PROGRESS IN MICROPROPAGATION OF WOODY PLANTS IN THE UNITED STATES AND WESTERN CANADA

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Until the mid-1970's most successful commercial micropropagation had been with herbaceous plant material. Several orchids, foliage plants, and strawberries had become commercially possible. A few woody plants were being micropropagated such as *Tupidanthus* and *Ficus*. But the majority of woody plant material still remained to be cultured. Perhaps the main reason for the lack of success with this group of plants, was that researchers were attempting to apply the techniques of herbaceous microculture to woody plants. Needless to say, the successes were few.

As pointed out by others (14), the microculture of woody plants is not a new development. In fact, in 1940, Gautheret (5,6) and Nobecourt independently of each other, using the newly discovered auxins, cultured cambial tissue of trees. Later, Jacquiot (7) conducted additional research on bud differentiation from cambial explants of several trees. In California, Ernest Ball (2), working with *Sequoia*, studied the differentiation of buds in cultured shoot tips. In France, Morel (11) had previously used these techniques in freeing certain plants from viruses. Through his research Morel discovered that, using a suitable medium, he could proliferate buds of orchids in a liquid-agitated culture. Shortly after, these techniques were used to commercially propagate many select orchids. With the discovery and synthesis of cytokinins by Skoog commercially successful micropropagation was possible. It was found that this group of chemicals was necessary for bud development in plants. Although no viable plants were formed from their work, the research of these individuals and others provided the basic knowledge for woody plant microculture. Further research was needed to determine the mechanisms controlling the growth and development of woody plants *in vitro*.

In 1964, *Populus tremuloides* was probably the first woody plant to be successfully cultured. Both shoots and roots were regenerated from callus (9). Winton (16) and Walter (17), separately, in 1968 reported on the formation of plantlets from aspen callus.

We, at Briggs Nursery, were fortunate that Dr. Wilbur Anderson (1) in 1968 was working on *Rhododendron* microculture. Dr. Anderson, one of Dr. Toshio Murashige's first students to work on woody tissue culture, came to work at the Northwestern Washington Research and Extension Center in Mt. Vernon, Washington. Progress on *Rhododendron* was slow, but the development of a low salt medium, use of an effective cytokinin (2iP), and a better understanding of what was controlling the adult/juvenile phase, provided the necessary information to culture these plants.

By the mid-1970's considerable research was in progress at several of the universities and commercial laboratories. Several graduates of Dr. Murashige were working on herbaceous and woody plants on the U.S. west coast. On a commercial level, Jiro Matsuyama (10) was working on a number of woody trees and shrubs. Dr. Mapes (8) of the University of Hawaii, a student of Dr. F.C. Steward (15), came to Oregon to work with the timber industry on trying to develop mass single cell production. In western Canada, Dr. David Lane was doing research on *Prunus*, *Malus*, and other woody plants. Dr. Robert Harris at the Saanichton Research Station in British Columbia, Canada, did considerable research on liquid media and heat treatment of cultured plants for elimination of virus. Dr. Richard Zimmerman of the U.S.D.A., Beltsville, Maryland was doing research with *Vaccinium*, *Rubus* and *Malus*. At the University of Wisconsin, Dr. Brent McCown was working with several species and hybrids of *Betula* and *Quercus*.

At the same time, encouraging progress had been made with certain species of gymnosperms: *Pinus* by Sommer and Brown (12,13), Tsai Cheng with *Pseudotsuga* (3) and *Sequoia* (2). At present, several woody plants have been cultured. Table 1 lists woody plants cultured either at commercial or research level with information as to their culture requirements and rootability in and out of culture. The list is compiled from a survey of approximately fifty researchers and commercial laboratories. With a better understanding of nutrient and hormonal requirements, many more plants will undoubtedly be cultured.

As with any business, for micropropagation to be successful good management is a must. In the long run, the well-managed labs will be the successful ones. In the future, closer attention will be paid to refining the growth requirements of the cultured plants. Methods for speeding the growth cycle and yield of plants in culture by altering the nutrient content and culture environment will be studied. Economical forms of lighting and length, quantity, and quality of photoperiod will be investigated for major crops in culture. Efficient ways of handling the plants in and outside the lab will become more important. Refrigerated cold storage is already being used to store *in vitro* plant material for the following growing season. Perhaps with further research more of the conifers will be successfully cultured. Embryogenesis is exciting and has several advantages over conventional shoot tip micropropagation if it could be applied to a majority of woody ornamentals. As indicated by others (4) "fluid drilling" of plants could be possible without a hardening-off stage and providing a uniform true-to-name crop.

Micropropagation will increase in its importance to plant breeders. Anther culture can provide haploid material a breeder can use to study inheritance and produce homozygous breeding stock. With micropropagation, plants are becoming marketable much sooner and in larger numbers. This will, in turn, accelerate the development and improvement of several crops.

Table 1. Woody Plants in Microculture in the United States and Western Canada. (See key on page 247.)

Multiplication			Medium		Growth Regulator			Rooting	
Plant	Production	Research	High salt	Low salt	BA	2iP	Other	Multiplication to Soil	Stage III
Acer platanoides 'Crimson King'	9	15	9,15		9,15				9,15
A. rubrum 'Red Sunset'	15,24	15,24			15,24				15,24
A. saccharinum	15	15			15				15
Actinidia chinensis	18	17	17,18				17,18	18	
Aesculus glabra		23		23				23	
Alnus (several spp.)		19,23		19,23				19,23	
Amelanchier	10	4,17		4,10	4,10			10	
A. alnifolia	3		3		3			3	
A. arborea	10,12		12	10	10,12			10,12	
A. × *grandiflora*	3,10,12		3,12	10	3,10,12			3,10,12	
A. laevis	10,12	11	11,12	10	10,11,12			10,11,12	
A. stolonifera		11	11		11			11	
Arctostaphylos		19		19	19	19			
A. uva-ursi	3	17		3	3	3			3
Betula	2,3,15	4,5,12 13	12,15	2,3,4,5, 13	2,3,4,5, 12,13,15			3,5,13	2,15
Campsis radicans	18			18			18	18	
Castanea spp.	18			18			18	18	
Celtis occidentalis	10	14	14	10	10,14			10,14	14
Cercidiphyllum japonicum		4	4		4				
Chamaecyparis nootkatensis		4	4	4	4				
C. n. 'Pendula'		3		3	3				
C. obtusa 'Nana'		3		3	3				3
C. pisifera 'Boulevard'		13		13	13			13	

Table 1. Continued

Multiplication			Medium		Growth Regulator			Rooting	
Plant	Production	Research	High salt	Low salt	BA	2iP	Other	Multiplication to Soil	Stage III
Clematis armandii		3,17	3,17		3,17			3	3
		3,4	3,4		3,4		4(IAA)		
Corylopsis	3	4	3,4	4	3,4				3
Corylus avellana nut cvs.	15			1,15	1,15	1,15			1
C. avellana 'Contorta'		3	3	3	3	3			
Cotinus cvs.	3,12		12	3	3,12			3	3,12
Crataegus cvs.	12		12		12			12	
Daphne × *burkwoodii*		17	17				17		
		3		3	3				3
D. cneorum	4	2,3		2,3,4	2,3,4				3
D. mezereum	4			4	4				
D. odora	2	3		2,3	2,3			2	
Dirca palustris		13,23		13,23	13,23			23	
Eucalyptus	8		8						
Ficus benjamina	2,8		2			2			2
F. elastica 'Decora'	8	25	25		25				25
F. lyrata	2,8,21		2,21		2	21			2,21
Forsythia		5		5	5			5	
Fothergilla		12	12		12		12(NAA)	12	12
Garrya elliptica	3			3	3				3
Hamamelis		3,4,10,12	3,12	3,10	3,10,12		12(NAA)	10	3
Hydrangea		15,23	15	23	15,23			23	15
Ilex verticillata		21		21					
		23		23	23			23	
Kalmia latifolia cvs.	2,3,4,10 12,22,26	1,13		1,2,3,4, 10,12,13, 22,26		1,2,3,4 10,12,13, 22,26	1,4,12 22 (IAA)	3,4,10,13 22,26	1,2,3,13

Table 1. Continued

Multiplication			Medium		Growth Regulator			Rooting	
Plant	Production	Research	High salt	Low salt	BA	2iP	Other	Multiplication to Soil	Stage III
Lagerstroemia indica		23		23	23			23	
Lapageria rosea	3			3	3				3
Leucothoe	7			7	7			7	
Lonicera spp.		23		23	23			23	
Magnolia		3,4,9 10,15	3,10	3,4,9,10 15	3,4,9, 10,15	4		10	9
Mahonia aquifolium		2,3,19	2	3,19	3,19	2,19			2,3
M. repens		19		19	19	19			
Malus		13,14,17	14,17	13	13,14,17			13,14	14
fruiting cvs.	9,15	3,28	3,9,15,28		3,9,15,28			28	3,9,15,28
understock	3,9,15	25,28	3,9,15,25,28		3,9,15,28			3,9,28	15,25,28
ornamental	9,12,14	4,11	9,11,12,14	4	4,9,11,12,14			11,12	9,11,15
Nandina domestica									
'Carolina'	2		2			2			2
'Harbor Dwarf'	6,8,22	20		6,20	6,20			20	6,20
'Nana'		2	2			2			2
'Nana Compacta'	8,21		21		21	21			21
'Nana Purpurea'	6,22	2	2	6	6	2			2,6
Paeonia suffruticosa cvs.	6,10			6,10	6,10			10	6
Photinia		17							
Pieris japonica		4,17	4	4	4	4			
Pinus contorta		4	4	4	4				
P. eldrica		19		19	19	19			
P. taeda		27		27	27				27
Populus tremula 'Erecta'	10			10	10			10	
P. tremuloides	19			19	19			19	
Potentilla cvs.	3,5			3,5	3,5			3,5	

Table 1. Continued

Multiplication			Medium		Growth Regulator			Rooting	
Plant	Production	Research	High salt	Low salt	BA	2iP	Other	Multiplication to Soil	Stage III
Prunus avium (Mazzard)		17	17		17	17			
P. avium (Mazzard)	9		9		9	9			9
P. × *blireiana*	2			2	2				2
P. cerasifera cvs.	2,3,9, 15	25	3,9,15 25	2	2,3,9, 15,25	9			2,3,9, 15,25
P. × *cistena*	2,3,5,9		9	2,3,5	2,3,5,9		9 (IAA)	5	2,3,9
P. × 'Hally Jolivette'		11	11		11			11	11
P. persica	15	14,25	14,15,25		14,15,25				14,15,25
P. sargentii	4	2	4	2	2,4				
P. serrulata cvs.	2,3		3	2	2,3			3	2
P. triloba	2,3,9		9	2,3	2,3,9		9 (IAA)	3	2,3,9
P. yedoensis 'Akebono'		2		2	2				
Pseudotsuga menziesii		4,27	4	4,27	4,27				27
Pyrus spp.									
fruiting cvs.	9,15		9,15		9,15		9 (IAA)		9,15
ornamental	12,15	25	12,15,25		12,15,25			12	15,25
understock	9,15	25	9,15		9,15		9 (IAA)		9,15
Quercus		13,15		13	13				
Rhododendron	2,3,4,5 10,12,13, 14,16,21, 22,26	1,14,21		1,2,3,4,5, 10,12,13, 14,16,21, 22,26		1,2,3,4, 5,10,12, 13,14,16, 21,22,26	1,4,13 15,21 (IAA) 12 (IBA)	3,4,5,10, 12,13,14, 16,21,22, 26	1,2,3, 12,13 16
Azaleas									
deciduous	1,2,3,4,5, 12,16,22, 23	23		1,2,3,4,5, 12,16,22, 23		1,2,3,4,5, 12,16,22, 23	1,4,22 (IAA) 12 (IBA)	3,4,5,12, 16,22	1,2,3, 12,16
evergreen	3			3		3		3	

Table 1. Continued

Multiplication			Medium		Growth Regulator			Rooting	
Plant	Production	Research	High salt	Low salt	BA	2iP	Other	Multiplication to Soil	Stage III
Ribes spp.	2			2	2				2
Rosa cvs.	3,19	13,21,23	3,19	3,12,21, 23	3,13,19, 21,23			3,13,21, 23	3,19
R. foetida 'Persiana'		19	19		19				
Rubus cvs.	2,3	1,14,25, 28	2,14,25	1,2,3, 28	3,14,25, 28	1		3,28	1,2,14, 25,28
Salix spp.	23	23		23	23			23	
Sequoia sempervirens	18	27	18	27	27		18	18	18,27
cvs.	3,4		4	3	3,4	3,4			3
Sequoiadendron giganteum	4			4	4			4	
Simmondsia chinensis	19	23	19	23	19,23			23	19,23
Spiraea	3			3	3			3	
Stewartia spp.		3,12	3	12	3		12		
Syringa vulgaris cvs.	3,12	4,23	3,4,12	3,23	3,4,12,23		12 (NAA)	3,23	12
Thuja occidentalis cvs.	4,5,13	3		3,4,5,13	3,4,5,13			3,5,13	
Tilia americana		23		23	23			23	
Ulmus cvs.	10			10	10			10	
Vaccinium angustifolium	7			7		7		7	7
V. angustifolium × *V. corymbosum*	23	23		23		23		23	
V. ashei	7			7		7		7	7
V. corymbosm	3,7			3,7		3,7		3,7	3,7
V. vitis-idaea		23		23		23		23	23
Viburnum cvs.		12,23	12	23	12,23			23	
Vitis cvs.	9	3	9	3	3,9			3	9

Key to Table 1. Names and addresses of laboratories who submitted information on woody plants.

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6. Hartman's
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8. K & M Nursery, Inc.
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20. Oakdell Nurseries
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21. Oglesby Nursery, Inc.
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