MORPHOLOGICAL AND BIOCHEMICAL ASPECTS OF ROOTSTOCK-SCION INTERACTION AT PEAR FRUIT TREE SPECIE DUE TO INCREASING OF BUDDING HEIGHT

ASPECTE MORFOLOGICE ŞI BIOCHIMICE ALE INTERACŢIUNII ALTOI PORTALTOI LA SPECIA PĂR, ÎN CONDIŢIILE MODIFICĂRII ÎNĂLŢIMII DE ALTOIRE

CĂULEŢ Raluca - Petronela,
MORARIU Aliona, GRĂDINARIU G.
University of Agricultural Sciences and Veterinary Medicine Iasi, Romania

Abstract. *The influence of budding height (10, 20 and 40 cm) on bud survival and performance of maiden trees was investigated in experiments conducted in NE of Romania in 2006-2009. Pear rootstocks Pyrus sativa and Cydonia oblonga, were tested with cv. Untoasă Hardy. Neither rootstock nor budding height affected bud take. Buds on Pyrus sativa survived the winter better than Cydonia oblonga. There were significant differences in scions length, trunk cross sectional area and leaf area during all growth periods. Height of grafting had an important effect on the accumulation of sugars and dry matter. Trees budded at 40 cm had a bigger dry matter content when Cydonia oblonga was used as rootstock.*

Key words: rootstock, scion, budding height, trunk cross sectional area, leaf area, sugars, dry matter

Rezumat. *Lucrarea de faţă urmăreşte studierea influenţei înălţimii de altoire (10 cm, 20 cm şi 40 cm) asupra creşterii şi dezvoltării pomilor în pepinieră, în condiţiile pedoclimatice din NE României în perioada 2006-2009. Soiul de păr Untoasă Hardy a fost altoit pe portaltoii Pyrus sativa şi Cydonia oblonga. Nu a fost semnalată o influenţă semnificativă a portaltoiului sau a înălţimii de altoire asupra prinderii la altoire. Mugurii grefaţi pe Pyrus sativa au înregistrat un procent mai mare de rezistenţă peste iarnă comparative cu cei altoiţi pe Cydonia oblonga. S-au remarcat diferenţe semnificative în ceea ce priveşte lungimea altoiului, a secţiunii transversale a trunchiului şi a suprafeţei foliare a pomilor pe parcursul perioadei de vegetaţie. Înălţimea de altoire a influenţat în mod semnificativ acumularea de glucide şi substanţă uscată. Pomii altoiţi la 40 cm au avut un conţinut mai mare de substanţă uscată în cazul altoirii pe Cydonia oblonga.*

Cuvinte cheie: portaltoi, înalţime de altoire, secţiune tansversală a trunchiului, suprafaţa foliara, substanţă uscată

INTRODUCTION

The objective of our research was to study the effect of budding height of different pear rootstocks on the quality parameters of planting material produced under NE of Romania environmental conditions.

MATERIAL AND METHOD

The trial was performed at the S.D.E. "V. Adamachi" nursery in 2006-2009. Pear rootstocks *Pyrus sativa and Cydonia oblonga* were budded with pear cv. Untoasă Hardy in early August. Rootstocks were planted at a spacing of 0.9 x 0.2 m and budded at the height of 10, 20 and 40 cm (control variant being represented by grafting at 10 cm). The following spring, rootstocks were cut just above the bud and bud survival was measured. During and at the end of the vegetative period, tree height (cm), length of scion shoot (cm), trunk cross sectional area and leaf area were determined. Leave's dry matter content and sugars contained were analyzed. The trial consisted of three replicates with 50 trees in each. Variance analysis of main quality traits was done. Dry matter content was obtained after drying 4 hours fresh material at 105 ^{o}C and weighting at analytical balance. Soluble sugars content was determinate from leaves, by Schorll method and reported at dry substance.

RESULTS AND DISCUSSIONS

There was no significant effect of rootstock and budding height on bud healing in the autumn. Significant differences among rootstocks and budding height were observed when bud survival was evaluated in the following spring.

Irrespective of budding height, the highest percentage of live buds was found on vigorous rootstock (up to 90%) and the worse bud survival was recorded *Cydonia oblonga* (tab. 1).

Table 1

Aspects concerning grafting success and bud over-wintering at pear fruit trees grafted at 10 cm, 20 cm and 40 cm

Scion/ Rootstock	Height of grafting	Grafting success (%)	Bud overwintering (%)
Untoasă Hardy/ *Pyrus sativa*	V1 = 10 cm	89.85 (Mt)	95.16 (Mt)
	V2 = 20 cm	87.82	90.55 (00)
	V3 = 40 cm	82.25 (0)	88.55 (000)
DL 5% (mm)		3.5	0.44
DL1%(mm)		6.96	0.87
DL 0,1% (mm)		12.15	0.57
Untoasă Hardy/ *Cydonia oblonga*	V1 = 10 cm	87.77 (Mt)	93.36 (Mt)
	V2 = 20 cm	85.51	88.84 (000)
	V3 = 40 cm	81.53 (0)	84.83 (000)
DL 5% (mm)		2.5	0.50
DL1% (mm)		4.97	0.99
DL 0,1% (mm)		8.68	0.74

In the next year, a visible influence of the grafting height on shoots growing has been observed beyond the beginning of the summer, when variants engrafted at 10 cm recorded bigger values of the shoot's length comparing with variants engrafted at 20 and 40 cm. an important influence of the rootstock on the scion has been also recorded, engraftment on *Pyrus sativa* leading to a pronounced shoot's growing comparing with engraftment on *Cydonia oblonga*. (tab. 2).

Table 2

Average length of scion shoot ant total length of pear fruit tree, during the growing season (2007-2009)

Scion / Rootstock	Average of scion's length (cm)			Total fruit tree's length (cm)			Limit differences (cm)		
	V1	V2	V3	V1	V2	V3	DL 5%	DL 1%	DL 0,1%
	JUNE								
Untoasă Hardy/ *Pyrus sativa*	39.66 (Mt)	31.10 (0)	25.62 (000)	49.66 (Mt)	51.10 (xxx)	65.62 (xxx)	**1.41**	**2.78**	**3.71**
Untoasă Hardy/ *Cydonia oblonga*	34.87 (Mt)	25.64 (00)	18.30 (000)	44.87 (Mt)	45.64 (xx)	58.30 (xxx)	**1.91**	**3.77**	**5.03**
	JULY								
Untoasă Hardy/ *Pyrus sativa*	97.52 (Mt)	84.00 (0)	80.35 (00)	107.52 (Mt)	104.00	120.35 (x)	**1.96**	**3.87**	**5.16**
Untoasă Hardy/ *Cydonia oblonga*	80.13 (Mt)	74.68	64.50 (00)	90.13 (Mt)	94.68	104.50 (x)	**2.46**	**4.86**	**6.48**
	AUGUST								
Untoasă Hardy/ *Pyrus sativa*	115.55 (Mt)	112.65	107.50	125.55 (Mt)	132.65	147.50 (xxx)	**2.08**	**4.11**	**5.48**
Untoasă Hardy/ *Cydonia oblonga*	109.50 (Mt)	96.60 (00)	85.75 (000)	119.50 (Mt)	116.60	125.75	**2.33**	**4.60**	**6.14**
	SEPTEMBER								
Untoasă Hardy/ *Pyrus sativa*	143.10 (Mt)	132.85 (0)	128.20 (00)	153.10 (Mt)	152.85	168.20	**3.23**	**6.39**	**8.51**
Untoasă Hardy/ *Cydonia oblonga*	130.40 (Mt)	122.28	108.44 (00)	140.40 (Mt)	142.28	148.44	**2.68**	**5.30**	**7.06**

Irrespective of rootstock used, along with budding height increasing, it has been observed, a decreasing of scion's length with 10.14% in case of grafting on *Pyrus sativa* and a reduction with 16.8% when *Cydonia oblonga* was used as rootstock. This reduction seems to confirm the hypothesis according to which the limitation of the scion's growth depends mostly on the vigor of the used rootstocks (E.A. Mielke, L. Smith, 2002).

Trunk cross sectional area is a synthetic coefficient of the tree's vigor, which was calculate using tree's trunk diameter measured at 50 cm from above the soil level. A visible influence of the rootstock and grafting height has been observed. Trees grafted on invigorating rootstock recorded bigger values of the trunk cross sectional area than those which were grafting on devigorating rootstock (tab. 3).

Table 3

Trunk cross sectional area at pear fruit tree grafted at 10 cm, 20 cm and 40 cm

Scion / Rootstock		Trunk diameter (mm)	Trunk cross sectional area (mm^2)	Limit differences (mm)		
				DL 5%	DL1%	DL 0,1%
Untoasă hardy/ *Pyrus sativa*	V1 = 10 cm	**7.95** (Mt)	**4.96** (Mt)	0,85	1,68	2,24
	V2 = 20 cm	**8.43**	**5.58** (x)			
	V3 = 40 cm	**10.06** (x)	**7.94** (xxx)			
Untoasă Hardy/ *Cydonia oblonga*	V1 = 10 cm	**7.97** (Mt)	**4.99** (Mt)	1,41	2,79	3,72
	V2 = 20 cm	**7.38**	**4.28** (0)			
	V3 = 40 cm	**7.35**	**4.24** (0)			

Also it has been observed a general tendency of T.C.S.A. increasing when height of grafting was increased from 10 to 20 and 40 cm, when *Pyrus sativa* was

used as rootstock. Determinations made under this experience have shown a tendency to increase T.C.S.A. when *Pyrus sativa* was used as rootstock, but in case of grafting on *Cydonia oblonga* the general trend of T.C.S.A. is to decrease with increasing height of grafting. Similar results were obtained by other researchers concluded that although the first year after grafting T.S.C.A. showed an increasing trend, in the next years the values of this indicator decrease showing in this way the trees vigor reduction (E.A. Mielke and L. Smith, 2002).

The degree of trees branching grew at 20cm and 40 cm grafted variants comparing with control variant (grafted at 10 cm), and also it has been observed a reduction of the leaves number/tree, in a grater percent when quince was used as rootstock (tab. 4).

Table 4

Aspects concerning of fruit tree leaf area at pear fruit tree

Scion / Rootstock		Pitch number of features / tree	Pitch number of leaves /tree	Average area of one leaf (cm ^{2})	Fruit tree leaf area (cm ^{2})
Untoasă Hardy / *Pyrus sativa*	(V1)	1.07 (Mt)	123.00 (Mt)	15.16 (Mt)	1864.11 (Mt)
	(V2)	1.10	102.50	17.54 (xxx)	1798.06
	(V3)	1.75 (xxx)	96.00 (0)	17.05 (xx)	1637.18 (0)
DL 5%		0,48	1,18	0,28	
DL 1%		0,95	2,33	0,55	
DL 0,1%		1,26	3,11	0,74	
Untoasă Hardy /*Cydonia oblonga*	(V1)	0.10 (Mt)	177.60 (Mt)	16.35 (Mt)	2904.36 (Mt)
	(V2)	0.14	153.00 (0)	15.76	2411.86 (00)
	(V3)	0.16 (x)	134.20 (00)	17.61 (x)	2363.52 (00)
DL 5%		0,52	2,11	0,24	
DL 1%		1,02	4,17	0,47	
DL 0,1%		1,36	5,57	0,63	

In all studied variants height grafting leaded to a reduction of the trees leaf area in a bigger percent on quince grafted variants. Trees vigor reduction, especially in case of devigorating rootstock utilization, is explained by the majority of researchers by decreasing rootstock hydraulic conductivity, reason for which we proposed to verify if height budding is o not connected with a hydraulic deficit at the level of foliar apparatus by determining the leaves solids content.

At he higher budded variants, it has been determined an increasing of the dry matter content, higher values of this indicator being determined in case of grafting on *Cydonia oblonga* (tab.5).

During the period June – September dry mater content increased relatively uniform at all studied variants.

This case seems to confirm the theory of hydraulic conductivity limitation, according to which devigorating rootstocks determines a height dry matter accumulation comparing with invigoratind rootstocks utilization, fact also argued by the higher values of this indicator determined at the variants grafted on quince.

It is known the fact that devigorating rootstocks determine in scion's leaves a higher accumulation of soluble sugars. A possible reason of this accumulation may be the scion's deficiencies in transport of sugars from leaves to roots, which has a lower

intensity when trees are grafted on devigorating rootstocks (Kamboj, 1996). On the other hand the root system of devigorating rootstocks has a lower hydraulic conductivity comparing with those of invigorating rootstocks, the water supply is reduced and tree behaves as in water stress conditions. This situation has been found on trees grafted on *Cydonia oblonga* which recorded bigger values of sugar content, comparing with those recorded in case of grafting on *Pyrus sativa*.

Table.5

Leave's dry matter variation (%) at pear fruit tree species

Scion / Rootstock	Grafting height	2007-2009			
		June	July	August	September
Untoasă Hardy / *Pyrus sativa*	V1 = 10 cm	2,13 (Mt)	4,24 (Mt)	6,75 (Mt)	6,59 (Mt)
	V2 = 20 cm	3,34 (x)	5,52	9,26	8,52
	V3 = 40 cm	4,02 (xx)	6,1 (xx)	10,4 (xx)	9,51 (xx)
DL 5% (mg/g s.u.) DL 1% (mg/g s.u.) DL 0,1% (mg/g s.u.)		0,91 1,79 3,14	1,24 3,02 5,71	31,32 3,10 5,79	1,44 3,21 5,90
Untoasă Hardy / Cydonia oblonga	V1 = 10 cm	2,37 (Mt)	4,41 (Mt)	6,90 (Mt)	6,78 (Mt)
	V2 = 20 cm	3,55 (x)	5,68	9,40	8,91
	V3 = 40 cm	4,27 (xx)	7,42 (xx)	10,95 (x)	10,11 (x)
DL 5% (mg/g s.u.) DL 1% (mg/g s.u.) DL 0,1% (mg/g s.u.)		*0,93* *1,81* *3,17*	*1,25* *3,08* *5,76*	*31,34* *3,11* *5,73*	*1,42* *3,26* *5,92*

From the obtained results can be seen clear differences regarding grafting at 10 cm, 20 cm and 40 cm. Since June it was record increases in the amount of carbohydrates in leaves with budding height increasing from 56% (V2) to 88 % (V3,) in case of grafting on *Pyrus sativa* and from 50% (V2) to 80 % (V3) when *Cydonia oblonga* was used as rootstock. During the growing period these differences were more subdued (tab. 6).

Table 6

Sugar soluble content variation (mg/g s.u.) at pear fruit trees

Scion / Rootstock	Grafting height	2007-2009			
		June	July	August	September
Untoasă Hardy / *Pyrus sativa*	V1 = 10 cm	2,13 (Mt)	4,24 (Mt)	6,75 (Mt)	6,59 (Mt)
	V2 = 20 cm	3,34 (x)	5,52	9,26	8,52
	V3 = 40 cm	4,02 (xx)	6,1 (xx)	10,4 (xx)	9,51 (xx)
DL 5% (mg/g s.u.) DL 1% (mg/g s.u.) DL 0,1% (mg/g s.u.)		0,91 1,79 3,14	1,24 3,02 5,71	31,32 3,10 5,79	1,44 3,21 5,90
Untoasă Hardy / Cydonia oblonga	V1 = 10 cm	2,37 (Mt)	4,41 (Mt)	6,90 (Mt)	6,78 (Mt)
	V2 = 20 cm	3,55 (x)	5,68	9,40	8,91
	V3 = 40 cm	4,27 (xx)	7,42 (xx)	10,95 (x)	10,11 (x)
DL 5% (mg/g s.u.) DL 1% (mg/g s.u.) DL 0,1% (mg/g s.u.)		*0,93* *1,81* *3,17*	*1,25* *3,08* *5,76*	*31,34* *3,11* *5,73*	*1,42* *3,26* *5,92*

As a dynamic, during the vegetation period the variation of the sugar content was the same irrespective the rootstock and budding height. Sugar content

is increasing until August and then decrease, starting September, as a consequence of their translocation in organs of resistance (trunk and roots) and transformation in reserve substances. Remarkably is that reduction of sugar content in September is bigger at the 20 cm and 40 cm grafted trees, comparing with control variant. For example, if in case of grafting on *Cydonia oblonga* at 10 cm differences between sugar content determined in August and September were only 2%, in case of grafting at 20 cm differences were about 5.3% and when grafting height was increased at 40 cm differences were about 7.7%. These differences were higher when *Pyrus sativa* was used as rootstock. This dynamic of sugar content during the vegetation period can lead us to the hypothesis according to which at pear fruit tree increasing the height of grafting determine, in leaves, an increased synthesis of soluble sugars which is translocated in perennial organs as reserve substances.

CONCLUSIONS

1. Irrespective of budding height, once with height grafting increasing, it has been found a reduction of scions length in a bigger percent in case of grafting on *Cydonia obonga* comparing with case when grafting was made on *Pyrus sativa*, total trees length recording insignificant statistical variations.

2. Trunk cross sectional area increased with height of grafting when *Pyrus sativa* was used as rootstock, and decreased with height of grafting, when graft was made on *Cydonia oblonga*

3. Comparing with grafting at 10 cm in case of variants grafted at 20 and 40 cm, leaves average area was bigger, but number of leaves/tree decreased so average of leaf area at this variants

4. Average leaf area recorded increasing values once with grafting at a height level above the soil, but not sufficient to offset the low number of leaves/tree, so that, at the 20 cm and 40 cm grafting trees it has been determined a leaf area reduction comparing with grafting at 10 cm, in a bigger percent, in case of grafting on *Cydonia oblonga*

5. Irrespective of budding height, at 20 cm and 40 cm grafted trees a higher content of dry matter and soluble sugars has been recorded.

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