MORPHOLOGICAL AND BIOCHEMICAL ASPECTS OF ROOTSTOCK-SCION INTERACTION DUE TO INCREASING BUDDING HEIGHT

ASPECTE MORFOLOGICE ŞI BIOCHIMICE ALE INTERACŢIUNII ALTOI PORTALTOI LA MĂR ŞI PĂR IN CONDIŢIILE MODIFICĂRII ÎNĂLŢIMII DE ALTOIRE

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Abstract. *The influence of budding height (10, 20 and 40 cm) on bud survival and performance of maiden trees was investigated in experiments conducted at S.D.E. "V. Adamachi" between 2006-2008. Apple rootstocks MM.106, M9 and pear rootstocks Pirus sativa and Cydonia oblonga, were tested with cv. Florina and Untoasa hardy. Neither rootstock nor budding height affected bud take. Buds on MM.106 and Pirus sativa survived the winter better than M.9 and Cydonia oblonga. There were significant differences in scions length 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 comparing with those grafted at 10 cm especially when M9 and Cydonia oblonga were used as rootstock.*

Key words: rootstock, scion, budding height, sugars, dry matter

Rezumat. *Lucrarea de faţă urmăreşte influenţa înălţimii de altoire (10, 20 şi 40 cm) asupra rezistenţei mugurilor altoi peste iarnă şi a calităţii pomilor aflaţi în câmpul II al pepinierei în condiţiile S.D.E. V. Adamachi în perioada 2007-2008. Portaltoii de măr (MM106 şi M9) şi păr (Pirus sativa şi Cydonia oblonga) au fost altoiţi cu soiurile Florina şi respectiv Untoasă hardy. Indiferent de portaltoiul folosit, nu s-au constatat diferenţe semnificative ale înălţimii de altoire asura procentului de prindere, însă, s-a observat că pomii altoiţi pe MM06 şi Pirus sativa au rezistat mai bine peste iarnă comparativ cu cei altoiţi pe M9 şi Cydonia oblonga. În ceea ce priveşte lungimea lăstarilor altoi s-au constatat diferenţe pe parcursul perioadei de vegetaţie. Înălţimea de altoire a influenţat şi dinamica acumulării de substanţă uscată şi glucide în frunzele altoilor. Astfel, pomii altoiţi la 40 cm au avut un conţinut mai mare de glucide şi substanţă uscată comparativ cu cei altoiţi la 10 cm, mai ales când portaltoii utilizaţi au fost M9 şi gutui.*

Cuvinte cheie: portaltoi, altoire, înălţime de altoire, glucide, substanţă uscată

INTRODUCTION

Higher budding may be an effective way to reduce the vigour of trees and increase the productivity. Numerous trials show that increasing budding height increases vigour control and yield efficiency of apple trees in the orchard (Quamme et al., 1998; Webster, 1993). However, there are significantly less data that show the behavior of high budded rootstocks in the nursery.

After high budding, the scion bud may fail to grow in the nursery (Wertheim, 1998), despite the formation of a successful scion-rootstock graft union (Howard & Oakley, 1993).

The objective of our research was to study the effect of budding height of different apple and pear rootstocks on the quality parameters of planting material produced under S.D.E. "V. Adamachi" environmental conditions.

MATERIALS AND METHODS

The trial was performed at the S.D.E. "V. Adamachi" nursery between 2006-2008. Apple rootstocks MM.106, M.9 and pear rootstocks *Pirus sativa and Cydonia oblonga* were budded with apple cv. Florina (F/M9; F/MM106) and pear cv. Untoasa hardy (U.H/*P.s.*; U.H/*C.o*) 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. Rootstock diameter was 9-11 mm. The soil was deep fertile loam clay. Fertilization, mainly with nitrogen, was applied according to soil analysis. 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) were measured and dry matter 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 4hours fresh material at 105 ^{o}C and weighting at analytical balance. Soluble sugars content was determinate from leaves, by Schorll method and reported at fresh substance.

RESULTS AND DISCUSSIONS

Bud Healing

There was no significant effect of rootstock and budding height on bud healing in the autumn. There were also no interactions between rootstocks and budding height.

Bud Overwintering

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 MM.106 and *Pirus sativa* (up to 90%). The worse bud survival was recorded on M.9 and *Cydonia oblonga* (table 1).

Table 1

Bud overwintering at Apple and Pear Trees Grafted on Different Rootstocks at 10, 20 and 40 cm

Scion / rootstock	Budding height		
	10 cm	20 cm	40 cm
Florina / MM 106	97.58	92.70	91.80
Florina / M9	91.18	86.62	85.97
Untoasa Hardy / *Pirus sativa*	96.12	92.31	90.47
Untoasa Hardy / *Cydonia oblonga*	94.30	90.54	86.72

Increasing the budding height caused significant differences in the number of live buds. The genetic makeup of the rootstock's seemed to determine bud

survival. The cold sensitive M.9 rootstock and *Cydonia oblonga* which are sensitive to temperature fluctuations, had in average 14 % more winter damaged buds when budded at 40 cm than at 10 cm.

Growth

Differences in growth intensity appeared at the beginning of the growing season and depended on rootstock and budding height. A big influence of the rootstock on scion was observed on both species, grafting on less vigorous rootstock's (M9 and *Cydonia oblonga*) determinate an earlier bud opening.

Height budding had an important influence on the length of the scions both on apple and pear trees. The vigour of scions decreased with increasing budding height. Nevertheless it can be observed an increasing of total tree length as grafting height was increased (table 2)

Increasing budding height determine a decreasing of scions length with 20% when grafting was made on M9 and 14,7 % when MM106 was used as rootstock. At pear trees, high budding has determined a decreasing of scions length with 21.46 % when grafting was made on *Cydonia oblonga* and 13,45 % when *Pirus sativa* was used as rootstock.

These observations suggest that part of the vigour influence, at least with apple and pear, is associated with stem characteristics of the rootstock and is not entirely attributable to its root characteristics. This may involve differences in stem xylem or phloem anatomy and function, the production of inhibitors or the inactivation of promoters within this rootstock/ interstock stem piece.

Statistical significances of the shoots and tree length are noted in Table 2.

Dry matter content increased during vegetative period both apple and pear and it was influenced by rootstock and budding height (table 3)

Height of grafting had an important effect on dry matter accumulation in leaves of maiden trees. When M9 was grafted at 40 cm, dry matter percent (at the end of the growing season) was heigher with 21.4% than grafting at 10 cm. When grafting was made on MM 106, dry matter percent increased only with 18.3%. This fact can be explained by higher capacity of M9 rootstock to determine dry matter accumulation in leaves. At pear trees, dry matter percent increasing was 11.3% when grafting was made on *Pirus sativa* and 28,1 % when *Cydonia oblonga* was used as rootstock. It seems that increasing budding height determinate some modifications on scion level, leading to a bigger dry matter accumulation in leaves of the apple and pear trees.

Many researchers state that the amount and variety of carbohydrates found in plants differ in various plants organs and conditions (Smeekens, 1998; Gibson 2000). In our trails sugars content increased all throughout the growing season. In drought conditions sugars accumulations is intensive as a result of macromolecular compounds biodegradation and their transformation in compounds with smaller molecular weight (soluble sugars, aminoacids etc.) (Lasko, 1985). This can be the reason why in 2007 sugars content was higher.

Table 2

Average length of the scions and total tree length at apple and pear trees on the growing season

Scion / rootstock	2007						2008					
	Scion lenght (cm)			Tree total lenght (cm)			Scion lenght (cm)			Tree total lenght (cm)		
JUNE												
	V1	**V2**	**V3**	**V1**	**V2**	**V3**	**V1**	**V2**	**V3**	**V1**	**V2**	**V3**
F/ MM106	19.64 (Mt)	15.87 (000)	14.18 (000)	29.64 (Mt)	35.87 (***)	54.18 (***)	23.12 (Mt)	18.45 (000)	16.25 (000)	33.12 (Mt)	35.42 (***)	51.3 (***)
F/ M9	19.21 (Mt)	13.21 (000)	11.89 (000)	29.21 (Mt)	33.21 (***)	51.89 (***)	22.66 (Mt)	15.42 (000)	11.3 (000)	32.66 (Mt)	38.45 (**)	56.25 (***)
U. H./ *P.s*	19.3 (Mt)	15.38 (000)	10.15 (000)	29.30 (Mt)	35.38 (***)	50.15 (***)	22.77 (Mt)	19.64 (000)	15.67 (000)	32.77 (Mt)	39.64	55.67 (***)
U. H./ *C. O.*	18.04 (Mt)	12.01 (000)	9.39 (000)	28.04 (Mt)	32.01(***)	49.39 (***)	22.47 (Mt)	15.33 (000)	10.53 (000)	32.47 (Mt)	35.33 (***)	50.53 (***)
JULY												
	V1	**V2**	**V3**	**V1**	**V2**	**V3**	**V1**	**V2**	**V3**	**V1**	**V2**	**V3**
F/ MM106	45.98 (Mt)	41.7 (000)	36.55 (000)	55.98 (Mt)	61.7 (**)	76.55 (***)	52.94 (Mt)	48.66 (000)	37.24 (000)	62.94 (Mt)	68.66 (**)	75.84 (***)
F/ M9	42.11 (Mt)	36.12 (00)	31.33 (000)	52.11 (Mt)	56.12 (*)	71.33 (***)	48.42 (Mt)	42.13 (000)	35.84 (000)	58.42 (Mt)	62.13 (**)	77.24 (***)
U. H./ *P.s*	35.5 (Mt)	26.17(000)	22.05 (000)	45.50 (Mt)	46.17	62.05 (***)	42.33 (Mt)	30.53 (000)	25.25 (000)	52.33 (Mt)	50.53 (000	65.25
U. H./ *C. O.*	35.15 (Mt)	22.74	20.74	45.15 (Mt)	42.74	60.74 (***)	41.92 (Mt)	26.5 (000)	23.7 (000)	51.92 (Mt)	46.5 (00)	63.7
AUGUST												
	V1	**V2**	**V3**	**V1**	**V2**	**V3**	**V1**	**V2**	**V3**	**V1**	**V2**	**V3**
F/ MM106	69.96 (Mt)	64.36 (0)	63.01(0)	79.96 (Mt)	84.36	103.01(***)	82.39 (Mt)	76.34 (00)	71.66 (000)	92.39 (Mt)	96.34 (*)	111.66 (***)
F/ M9	68.9 (Mt)	64.86	59.25 (00)	78.90 (Mt)	84.86 (*)	99.25 (***)	78.33 (Mt)	72.05 (000)	69.74 (000)	88.33 (Mt)	92.05 (**)	109.74(***)
U. H./ *P.s*	73.87 (Mt)	66.72 (000)	51.21 (000)	83.87 (Mt)	86.72	91.21 (**)	75.42 (Mt)	68.10 (000)	59.25 (000)	85.42 (Mt)	88.10	99.25 (***)
U. H./ *C. O.*	71.83 (Mt)	65.64 (000)	49.01 (000)	81.83 (Mt)	85.64 (***)	89.01 (***)	74.75 (Mt)	65.94 (000)	57.83 (000)	84.75 (Mt)	85.94 (000)	97.83 (*)
SEPTEMBRE												
	V1	**V2**	**V3**	**V1**	**V2**	**V3**	**V1**	**V2**	**V3**	**V1**	**V2**	**V3**
F/ MM106	83.25 (Mt)	76.08 (000)	71.02 (000)	93.25 (Mt)	96.08 (**)	111.02(***)	98.32 (Mt)	89.52 (000)	80.71 (000)	108.32 (Mt)	109.52	120.71(***)
F/ M9	83.47 (Mt)	72.34 (00)	66.64 (000)	93.47 (Mt)	92.34	106.64(**)	94.65 (Mt)	82.21 (000)	72.48 (000)	104.65 (Mt)	102.21(0)	112.48 (***)
U. H./ *P.s*	91.29 (Mt)	85.28 (000)	70.98 (000)	101.29 (Mt)	105.28 (**)	110.98(***)	107.1 (Mt)	98.4	86.28 (00)	117.1 (Mt)	118.4	126.28
U. H./ *C. O.*	80.56 (Mt)	77.668	63.42 (000)	90.56 (Mt)	97.66 (***)	103.42(***)	95.05 (Mt)	88.25 (00)	69.17 (000)	105.05 (Mt)	108.25	109.17
OCTOBRE												
	V1	**V2**	**V3**	**V1**	**V2**	**V3**	**V1**	**V2**	**V3**	**V1**	**V2**	**V3**
F/ MM106	95.32 (Mt)	87.11(000)	81.32 (000)	105.32 (Mt)	107.11(*)	121.32(***)	115.62 (Mt)	105.28 (0)	94.91 (000)	125.62 (Mt)	125.28	134.91(*)
F/ M9	95.57 (Mt)	82.83 (000)	76.30 (000)	105.57 (Mt)	102.83	116.30(***)	111.31 (Mt)	96.68 (00)	85.24 (000)	121.31 (Mt)	116.68	125.24(*)
U. H./ *P.s*	111.00 (Mt)	95.61(0)	82.54 (000)	121.00 (Mt)	115.61(*)	122.54(***)	116.00 (Mt)	105.88	92.84 (000)	126.00 (Mt)	125.88	132.84(*)
U. H./ *C. O.*	96.41 (Mt)	88.93 (000)	72.62 (000)	106.41(Mt)	108.93	112.62(*)	111.45 (Mt)	94.96 (0)	77.34 (000)	121.45 (Mt)	114.96	117.34(*)

Table 3

Dry matter content (%) during the growing season at apple and pear trees drafted on different rootstock at 10 cm (V1), 20 cm (V2), and 40 cm (V3)

Scion / rootstock	2007				2008			
	June	July	Aug	Sept.	June	July	Aug.	Sept.
Florina / MM106 (V1)	22,47	26,13	27,61	38,05	24,20	27,58	27,35	34,21
Florina / MM106 (V2)	26,72	31,07	33,33	37,39	28,77	32,80	33,01	33,61
Florina / MM106 (V3)	29,53	34,34	38,83	42,92	30,80	34,25	38,46	41,88
Florina / M9 (V1)	25,01	27,08	31,26	35,79	23,92	26,69	29,94	33,47
Florina / M9 (V2)	30,95	32,99	38,93	41,79	28,32	30,09	34,14	40,87
Florina / M9 (V3)	31,96	35,86	39,38	45,70	30,41	33,23	37,98	42,58
Untoasa Hardy / *Pirus sativa*. (V1)	21,98	25,56	32,95	36,05	23,67	26,98	30,68	34,72
Untoasa Hardy / *Pirus sativa*. (V2)	28,97	33,68	35,23	40,03	27,19	31,55	34,90	38,89
Untoasa Hardy/ *Pirus sativa* (V3)	28,56	33,21	39,19	42,70	30,75	35,05	38,82	41,78
Untoasa Hardy/ *Cydonia oblonga* (V1)	25,98	30,21	29,54	33,47	24,97	28,89	29,26	30,09
Untoasa Hardy/ *Cydonia oblonga* (V2)	26,98	31,37	31,04	37,96	26,04	33,11	30,75	34,13
Untoasa Hardy/ *Cydonia oblonga* (V3)	28,14	34,53	38,65	45,55	27,68	32,67	35,34	41,25

Table 4

Sugars content (mg/g f. m.) during the growing season at apple and pear trees drafted on different rootstock at 10 cm (V1), 20 cm (V2), and 40 cm (V3)

Scion / rootstock	2007				2008			
	June	July	Aug	Sept.	June	July	Aug.	Sept.
Florina / MM106 (V1)	10,52	14,34	20,15	23,40	9,39	12,75	17,82	20,62
Florina / MM106 (V2)	17,74	18,00	21,25	24,04	15,84	16,01	18,80	21,18
Florina / MM106 (V3)	19,32	20,13	21,40	24,35	17,25	17,90	18,93	21,45
Florina / M9 (V1)	10,75	14,96	22,94	23,84	9,60	13,30	20,29	21,00
Florina / M9 (V2)	16,36	19,58	25,99	25,80	14,61	17,41	22,99	22,73
Florina / M9 (V3)	19,03	20,81	26,40	27,43	16,99	18,51	23,35	24,17
Untoasa Hardy / *Pirus sativa*. (V1)	10,91	14,44	20,12	23,68	9,74	12,84	17,80	20,86
Untoasa Hardy / *Pirus sativa*. (V2)	17,90	19,55	21,42	25,48	15,98	17,39	18,95	22,45
Untoasa Hardy / *Pirus sativa* (V3)	18,66	21,30	23,08	25,76	16,66	18,94	20,42	22,70
Untoasa Hardy / *Cydonia oblonga* (V1	10,93	13,12	19,26	23,12	9,76	11,67	17,04	20,37
Untoasa Hardy / *Cydonia oblonga* (V2	15,58	17,46	22,03	23,99	13,91	15,53	19,49	21,14
Untoasa Hardy / *Cydonia oblonga* (V3	18,12	19,31	23,64	25,64	16,18	17,17	20,91	22,59

Rootstock had a big influence on sugar accumulation. Irrespective of budding height more sugars were found in leaves of the maiden trees grafted on

M9 and *Cydonia oblonga* than MM 106 and *Pirus sativa*. Increasing grafting height lead to a bigger accumulation of sugars, both apple and pear trees (table 4).

It was a direct correlation between budding height and sugar content as well as between budding height and rootstock. Therefore trees budded at 40 cm on M9 had a better accumulation of sugars than trees grafted on MM106 at the same height. The same tendency was observed at pear trees too. When grafting was made at 40 cm on *Cydonia oblonga*, sugar content grew with 9.8% but when *Pirus sativa* was used as rootstock, sugar content was only with 8% higher.

CONCLUSIONS

1. Budding height influenced bud overwintering and decreased scions vigour mainly when M9 and *Cydonia oblonga* were used as rootstocks. Nevertheless it can be observed an increasing of total tree length as grafting height was increased.

2. Both rootstock and budding height influenced sugars and dry matter accumulation in leaves of the maiden trees. It seems that budding height determined increasing of rootstock effect on the scion, especially when week vigour rootstock (as M9 and *Cydonia oblonga*) are used.

REFERENCES

1. **Howard B.H., Oakley, W., 1993 -** *The effect of rootstock shoots growth on the level of bud-grafting success in apple.* J. Hort. Sc. 68(6): 891-897.
2. **Kviklys D., Lanauskas J., 2007** - *Effect of Budding Height and Rootstocks on the Quality of Apple Planting Material*. Acta Hort. 732
3. **Lakso A.N**., **1985 -** *The effects of water stress on physiological processes in fruit crop*s. Acta Hort. (ISHS) 171:275-290