Graft Compatibilities of Hornbeam (*Carpinus*) Species and Hybrids©

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INTRODUCTION

In the development of new plant selections it is critical to determine whether existing nursery practices are still appropriate for use during their propagation and production. For *Carpinus* selections of all species compositions, the standard nursery practice has been to graft them onto *C. betulus* (Tim Brotzman, Alan Jones, and Mark Krautmann, pers. comm.). The main reason for this has been the fact that the majority of hornbeam cultivars are from European hornbeam (*C. betulus*) and grafting these onto the other commonly available understock, American hornbeam (*C. caroliniana*) results in significant overgrowth of the understock by the scion material.

The purpose of this study was to determine whether scions of uncommon species and hybrid origins (Wiegrefe and Berg, 1998) are graft compatible and most appropriately grafted onto *C. betulus* or, alternatively, if some other commonly available rootstock would provide better graft compatibility and performance. The plant materials include two types of variation that could cause or exacerbate graft incompatibilities — differing ploidy levels and different sectional affinities within *Carpinus*. Ploidy level differences may provide partial or full explanation for the difference in vigor between European hornbeam (2n=64) and American hornbeam (2n=16) (Santamour, 1976) in the compatibility problems referred to in the previous paragraph. The greater genetic distance between members of *Carpinus* section *Distegocarpus* (*C. cordata* and *C. japonica*) and the rest of the species (section *Carpinus*) could also increase the probabilities of graft incompatibilties. In addition to determining which scion/rootstock combinations are compatible, we also hoped to determine whether any graft incompatibilities were due to: (1) ploidy level difference, (2) sectional alliance, and (3) to identify how the incompatibility was expressed.

MATERIALS AND METHODS

Scions of various species composition (Table 1) were grafted by professional propagators (Heritage Seedlings, Inc., Salem, Oregon) onto *C. betulus,* and onto *C. caroliniana,* and/or *C. japonica*, depending on scion and rootstock availability. The grafting was done in mid-February of 2001 using the hot callus method (Lagerstedt, 1981). Plants were grown in soilless medium in containers, with annual upgrades in pot sizes in Quonset huts covered with 30% shade cloth during the growing season. During the winter, the Quonsets were covered with two layers of white polyethylene and temperatures were kept above 36 °F using thermostatically controlled electric heaters.

On 25 Sept. 2002, diameter measurements were taken of the plants 2.5 cm (1 inch) above and the same distance below the graft union. The graft union was generally 8–10 cm (3–4 inches) above the surface of the medium. Ratios of the diameters of the scion to rootstock were calculated. Variation was analyzed using the General Linear Model (GLM) subprogram in (SYSTAT® 10, SPSS Inc., Chicago,

Table 1. The taxa used as scions, the accession number (for cross reference with herbarium vouchers), and the quantity of grafted plants on each rootstock.

Taxa	Accn. No.	Chromosome Number 2n=	*Carpinus* rootstock species		
			betulus	*caroliniana*	*japonica*
C. betulus 'Purpurea' × *C. betulus*	96X042	72	6	10	19
C. betulus 'Purpurea' × *C. tschonoskii*	96X047	54	6	19	28
C. caroliniana × *C. betulus*	96X008	45	5	4	
C. caroliniana 'Ascendens' (syn. Pyramidalis') × *C. betulus*	96X019	45	3	1	
C. caroliniana 'Ascendens' × *C. betulus* 'Heterophylla' (syn. 'Quercifolia')	96X017	45	29	8	
C. caroliniana	97-143	18	4	2	
C. caroliniana × *C. caroliniana*	96X002	18	15	12	
C. caroliniana 'Ascendens' × *C. caroliniana*	96X012	18	9	4	
C. caroliniana 'Ascendens' × *C. cordata*	96X010	18	5	1	2
C. caroliniana × *C. coreana*	96X004	18	4	3	
C. caroliniana × *C. orientalis*	96X003	18	2	1	
C. caroliniana 'Ascendens' × *C. orientalis*	96X013	18	6		
C. caroliniana × *C. tschonoskii*	96X005	27	10	7	
C. cordata × *C. cordata*	96X039	18	4		10
C. cordata × *C. japonica*	96X040	18	1		18
C. coreana	97-224	18		1	
C. laxiflora	97-223	18		1	
C. tschonoskii	98-101	36		1	5

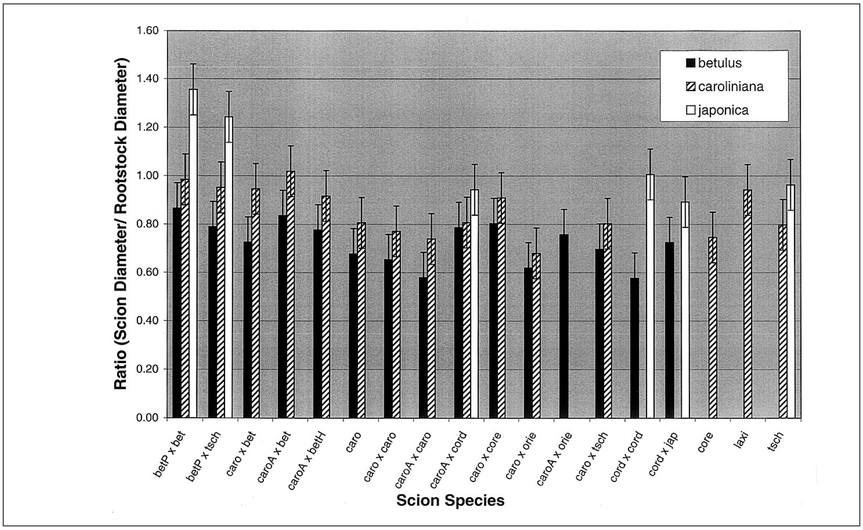

Figure 1. Scion diameter/rootstock diameter.

Illinois). Threshold Honestly Significant Difference (HSDs) was calculated using Q statistic, mean squared error, and an average of the number of individuals per treatment.

RESULTS

The H_0 that the means of each of the measurements were equal across all scion/rootstock combinations was rejected at P<.01 for all tests (ratio of scion diameter/rootstock diameter, scion diameters, and rootstock diameters). The means with associated 95% C. I. are shown in Fig. 2 to 3.

DISCUSSION

I anticipated very wide graft compatibility because of reports of successful grafts of *Carpinus* onto *Ostrya* (Rushforth, 1986). Even from our small study, however, it is apparent that this is not the case. In addition to the calculated means and ratios, it was visually apparent that some plants had minimal or reverse taper. Because we did not have a complete set of same-species grafts, it was difficult to determine the taper ratio inherent to each genotype. It was noted, however, that scion/rootstock ratios above 1.0 might not be structurally sound. For those scions where we had an exact or close match, the taper ratios were: *C. betulus* 0.87, *C. caroliniana* 0.77, and *C. japonica* 0.89. Subsequently, a number of the plants with reverse taper (ratio > 1.0) died and/or broke below the graft union in moderate winds (data not shown). Some combinations were also prone to excessive callus production (Fig. 4). Although others have determined that this alone does not result in weaker trees, those plants will be watched carefully for additional signs of incompatibility.

Rootstock Observations:

Carpinus betulus. There are examples in maples and pears of scions grafted onto rootstocks of other species outperforming within-species grafts. In checking to see

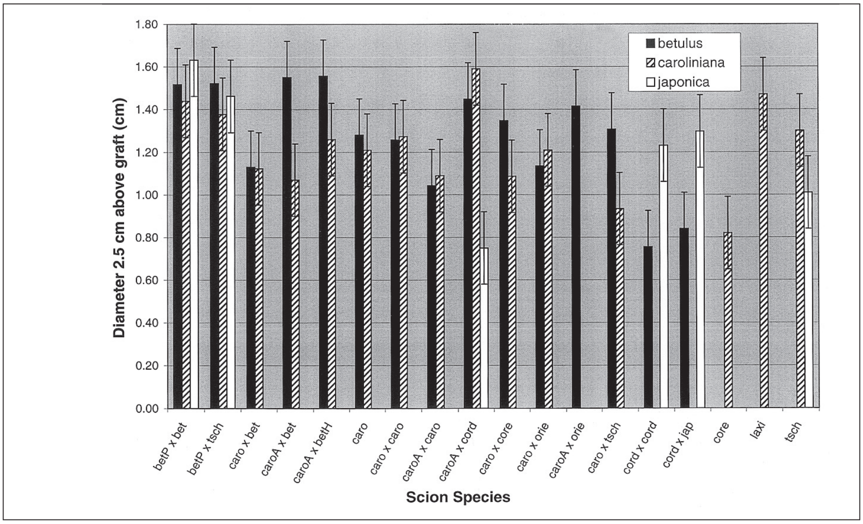

Figure 2. Scion diameters.

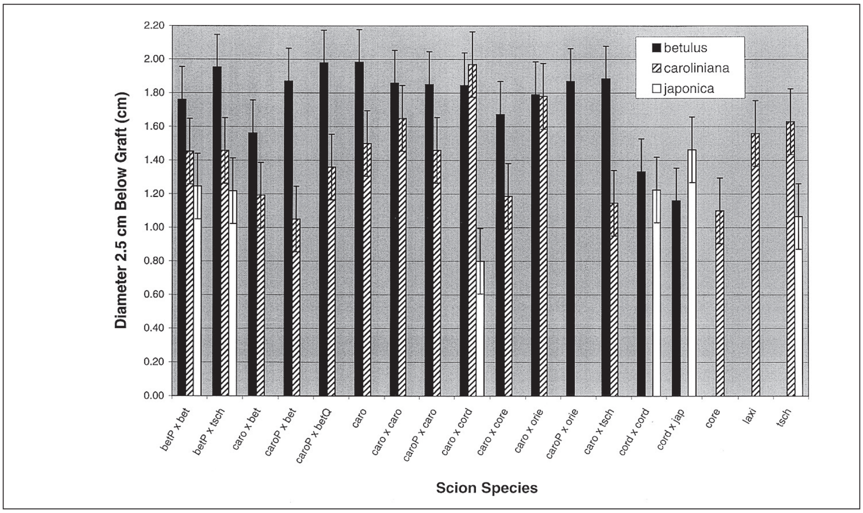

Figure 3. Rootstock diameters.

Figure 4. Excessive callus growth on individual with *Carpinus betulus* × *Carpinus tschonoskii* grafted onto *Carpinus japonica.*

whether *C. betulus* might be this sort of super understock, we were disappointed. In the recommendations we developed from the data to date (Table 2), it can be seen that scions with a component of section *Distegocarpus* (i.e., *C. japonica* or *C. cordata*) should not be grafted onto *C. betulus.* All scions with species components within section *Carpinus* performed acceptably on *C. betulus.*

Carpinus caroliniana. This was not used as rootstock for scions completely composed of section *Distegocarpus* species, but performed the best of any of the three as rootstock to the intersectional hybrid, *C. caroliniana* × *C. cordata.* The rootstock did not provide the vigor conferred by *C. betulus* on many of the other scions, but may be more appropriate in some instances, e.g., where greater drought tolerance is desired (Graves and Wiegrefe, 2003). For hybrids between *C. betulus* and *C. caroliniana* response to different rootstocks varied considerably between genotypes, from not significantly different (caro × bet) to drastically different (caroP × bet). Any new hybrids between the two species will need to be tested for their individual performance on both rootstocks.

Carpinus japonica. This rootstock did not provide acceptable results, except when used with scion materials completely comprised of section *Distegocarpus* species.

Scion Observations. The performance of the various scions varied by genotype. Recommendations are listed in Table 2, including inferred explanations for less than acceptable performance.

These data are preliminary and a subset of the grafted plants has been field planted for long-term evaluation.

Table 2. Recommendations for rootstocks for various scions based on 18 months of growth after grafting. Codes: R = recommended, A = acceptable, U = unacceptable, 1 = confers added vigor, 2 = starves scion, 3 = starves rootstock.

	Carpinus rootstock species		
Scion species	*betulus*	*caroliniana*	*japonica*
betA × bet	R (1)	A	U (3)
betA × tsch	R (1)	A	U (3)
caro × bet	A	A	-
caroA × bet	R (1)	U (3)	-
caroA × betQ	R (1)	A	-
caro	A	A	-
caro × caro	A	A	-
caroA × caro	A	A	-
caroA × cord	A	R (1)	U (3)
caro × core	R (1)	A (2?)	-
caro × orie	A	A	-
caroA × orie	A	-	-
caro × tsch	R (1)	U (3)	-
cord × cord	U (3)	-	A (3?)
cord × jap	U (3)	-	A
core	-	A (3?)	-
laxi	-	A	-
tsch	-	A	U (3)

LITERATURE CITED

Brotzman, T. Brotzman's Nursery, Inc., Madison, Ohio 44057 U.S.A.

Graves, W.R. and S.J. Wiegrefe. 2003. Drought and inundation stress responses of hornbeam (*Carpinus*) species and hybrids. (Abstract) HortScience 38(5):845-846.

Jones, A. Manor View Farm, Inc., Monkton, Maryland 21111 U.S.A.

Krautmann, M. Heritage Seedlings, Inc., Salem, Oregon 97301 U.S.A.

Lagerstedt, H.B. 1981. A new device for hot-callusing graft unions. HortScience 16:529-530.

Rushforth, K. 1986. Hornbeams and Hop Hornbeams. The Plantsman 7(3):173-191.

Santamour, F.S., Jr. 1976. Interspecific hybridization in *Carpinus*. Proceedings First Conf. Metropolitan Tree Improvement Alliance, Lanham, Maryland, 27 July 1976.

Wiegrefe, S.J. and **L.C. Berg.** 1998. New interspecific hornbeam hybrids bred for improved tolerances to environmental stresses. In: T. Raney (ed.), Proceedings of the Metropolitan Tree Improvement Alliance held in conjunction with the Landscape Plant Development Center, St. Louis, Missouri, 30 Sept. – 1 Oct. 1998. <http://fletcher/ces.state.nc.us/programs/nursery/metria/metria10/carpinus/carpinus.html>