

FACTORS AFFECTING GRAFTING OF *Acer pseudoplatanus* L.

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Abstract. Grafting of Sycamore (*Acer pseudoplatanus* L.) was performed on to rootstock of the same species. Two phonological conditions of the rootstock were studied – dormant and active. Three methods were tested – chip budding, splice graft and cleft graft. Criteria for evaluating the results were success rate, length of the shoots, number shoots and percentage of the shoots developed from the buds applied. We recommend grafting on both “dormant” and “growing” rootstock by splice graft. The success rate in spring (dormant rootstock) was $90.00 \pm 10.75\%$ and in summer (growing rootstock) - $85.00 \pm 10.75\%$.

Keywords: sycamore maple, chip budding, cleft graft, splice graft.

Rezumat. Factorii care influențează altoirea la *Acer pseudoplatanus* L. Altoirea la paltin (*Acer pseudoplatanus* L.) a fost efectuată pe un portaltoi aparținând aceleiași specii. Au fost analizate două condiții fenologice ale portaltoiului – în stare latentă și activă. Au fost testate trei metode – chip budding, altoirea în despicătură și altoirea sub scoarță. Criteriile folosite în evaluarea rezultatelor au fost rata de success, lungimea lăstarilor și procentul lăstarilor dezvoltați din butașii folosiți. Recomandăm altoirea atât pe material în stare latentă cât și activă prin metoda altoire în despicătură. Rata de succes primăvara (portaltoi în stare latent) a fost de $90,00 \pm 10,75\%$ și vara (portaltoi activ) de $85,00 \pm 10,75\%$.

Cuvinte cheie: paltin, chip budding, altoirea în despicătură, altoirea sub scoarță.

INTRODUCTION

Acer pseudoplatanus L. is a valuable species from economic point of view (PANDEVA, 2004), because of its good adaptive ability in different soil conditions (DOBRINOV, 1982; JOYCE, 1998) and its ornamental qualities (DIRR, 1998). Despite these facts though, it remain not enough investigated in order to improve its genetic variability (PANDEVA, 2004; THOMPSON et al., 2001).

Vegetative propagation of selected individuals gives the opportunity for production of clones and potential for productivity and value in crescent of the new plantations (THOMPSON et al., 2001).

The species in the genus *Acer* have been propagated by different methods: rooting of stem cuttings, grafting (DIRR & HEUSER, 1987) and micropropagation (HARTMANN, 2010).

It is always preferable for vegetative propagation to be used matured genotypes, as their phenotypic expression of genetic potential is already revealed (FRANCLET, 1980; ZOBEL, 1981). When the rooting of cuttings is difficult or impossible, the method of grafting and budding is used for cloning valuable genotypes (BROSHTILOV, 2000).

KRÜSSMANN (1997) and HARTMANN et al. (2010) highlight on the fact, that the species of the genus can be separate to two groups of interoperability – “milky” sap and “non-milky” sap groups. On that base *Acer pseudoplatanus* L. is a suitable rootstock for *A. heldreichii*, *A. trautvetteri* and others. According to DIRR & HEUSER (1987) and BERTELS (2012) Sycamore rootstock is used for grafting and budding of the same species. Most commonly 2 year old seedlings are used as a rootstock (DIRR & HEUSER 1987; THOMPSON et al., 2001; GRBICH, 2004).

A prerequisite for the grafting success is the phonologic condition of the two components. SHMID (2002) points out two optimum periods – from the end of winter to the beginning of spring and summer period (July, August), after the end of growing and development of summer wood. For the winter/spring grafting, it is necessary the rootstock to be active and the scions to be dormant.

HARTMANN et al. (2010) recommends the seeds of *Acer pseudoplatanus* to be sown in February straight in containers, and to be grown until the second summer in them. After that, at the end of winter, the containers need to be moved in greenhouse, where they get ready for grafting. Straight after the first signs of development they are ready for grafting. The success rate reported is 85%.

In field conditions, budding close to the ground or at the height of the crown is common and takes place in June, July or August. Handmade grafting via lateral adhesion in high humidity in greenhouse and under polythene takes place either in early spring (February, March) or in August. The recommended temperatures are 17-18°C of the soil and 15-20°C of the air (BERTELS, 2012). The summer period is recommended also by GRBICH (2004).

According to DIRR & HEUSER (1987) though, Sycamore is grafted in January or February on bare-root rootstocks. At this period both rootstock and scion are dormant. Chip budding needs to be used as a technique, because it is difficult to separate the bark of the rootstock. Grafting is used as well – Splice graft or whip and tongue graft, side graft (HARTMANN et al., 2010).

When budding species from Aceraceae family, it is important the rootstock not to be intensively growing, because it may cause rejection of the bud. In the opposite case, when the budding takes place too early, the cut heels and rejects the bud. In that case second budding can be done in the second half of August (KRÜSSMANN, 1997).

THOMPSON et al. (2001) recommends cleft graft on dormant rootstock in February. The reported success rate is 73%. KRÜSSMANN (1997) recommends for all maples an early spring splice graft, in which it is important to have buds from the rootstock and the scion opposite to each other on the two sides of the shoot. That helps to prevent drying.

The analysis of the published information shows that there are a lot of factors affecting the success of grafting of Sycamore. The aim of this study is to find the most suitable period and method of grafting for the South-East European region.

MATERIAL AND METHODS

The grafting took place in the forest nursery of Vetren, owned by FS (forestry service) Maglij. The scions were taken from one year old shoots of a 40 year old marked individual of Sycamore. Three different methods was used – chip budding (Photo 1), splice graft (Photo 2) and cleft graft (Photo 3).

The optimum phonologic periods were tested:

- Summer grafting – August;
- Spring grafting on dormant rootstock – March;

The scions carried an exact number of buds for every method – chip budding (1), splice graft (3) and cleft graft (4).

The grafts were wrapped with elastic ties.

Only one graft was made on a single rootstock. Every variant included 3 replications of 20 grafts.

Irrigation was provided daily for 1 hour by automatic drip irrigation system, with space between the drippers of 33 cm and debit of 2 litres per hour.

During the whole vegetation period, all the upcoming shoots from the rootstock were regularly removed.

The results were evaluated after the end of the first vegetation period. Success rate (%), length of the terminal shoot, number and percentage of the shoots developed per scion were the criteria evaluated. All results were analysed by analysis of variance (ANOVA) and post hoc LSD test using SPSS 10.0 (SPSS for windows 1999). Percentage values were transformed using arcsine square root (\sqrt{p}) (COMPTON, 1994) to normalize error distribution prior variance analysis.

RESULTS

The results show big potential of Sycamore for vegetative propagation by grafting in both phenologic periods, if the required biological prerequisites are correctly followed (table 1).

Table 1. Effect of the period and the method of grafting on its success (%).

Method/Period	Spring	Summer
Chip budding	68.33 ± 10.75 a	65.00 ± 10.75 a
Splice graft	90.00 ± 10.75 b	85.00 ± 10.75 ab
Cleft graft	75.00 ± 10.75 ab	73.33 ± 10.75 ab

The means and standard error within a column followed by the same letter were not significantly different, estimated by One-Way ANOVA followed by a post hoc LSD test at $p \leq 0.05$.

The method with the lowest success rate was chip budding 68.33±10.75 % (in spring) and 65.00±10.75 % (in summer). These percentages though are statistically identical with the ones recorded for the splice and cleft grafting with one exception (spring splice graft - 90.00 ± 10.75) (Table 1).

As the splice and cleft grafts considered, there was not a statistically significant difference between the success rate of the two. In spring it was from 75.00 ± 10.75% (cleft graft) to 90.00 ± 10.75% (splice graft) and in summer – from 73.33% ± 10.75 (cleft graft) to 85.33 ± 10.75% (splice graft) (Table 1).



Photo 1. Chip budding (original). Photo 2. Splice graft (original) . Photo 3. Cleft graft (original).

Comparing the two periods, for every method separately, did not allow an optimal period to be defined.

The success rate of grafting does not depend on the period (significance level of 0.710), on the method (significance level of 0.269), neither on the combination of the two (significance level of 0.988) (Table 2).

Table 2. Significance of factors and their interaction on coalescence between scion and rootstock.

Factor	df	F	Sig
Period	1	0.144	0.710
Method	3	1.457	0.269
Period x Method	2	0.012	0.988

From a producer's point of view, it is important not only the successful coalescence between scion and rootstock, but the following growth of the scion as well (Table 3).

The slowest growth was recorded when cleft and splice graft were used in spring – 13.81 ± 1.44 cm and 17.59 ± 1.64 cm respectively, without a statistical difference between the two. The most intensive growth (37.87 ± 1.67 cm) was recorded when cleft graft was done in summer. The other variants show such values of the mean growth that did not allow us to define a preferable method of grafting for the induction of the most intensive and fastest growth. These mean values vary from 25.24 ± 2.89 cm (spring chip budding) to 34.62 ± 3.19 cm (summer chip budding) (Table 3).

Table 3. Effect of the period and method of grafting on the length of the shoots.

Method	Mean length of the shoots (cm)	
	Spring	Summer
Chip budding	25.24 ± 2.89 bc	34.62 ± 3.19 de
Splice graft	17.59 ± 1.64 a	29.32 ± 1.79 cd
Cleft graft	13.81 ± 1.44 a	37.87 ± 1.67 e

The means and standard error within a column followed by the same letter were not significantly different, estimated by One-Way ANOVA followed by a post hoc LSD test at $p \leq 0.05$.

The mean length of the shoots depend on the period of grafting (significance level of 0.000) and the method (significance level of 0.001) as well as on the combination of the two (significance level of 0.000) (Table 4).

Table 4. Significance of factors and their interaction on length of the shoots.

Factor	df	F	Sig
Period	1	69.779	0.000
Method	3	5.517	0.001
Period x Method	2	9.049	0.000

Legend: R Squared = 0,166 (Adjusted R Squared = 0,159)

From the studied methods, chip budding registered the lowest number of shoots developed – 1.23 ± 0.19 (in summer) and 1.33 ± 0.18 (in spring) (Table 5). This result is logical, because with the method of chip budding there is only one bud applied per scion as opposite to minimum 3 with the other methods of grafting. Nevertheless the result shows that more than one shoot was developed in some of the chip budded trees, which is indication of development of dormant buds from the bud shield.

More shoots were developed when the method of splice graft was applied – from 2.51 ± 0.15 (in summer) to 2.69 ± 0.15 (in spring) (Table 5). As in case of this method every scion had 3 buds, it registers the highest result (81.77 ± 9.04 to 89.74 ± 8.60) from the three methods (Table 5).

Most shoots developed when the method of cleft graft was used – from 3.19 ± 0.14 (in spring) to 3.43 ± 0.17 (in summer). In percents, it is from 79.83 ± 8.21 to 85.63 ± 9.80 (Table 5).

Though there was no difference from the statistical point of view between mean percentages of developed buds at couple methods of grafting, there is a statistical difference between the grafting methods and budding.

Table 5. Effect of the period and method of grafting on the developed shoots.

Method	Mean number of developed shoots		Mean percentage of developed buds (%)	
	Spring	Summer	Spring	Summer
Chip budding	1.33 ± 0.18 a	1.23 ± 0.19 a	133.33 ± 10.79 b	112.81 ± 11.14 b
Splice graft	2.69 ± 0.15 b	2.51 ± 0.15 b	89.74 ± 8.60 a	81.77 ± 9.04 a
Cleft graft	3.19 ± 0.14 c	3.43 ± 0.17 c	79.83 ± 8.21 a	85.63 ± 9.80 a

The means and standard error within a column followed by the same letter were not significantly different, estimated by One-Way ANOVA followed by a post hoc LSD test at $p \leq 0.05$.

The method and the period of grafting have a statistically proven effect on the mean number of developed shoots (significance level of 0.000). The number of the shoots depends on the interaction of the two as well with the same significance level of 0.000 (Table 6).

Table 6. Significance of factors and their interaction on mean number of shoots and percentage of developed buds.

Factor	mean number of shoots			percentage of developed buds		
	df	F	Sig	df	F	Sig
Period	1	1532.419	0.000	1	0.298	0.585
Method	3	48.416	0.000	3	8.572	0.000
Period x Method	2	1.128	0.000	2	0.438	0.646
R Squared = 0.324 (Adjusted R Squared = 0.310).				R Squared = 0.082 (Adjusted R Squared = 0.064).		

The period did not affect the development of the buds (significance level of 0.585). On the contrary, the method of grafting had a significant effect on the percentage of developed buds (significance level of 0.000). The interaction between the two did not prove to be significant (significance level of 0.646) (Table 6).

DISCUSSION

Our results show that Sycamore is a species with high regenerative capability of its tissues. That fact explains the diversity of recommendations about successful grafting procedures. As our results confirm successful coalescence between the tissues is possible when grafting is made in spring period, as recommended by HARTMANN et al. (2010), DIRR & HEUSER (1987), THOMPSON et al. (2001) and KRÜSSMANN (1997), as well as budding in summer (KRÜSSMANN 1997; BERTELS 2012; GRBICH 2004). Chip budding proved to be useful, also in spring. In our study, the separation of the bark was not possible in both seasons, which makes the method of budding more favourable.

Our results show the possibility of successful splice and cleft grafting in summer, which has not been reported before in that season. The results confirm as well the recommendations of KRÜSSMANN (1997) and HARTMANN (2010) for splice graft and THOMPSON et al. (2001) for cleft graft in spring.

The usage of two year old rootstock recommended by (DIRR & HEUSER 1987; THOMPSON et al., 2001; GRBICH, 2004) was confirmed and it was indicated the possibility of using three year old rootstock.

CONCLUSIONS

For vegetative propagation of Sycamore, methods of chip budding, splice and cleft grafting can be successfully applied. We recommend spring and summer splice grafting as the most appropriate method. The present study proves the possibility of both grafting and budding in the two studied periods (spring and summer). These findings allow significant widening of the available working period and free choice of transplanting material.

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