VARIATION OF STRUCTURE AND XYLEM CONDUIT DIMENSIONS IN RELATION WITH INCOMPATIBILITY AT GRAFTED FRUIT TREES

VARIAȚII ALE STRUCTURII ŞI DIMENSIUNILOR VASELOR CONDUCĂTOARE XILEMICE ÎN RELAȚIE CU INCOMPATIBILITATEA LA POMII ALTOIȚI

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Abstract. *To assess hydraulic architecture and limitations to water transport across scion – rootstock combinations we compared xylem anatomy and calculated relative surface area of stem in different zones toward grafting point. The grafting success percentage and variations in growth were also determined. The grafted combinations were: pears cultivars (Curé, Triumph, Trivale, Comptesse de Paris and Williams) grafted on Cydonia oblonga and plums cultivars (Stanley, Tuleu gras, Centenar, Pescarus and Record) grafted on Prunus cerasifera. The study showed a correlation between compatibility degree and differences of xylem architecture of scion and rootstock.*

Key words: rootstock, scion, graft incompatibility, xylem vessel

Rezumat. *Pentru definirea structurii anatomice a vaselor conducătoare şi influența acesteia asupra circulației sevei la unele combinații altoi portaltoi, s-au comparat dimensiunile şi aria vaselor xilemului in diferite zone ale tulpinii față de punctul de altoire. Datele obținute au fost corelate cu aspectele anatomo-morfologice ale incompatibilității apărute la combinațiile studiate. Au fost luate în studiu speciile păr (soiurile Curé, Triumph, Trivale, Comptesse de Paris şi Williams) şi prun (soiurile Stanley, Tuleu gras, Centenar, Pescarus si Record) altoite pe gutui şi respectiv corcoduş. Rezultatele au pus în evidență existența unor corelații între gradul de compatibilitate la altoire şi diferențele dintre dimensiunile vaselor xilemice ale partenerilor.*

Cuvinte cheie: portaltoi, altoi, incompatibilitate la altoire, vase xilemice

INTRODUCTION

Fruit trees are usually formed by a combination of scion and rootstock. For that combination to be successful, a good union between a scion and rootstock is necessary (Errea et al., 2001 and Feucht, 1988). Graft-incompatibility is a widespread problem in fruit-tree production, grafted partners often belong to the same species or genus but the use of genetically divergent genotypes is also common.

Quince is a common rootstock for pear (*Pyrus communis* L.) because of size control, which makes high density orchards possible. However, quince is grafted incompatible with some of the major pear cultivars such as Bartlett (Tukey, 1978; Hartmann et al., 1997). Pear grafted to quince shows varying degrees of incompatibility depending on both scion and rootstock. This mechanism is not well known and few assumptions have been put forth to explain it (Gur et al., 1968; Yeoman & Brown, 1976; Musacchi et al., 1997). The earliest methods used to detect graft incompatibility relied on external symptoms such as graft union malformations, yellowing of foliage, decline in vegetative growth and vigor and marked differences in growth rate of scion and rootstock (Hartmann et al., 1997), or anatomical abnormalities after grafting. This requires waiting until the symptoms are visible, which may take years. Additionally, early anatomical observations may not always correlate with long-term graft survival (Andrews and Marguez, 1993). Incompatible graft unions are reported to have reduced hydraulic conductivity in the graft union. This impairment might explain the effect of some of the most widely used dwarfing rootstocks, such as Quince C in pear. The mechanism, in which incompatibility is expressed, is not clear and several hypotheses have been advanced in attempt to explain incompatibility. The majority of hypothesis referred to an early stage of development has been related to herbaceous systems. However, few studies have been made on early establishment in woody plants, where in many cases incompatibility is manifested by the breaking of the trees at the point of the union particularly when they have been growing for some years (apricot on Prunus grafts, pear on quince grafts). Early anatomical studies led to the hypothesis of rootstocks influencing tree water relations (Beakbane and Thompson, 1939; Beakbane, 1956). Since then, several other studies relating plant anatomy to growth have been conducted (e.g. Simons, 1986; Ussahatanonta and Simons, 1988; Soumelidou et al., 1994), reporting the presence of smaller and/or fewer vessels in the roots and/or graft tissue of plants grafted on low vigor rootstocks, and suggesting lower hydraulic conductivities of these plant regions.

This review provides a summary of the new advances in studies on the mechanism of graft compatibility focused on the early responses of grafting and how these studies can be correlated with the changes observed in some *Prunus* combinations at early stages.

MATERIAL AND METHODS

The experiment was carried out in the experimental field of „Ion Ionescu de la Brad" Agricultural Sciences and Veterinary Medicine University from Iasi from „V. Adamachi" S.D.E.

The used biological material was represented by varieties of the sort *Pyrus* (Triumph, Trivale, Williams and Paris Countess) incompatible with *Cydonia oblonga* and varieties of the sort *Prunus* (Pescarus, Centenar, Record, Tuleu Gras) incompatible with *Prunus cerasifera*. The studies were carried out on grafted trees in the third vegetation year. The varieties of the pear tree Curé and the plum tree Stanley were used as witnesses due to the fact that the first one held a good affinity with the quince tree and the second one was compatible with *Prunus cerasifera*.

In order to make the anatomical-morphological observations, the sections were cut with SLEE MAINZ CUT 6062 semiautomatic section cutter and the coloring was made with methylene blue and ruthenium red. The observations were made with the help of MOTIC B SERIES optical microscope using the 10x and 4x lenses.

The cross sections were used to determine the radial and tangential diameter of the vessels. The diameter of the vessels was measured directly in the microscope with MOTIC image plus 2.0

RESULTS AND DISCUSSIONS

Morphological sections made it in three different stem zones and presented in figure no. was relived sundries grafting zone structural abnormalities for varieties with a low affinity capability. We can observe wood desultory, undifferentiated parenchyma layers between scion and rootstock and in some cases parenchyma with suber and necrosis. At compatible combinations Curé/ *Cydonia oblonga* and Stanley/*Prunus cerasifera* the grafting zone has a satisfactory development, with wood tissue completely developed, but with deviations from radial structure of xylem vessel due to the engrafting process.

It was made measurements of xylem vessel in 3 stem parts and the results are presented in table 1, were could observe a significant differences of vessel diameter between pear and plum.

Table 1

Xylem vessels size at different plums and pears cultivars and stem zones (µm)

Variety	Diameter (µm)			Area (µm)		
	Scion	Rootstock	Engrafting point	Scion	Rootstock	Engrafting point
Curé	7,04	7,43	7,99	38,95	43,34	50,05
Contesse de Paris	8,70	6,33	6,89	59,35	31,45	37,21
Triumph	5,38	7,41	6,61	22,72	43,1	34,3
Trivale	8,03	6,05	6,72	50,62	28,73	35,40
Willams	8,21	7,11	7,68	52,85	39,67	46,30
Stanley	10,54	6,23	8,59	87,21	30,40	57,92
Record	9,81	6,34	9,89	75,55	31,41	76,78
Pescarus	9,64	6,14	10,18	72,94	29,59	81,35
Centenar	11,21	6,82	9,72	98,64	36,51	74,16
Tuleu gras	10,48	6,71	9,47	86,21	35,34	70,39

The highest diameter between pear varieties was recorded at Comtese de Paris 8.7 µm while for plum varieties the vessel diameter was more then 9.81 µm. The rootstock vessel diameter was smaller then scion, but with comparable values for both species (6.05 – 7.43 µm at pear and 6.14 – 6.82 µm at plum). The only exception is represented by the Triumf variety which has the xylem vessel smaller in scion then engrafting point and rootstock.

Making a comparison between xylem vessel from rootstocks and scions at pears with different compatibility grades we can see at Curé variety, compatible with quince, the difference between vessel diameter in all three stem parts are very small (0.39). The other varieties witch present grafting incompatibility recorded differences are greater (1.1 – 2.37). At plum varieties that rule is unrepeated: Stanley, compatible with *Prunus cerasifera*, has a difference between scions and rootstocks vessel diameter by 4.31, and for incompatible varieties difference is varied between 3.47 and 4.39. By the way, we observe higher values of xylem vessel in the engrafting points for all incompatible varieties at plum.

For understanding differences between xylem vessel at scions, rootstock level and their role in incompatibility phenomenon settlement it was made correlation coefficient between partners vessel dimensions and the results obtained is presented in table 2.

Table 2

Correlation coefficient between xylem vessel size in different stem zones at some compatibility degree combinations

Variety	Scion / Rootstock	Scion / engrafting point	Rootstock / engrafting point
Curé	0,2092	0,3599	0,3298
Contesse de Paris	-0,101	-0,1903	0,155
Triumph	0,4060	-0,0245	-0,1168
Trivale	0,0771	-0,2978	-0,3803
Willams	-0,2723	0,5291	0,1943
Stanley	-0,0688	0,5313	-0,2966
Record	0,0399	0,3447	0,1775
Pescarus	-0,0257	0,2781	0,1135
Centenar	0,0014	0,1274	0,1142
Tuleu gras	0,0781	0,2948	0,2124

The most studies regarding on morpho-anatomical manifestation of incompatibility phenomenon is looking for interweave and modification model at engrafting point level. Some authors (Matula, Richs, Hafechost, citated by M. Coutanceau, 1072) is considering the most anomaly of engrafting points structure are caused by disparity between conductivity vessel of the partners. As a result, some cambial involutions or phloem discontinuities (islands rounded by sponge death cells) could be observed. V. Kaimakan was considering the rootstock influence determines visible modifications at conductivity vessel level, especially of sieve tubes, medullar razes cells and parenchyma cells from wood and bark. For example at incompatible pear varieties with quince, xylem vessel has small dimensions and xylem and phloem vessel number from springs is higher in comparison with varieties engrafted on generative pear. The author explains that phenomenon as a result of metabolic disparity between scion and rootstock witch has an inhibitor influence on scion behavior. Our results it appears to confirm that hypothesis because we observe a significant difference between conductivity vessel of scion and rootstock at incompatible combinations in comparison with compatible once. In the other part, in plums cases it is not obtained the same rule, higher differences between conductivity vessel of scion and rootstock, at Stanley variety engrafted on *Prunus cerasifera*, could be a positive result in fully functional tissues obtaining.

In the other way's specific rootstocks can significantly influence the vegetative growth of fruit trees (Rogers and Beakbane, 1957; Lockard and Schneider, 1981; Webster, 1995). Evidence indicates that rootstocks can have an effect on tree vegetative growth by influencing the hormonal balance (Kamboj et al., 1999), mineral nutrition (Jones, 1971), and/or water relations (Olien and Lakso, 1986). It has been argued that the differences in rootstock effects on one or more of these processes account for the observed differences in vegetative growth of trees. Although there have been some improvements in understanding of rootstock effects on tree growth, there is no widely accepted explanation of the underlying physiological mechanism behind this phenomenon (Webster, 2004). Recent research conducted on peach trees with rootstocks that impart different tree growth potentials has shown significant differences in stem water potential (Basile et al., 2003) associated with rootstock-induced differences in growth potential. There was a direct positive relationship between stem water potential and shoot growth among peach trees on different rootstocks (Solari et al., 2006b). Similar results have been reported for apple rootstocks (Olien and Lakso, 1986; Cohen and Naor, 2002) but the differences in hydraulic conductance have been attributed to the graft unions rather than the rootstocks themselves (Atkinson et al., 2003). It appears therefore that the dwarfing effect of specific peach rootstocks on tree growth may be related to hydraulic limitation of the rootstocks involved.

In our experiments at pear varieties engrafted on Quince it will observe morpho-anatomical abnormalities at union point more evident then plum varieties engrafted on *Prunus cerasifera*. Those abnormalities could generate scion hydric limitations having as effect conductivity vessel dimension reduced. An increased hydraulic potential generate by a well conductivity system at plums has an effect in optimal development of scion.

CONCLUSIONS

1. A significant difference between conductivity vessel of scion and rootstock at incompatible combinations in comparison with compatible once has been observed.

2. In plums cases the higher differences between conductivity vessel of scion and rootstock, at Stanley variety engrafted on *Prunus cerasifera*, could be a positive result in fully functional tissues obtaining.

3. At pear varieties engrafted on *Cydonia oblonga* we observed morpho-anatomical abnormalities at union point more evident then plum varieties engrafted on *Prunus cerasifera*. Those abnormalities could generate scion hydric limitations having as effect conductivity vessel dimension reduced.

4. A reduced dimension of xylem vessel size represents a symptom but not a cause of incompatibility phenomenon.

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REFERENCES

1. Basile B., Marsal J., DeJong T.M., 2003 - *Daily shoot extension growth of peach trees growing on rootstocks that reduce scion growth is related to daily dynamics of stem water potential.* Tree Physiol. 23, 695–704.

2. Beakbane A.B, Thompson E.C., 1947 - *Anatomical studies of stem and roots of hardy fruit trees. IV. The root structure of some new clonal apple rootstocks budded with Cox's Orange Pippin*. Journal of Pomology and Horticultural Science 23, 203±226.

3. Beakbane A.B, 1956 - *Possible mechanism of rootstock effect*. Annals of Applied Biology 44, 517±521.

4. Cohen S., Naor A., 2002 - *The effect of three rootstocks on water use, canopy conductance and hydraulic parameters of apple trees and predicting canopy from hydraulic conductance*. Plant Cell Environ. 25, 17–28.

5. **Errea et al.**, **P. Errea, L. Garay and J.A. Marín**, 2001 - *Early detection of graft incompatibility in apricot (Prunus armeniaca) using in vitro techniques*, Physiol. Plant 112 (2001), pp. 135–141.

6. Feucht, 1988 W. Feucht, 1988 - *Graft incompatibility of tree crops: an overview of the present scientific status,* Acta Horticulturae 227, pp. 33–41

7. Hartmann T.H., Kester E.D., Davies T.F., **Geneve L.R.** 1997. *Plant Propagation: Principles and Practices*. Prentice Hall, New Jersey. 770 p.

8. Hoover E.E., Hemstad P., Larson D., MacKenzie J., Zambreno K., Propsom F., **2004** - *Rootstock influence on scion vigor, hardiness, yield and fruit composition of st. pepin grape*. Acta Hort. (ISHS) 640:201-206