by hand and with manual grafting unit) and grafting times on persimmon (*Diospyros kaki* L.) propagation. Acta Sci. Pol. Hortorum Cultus, 14(4), 39–50.