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Differences observed in the graft compatibility between some cultivars of Muscadine grape (Vitis rotundifolia Michx.) and European grape (Vitis vinifera L. cv. Cabernet Sauvignon)

by

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Différences observées dans la compatibilité au greffage de quelques variétés de Muscadine (Vitis rotundifolia Michx.) avec Vitis vinifera L. cv. Cabernet Sauvignon

Résumé. — L'incompatibilité au greffage reconnue depuis longtemps entre la Muscadine (*Vitis rotundifolia* Michx.) et la vigne européenne (*V. vinifera* L.) est facilement surmontable par la méthode de la greffe en vert. Mais les résultats varient en fonction de la variété de Muscadine utilisée. Des symptômes typiques d'incompatibilité se manifestent tardivement lorsque *V. vinifera* cv. Cabernet Sauvignon est greffé sur les variétés de Muscadine Carlos ou Male.

A l'opposé, les variétés Yuga et Noble ne manifestent aucun symptôme. Ces observations permettent d'écarter l'hypothèse selon laquelle l'incompatibilité au greffage entre *V. rotundifolia* et *V. vinifera* serait due aux différences anatomiques et structurales qui existent entre ces deux espèces. L'examen macroscopique et microscopique du point de greffe laisse penser que les symptômes observés peuvent être rattachés à une incompatibilité «de translocation». L'hypothèse d'un facteur viral responsable des différences observées d'incompatibilité au greffage est actuellement en cours de vérification.

Introduction

The Muscadine grape (*Vitis rotundifolia* Michx.), though highly resistant to phylloxera, has been a failure as a rootstock, when introduced into France at the end of the nineteenth century. This has been due to its poor rooting ability and lack of adaptation to climatic conditions together with the fact, that *V. rotundifolia* has been shown to be graft-incompatible with other species of the genus *Vitis*, especially with *V. vinifera* L.

In a previous investigation (Bouquet and Hevin 1978), we have pointed out, that it might be important to investigate the causes of this graft incompatibility. We could observe that the green grafting method was very effective to associate *V. rotundifolia* used as stock and *V. rupestris* used as scion. The present paper shows that this method is also effective to graft *V. rotundifolia* and *V. vinifera*, but the results depend greatly on the genotypes of the Muscadine grapes used.

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Material and methods

Three old and two recent commercial cultivars of Muscadine grape are used as rootstocks in this experiment: Yuga, a bronze female variety, Male n° 1, a male variety (pollinator), Male n° 2, a male variety (pollinator), Carlos, a bronze hermaphroditic variety, and Noble, a black hermaphroditic variety.

All the plants, obtained from green cuttings, were one-year-old and grown under greenhouse conditions in containers irrigated with nutrient solution. The variety used as scion is *V. vinifera* cv. Cabernet Sauvignon.

Details on the green grafting method are given by BOUQUET and HEVIN (1978). Grafting operations were performed in April 1978.

Anatomical examination of the graft unions was made on transverse sections obtained with a sliding microtome after softening the lignified tissues in glycerol : alcohol : water (1:1:1). Ruthenium red and methylene blue were used as stains after bleaching the sections.

Results and discussion

Results of the grafting experiment are given in the table. Grafts were classified "successful" when the scions were growing 5 months after grafting and when the graft unions were normally lignified.

Differences in the graft compatibility between five cultivars of Muscadine grape and *V. vinifera* cv. Cabernet Sauvignon (green grafting method)

Différences de compatibilité au-greffage de cinq variétés de Muscadine avec *V. vinifera* cv. Cabernet Sauvignon (méthode de la greffe en vert)

Graft partners	Number of plants grafted	Number of successful grafts	Mortality 1978	Mortality 1979	Still alive 11/1979
Incompatible combinations:					
CS/Male n° 1	5	3	—	1	2 (very weak)
CS/Male n° 2	15	9	7	—	2 (weak)
CS/Carlos	15	14	1	12	1 (very weak)
Compatible combinations:					
CS/Yuga	15	15	—	—	15
CS/Noble	15	15	—	—	15

Mortality was observed in 1978 and 1979 on the combinations CS (Cabernet Sauvignon)/Male n° 1, CS/Male n° 2 and CS/Carlos. Progressive reddening of the leaves in late summer was followed by sudden withering of the scions or lack of bud breaking during the next spring. The rootstocks did not bud after the death of the scions. The growth of the surviving plants was very weak. These combinations were classified „incompatible".

So far, no symptom of incompatibility was observed on the combinations CS/YUGA and CS/NOBLE. Vigorous growth was induced in 1978 by culture under green-

house and abundant fructification was obtained in 1979. These combinations were classified "temporarily compatible", because the possibility of delayed incompatibility after several years of growth cannot yet be excluded.

Causes of graft incompatibility between Muscadine grapes and bunch grapes are classically ascribed to the great structural dissimilarities observed in the two sections of the genus *Vitis:* Different densities of the wood ($D_{Euvitis} < 1 < D_{Muscadinia}$) are closely correlated with differences in cell wall thickness in the xylem, but also with differences in the proportion of various cell types present. Cork cambium (phellogen) is superficial and subepidermal in Muscadine grapes, but it is deep-seated in the outer layers of phloem in bunch grapes. Bands of phloem fibers and sieve tubes are disposed radially in transverse sections of stems in Muscadine, but tangentially in bunch grapes.

In fact, our results rule out this hypothesis, because the differences observed in the graft compatibility of some varieties of *V. rotundifolia* with *V. vinifera* cv. Cabernet Sauvignon, are not correlated with structural variations between these varieties of Muscadine grape. On the contrary, the anatomical structure seems to be very unvarying in the section Muscadinia.

Graft unions in incompatible combinations do not show any mechanical weakness, but evident overgrowth of the scion was noticed, with appearance of some neoformed roots above graft union. Macroscopical examination of radial longitudinal sections of graft unions in incompatible combinations does not reveal any apparent vascular discontinuity between stock and scion. There is no trace of "black line" which is a typical symptom of many interspecific graft incompatibilities in fruit trees.

Microscopical examination of transverse sections of graft unions shows that vascular connections between stock and scion are not complete in the incompatible combinations unlike compatible combinations. Only 37.5 % of the incompatible graft unions examined show four cambial contacts established after the voids between stock and scion have been filled by a wound callus tissue. All the compatible graft unions examined show four cambial contacts (Fig. 1). 62.5 % of the incompatible graft unions show a maximum of three cambial contacts. When the contact is missing, vascular connection is interrupted by the presence of a layer of unlignified parenchymatous tissue (Fig. 2).

Moreover, when the cambial contacts are established, we can observe in some incompatible graft unions a very striking change in the orientation of secondary xylem and phloem cells produced by the derivatives of the neoformed cambial initials: Tracheids, vessels, sieve tubes and fibers are often quasi-horizontal, instead of following the vertical direction (Figs. 3 and 4). In fact, a slight displacement of the tissues can occur when the cambiums of the graft partners are not sufficiently close together at the time of grafting. This can be observed in transections of compatible graft unions. But the degree of distortion observed in the tissues of incompatible graft unions lets us think this is likely due to disturbances in the associated activity of the cambiums of stock and scion during establishment of vascular continuity and related to the symptoms of incompatibility.

The reddening of the leaves observed on incompatible combinations can be related to accumulation of starch above graft union. But iodine tests made on these associations after their withering and death show the presence of unnegligible quantities of starch in the stock and roots. Hence, the translocation of photosynthates is not completely interrupted at the graft union.

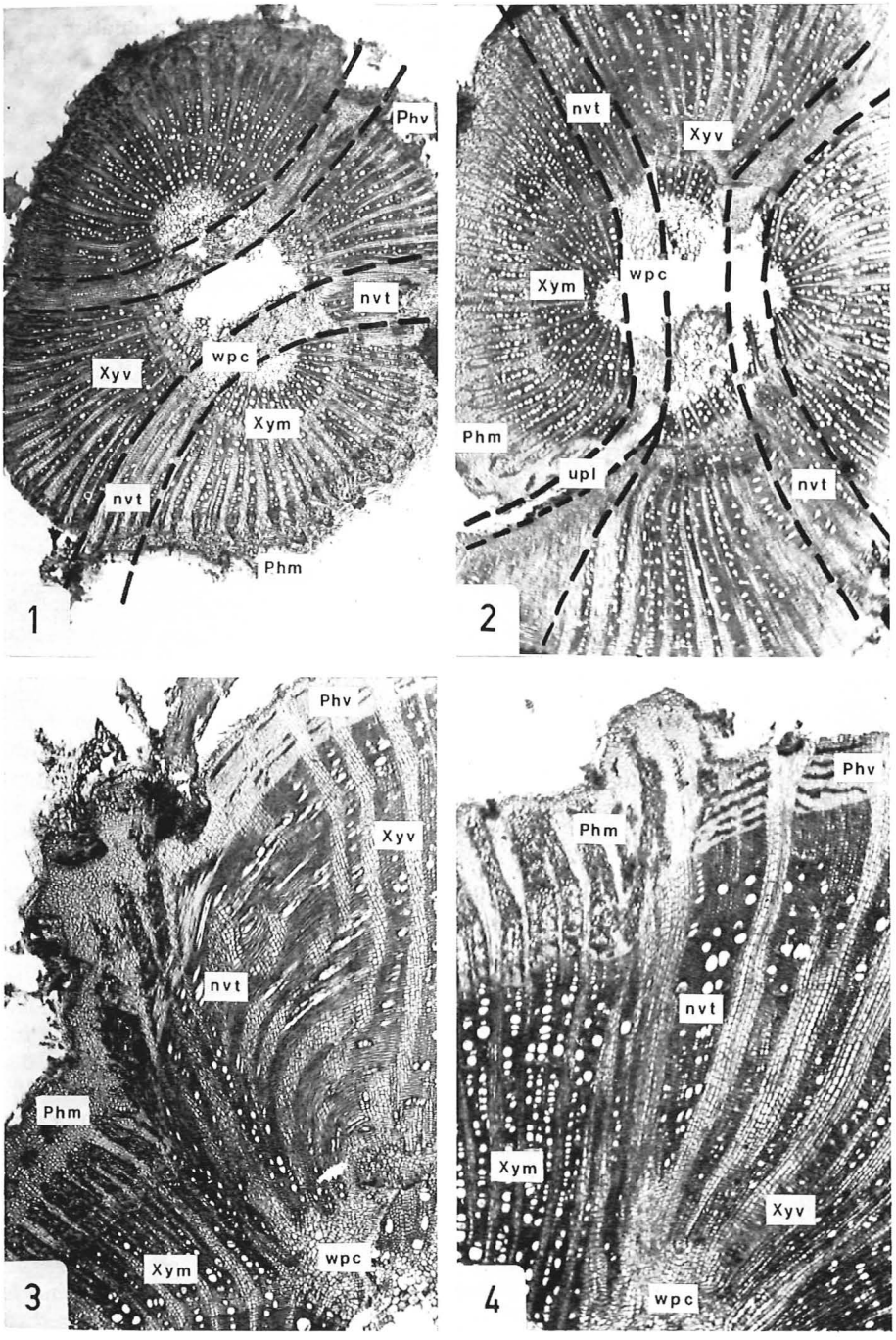

Fig. 1: Transection of compatible graft union showing complete vascular continuity.
Fig. 2: Transection of incompatible graft union showing incomplete vascular continuity: one cambial contact missing.

Microscopical examination of transections of stock below the graft union shows in incompatible combinations a lack of lignification in the xylem and some disorganization of phloem tissues. Evidence is available that cambial division and differentiation of cambial derivatives are under hormonal control (WAREING 1958). Therefore, the disturbances observed in cambial growth of the stock can be probably ascribed to a lack of translocation of endogenous growth regulators synthetized in the scion.

MOSSE (1962) classified graft incompatibilities of fruit trees into two broad groups, namely translocated and localized incompatibilities. Translocated incompatibility was associated with (1) accumulation of starch above the union and absence below it, (2) phloem degeneration, (3) different behaviour of reciprocal grafts, (4) normal vascular continuity at the union, although there might be marked overgrowth of the scion, and (5) early effects on growth. This type of incompatibility has been observed between peach *(Prunus persica)* and plum *(Prunus domestica)* (HERRERO 1951). Localized incompatibility was associated with (1) breaks in cambial vascular continuity which cause mechanically weak unions, (2) similar behaviour of reciprocal combinations, and (3) gradual starvation of the root system with slow development of external symptoms. This type of incompatibility is rather frequent in orchards. Sometimes, symptoms of incompatibility are delayed for many years, for example, when varieties of pear *(Pyrus communis)* are grafted on quince *(Cydonia oblonga)* (HERRERO 1951, BRIAN and DURON 1971).

Our observations let us think that graft incompatibility between Muscadine grape *(V. rotundifolia)* and European grape *(V. vinifera)* can be classified as translocated incompatibility despite the fact that vascular continuity can be incomplete in some combinations. Additional work is necessary to elucidate completely the causes of this graft incompatibility. Reciprocal grafts are actually in course, using Muscadine grapes as scions and *V. vinifera* cv. Cabernet Sauvignon as stock.

The differences in graft compatibility observed between Muscadine varieties are probably under genetical control. F_1 hybrids between *V. vinifera* and *V. rotundifolia* cv. Carlos (incompatible) and Noble (compatible) are now available. Graft

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Fig. 3: Transection of incompatible graft union showing horizontal distortion of neoformed vascular tissues.

Fig. 4: Transection of compatible graft union showing neoformed vascular tissues without distortion.

Abbreviations: Xym = Muscadine xylem; Phm = Muscadine phloem; Xyv = *V. vinifera* xylem; Phv = *V. vinifera* phloem; nvt = neoformed vascular tissues; wpc = wound parenchymatous callus; upl = unlignified parenchymatous layer.

Fig. 1: Coupe transversale d'une greffe compatible montrant une continuité vasculaire complète

Fig. 2: Coupe transversale d'une greffe incompatible montrant une continuité vasculaire incomplète: absence d'un contact cambial sur quatre.

Fig. 3: Coupe transversale d'une greffe incompatible montrant une distorsion horizontale des tissus vasculaires néoformés.

Fig. 4: Coupe transversale d'une greffe compatible montrant une disposition normale des tissus vasculaires néoformés.

Abréviations: Xym = xyleme de muscadine; Phm = liber de muscadine; Xyv = xyleme de *V. vinifera;* Phv = liber de *V. vinifera;* nvt = tissus vasculaires néoformés; wpc = cal parenchymateux de blessure; upl = couche de tissu parenchymateux non lignifié.

compatibility between these hybrids and *V. vinifera* cv. Cabernet Sauvignon will be tested.

But the possible role of a latent virus present in some Muscadine varieties and responsible for the observed differences in graft compatibility cannot be excluded. The existence of a hypothetical graft-transmissible factor is actually tested by means of grafting experiments between incompatible Muscadine varieties like Carlos or Male and compatible varieties like Noble or Yuga.

Summary

Well-known graft incompatibility between the Muscadine grape (*Vitis rotundifolia* MICHX.) and European grape (*V. vinifera* L.) is easily overcome with the green grafting method. But the results depend greatly on the genotypes of the Muscadine grape used. Typical symptoms of incompatibility appear after one year's growth when *V. vinifera* cv. Cabernet Sauvignon is grafted on Muscadine varieties like Carlos and Male. Other Muscadine varieties like Yuga and Noble do not show any symptom. These observations rule out the hypothesis that graft incompatibility between Muscadine grape and European grape was due to the existing structural and anatomical differences between these two species. Macroscopical and microscopical examination of the graft union lets us think that the observed symptoms can be related to a translocated incompatibility. The role of a hypothetical graft-transmissible factor is under investigation.

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