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.

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

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Table 1. Continued

			Me	Medium		Growth Regulator	lator	Ro	Rooting
Plant	Production	Research	High salt	Low salt	BA	2iP	Other	Multiplication to Soil	on Stage III
								ŀ	
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.	vs.15			1,15	1,15	1,15			1
C. avellana 'Contorta'		က	3	က	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	ဗ				3
D. cneorum	4	2,3		2,3,4	2,3,4				33
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	ស	•		5	
Fothergilla		12	12		12		12(NAA)	12	12
Garrya elliptica	3			3	က		,		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
llex verticillata		21		21					
		23		23	23			23	
Kalmia latifolia	2,3,4,10	1,13		1,2,3,4,		1,2,3,4	1,4,12	3,4,10,13	1,2,3,13
CVS.	12,22,26			10,12,13,		10,12,13,	22 (IAA)	22,26	
				22,26		22,26			

Table 1. Continued

Multiplication			Me	Medium		Growth Regulator	lator	K	Rooting
								Multiplication	ion
Plant	Production	Research	High salt	Low salt	BA	2iP	Other	to Soil	Stage III
Lagerstroemia indica		23		23	23			23	
Lapageria rosea	3			3	က				3
Leucothoe	7			7	7			7	
Lonicera spp.		23		23	23			23	
Magnolia		3,4,9	3,10	3,4,9,10	3,4,9,	4		10	6
		10,15		15	10,15				
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		S			28	3,9,15,28
understock	3,9,15	25,28	•		3,9,15,28			3,9,28	15,25,28
ornamental	~	4,11	9,11,12,14	4	1,12,	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	9	9	2			2,6
Paeonia suffruticosa cvs.				6,10	6,10			10	9
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	
P. tremuloides	19			19	19			19	
Potentilla cvs.	3.5			3,5	3,5			3,5	

Table 1. Continued

Mazzard) Production Research High salt Low salt BA 2iP Other zard) 9 17 17 17 17 zard) 9 17 17 17 vs. 2.3.9. 25 2.3.9. 9 9 vs. 2.3.9. 25 2.3.9. 9 14.15.25 9 vs. 2.3.9. 25 2.3.9. 9 14.15.25 9 14.15.25 9 14.15.25 9 14.15.25 9 14.15.25 9 14.15.25 9 14.15.25 9 14.15.25 9 14.15.25 9 14.15.25 9 14.15.25 9 14.15.25 9 14.15.25 9 14.15.25 9 14.15.25 9 14.15.25 9 14.15.25 9 14.15.25 9 14.15.3 9 14.15.3 9 14.15.3 9 14.15.3 14.15.3 9 14.15.3 14.15.3 9 14.15.3 14.15.3 14.15.	Multiplication			Me	Medium		Growth Regul	lator	R(Rooting
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2,3,4,5 1,14,21 1,2,3,4,5, 1,2,3,4, 1,4,13 10,12,13, 10,12,13, 14,16,21, 13,14,16, (IAA) 22,26 22,26 1,2,3,4,5, 1,2,3,4,5, 1,2,3,4,5, 1,2,3,4,5, 1,2,16,22, 12,16,22,	Quercus		13,15		13	13				
10,12,13, 10,12,13, 5,10,12, 15,21 14,16,21, 13,14,16, (IAA) 22,26 21,22,26 12 (IBA) 1,2,3,4,5, 23 1,2,3,4,5, 1,2,3,4,5, 12,16,22, 12,16,22, 12,16,22, 12 (IBA) 23 23 12 (IBA)	Rhododendron	2,3,4,5	1,14,21		1,2,3,4,5,		1,2,3,4,	1,4,13	3,4,5,10,	1,2,3,
14,16,21, 14,16,21, 13,14,16, (IAA) 22,26 22,26 12 (IBA) 22,26 12,3,4,5, 23 1,2,3,4,5, 12,16,22,		10,12,13,			10,12,13,		5,10,12,	15,21	12,13,14,	12,13
22,26 21,22,26 12 (IBA) uous 1,2,3,4,5, 23 1,2,3,4,5, 1,2,3,4,5, 1,4,22 12,16,22, 12,16,22, (IAA) 23 23 12 (IBA)		14,16,21,			14,16,21,		13,14,16,	(IAA)	16,21,22,	16
uous 1,2,3,4,5, 23 1,2,3,4,5, 1,2,3,4,5, 1,4,22 12,16,22, (IAA) 12,16,22, 23 23 12 (IBA)		22,26			22,26		21,22,26	12 (IBA)	26	
1,2,3,4,5, 23 1,2,3,4,5, 1,2,3,4,5, 1,4,22 12,16,22, 12,16,22, (IAA) 23 23 12 (IBA)	Azaleas									
12,16,22, (IAA) 23 23 12 (IBA)	deciduous	1,2,3,4,5,	23		1,2,3,4,5,		1,2,3,4,5,	1,4,22	3,4,5,12,	1,2,3,
23 23 12 (IBA)		12,16,22,			12,16,22,		12,16,22,	(IAA)	16,22	12,16
		23			23		23	12 (IBA)		
3	evergreen	က			က		က		က	

Table 1. Continued

			Me	Medium	C	Growth Reg	Regulator	R	Rooting
			ļ					Multiplication	
Plant	Production	Research	High salt	Low salt	BA	2iP	Other	to Soil	Stage III
Ribes spp.	2			2			:		_ 2
Rosa cvs.	3,19	13,21,23	3,19	3,12,21,	3,13,19,			3,13,21,	3,19
R. foetida 'Persiana'		19	19	67	1			6.7	
Rubus cvs.	2,3	1,14,25,	2,14,25	1,2,3,	3,14,25,	7	••	3,28	1,2,14,
· · · · · · · · · · · · · · · · · · ·		28		28	28				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			က
Sequoiadendron									
giganteum	4			4	4			4	
Simmondsia chinensis	19	23	19	23	19,23			23	19,23
Spiraea	3			3	33			33	
Stewartia spp.		3,12	3	12	က		12		
Syringa vulgaris cvs.	3,12	4,23	3,4,12	3,23	1,12,		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	
				7		7		7	7
V. angustifolium $ imes$									
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.	6	က	6	က	3,9			3	6

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

- Dr. Wilbur Anderson
 Northwestern Washington
 Research and Extension Center
 1468 Memorial Highway
 Mt. Vernon, WA 98273
- 2. B & B Laboratories, Inc. 1600 D Dunbar Rd. Mt. Vernon, WA 98273
- 3. Briggs Nursery, Inc. 4407 Henderson Blvd. Olympia, WA 98501
- 4. Les Clay & Son, Ltd.
 Box 304
 Langley, B.C. V3A 4R3
 Canada
- 5. Evergreen Nursery Co. Route 3 Sturgeon Bay, WI 54235
- 6. Hartman's P.O. Box 90 Palmdale, FL 33944
- 7. Hartmann's Plantation, Inc. Route 1 Grand Junction, MI 49056
- 8. K & M Nursery, Inc. P.O. Box 847 Carpinteria, CA 93013
- 9. Kelowna Nurseries Ltd. Box 178 Kelowna, B.C. ViY 7N5 Canada
- 10. Knight Hollow Nursery, Inc. 236 E. Sunset Court Madison, WI 53705
- 11. Dr. R. Daniel Lineberger Ohio State University 2001 Fyffe Court Columbus, OH 43210
- 12. Herman Losely and Son, Inc. 3410 Shepar Rd. Perry, OH 44081
- 13. Dr. Brent H. McCown University of Wisconsin Madison, WI 53706
- 14. Dr. Martin Meyer University of Illinois Urbana, IL 61801

- 15. Microplant Nurseries, Inc. 13557 Portland Rd. N.E. Gervais, OR 97026
- 16. Mikkelsens, Inc. P.O. Box 1536 Ashtabula, OH 44004
- 17. Dr. Paul Monette Saanichton Research Station Sidney, B.C., Canada
- 18. Monrovia Nursery Co. P.O. Box Q Azusa, CA 91702
- 19. Native Plants 360 Wakara Way Salt Lake City, UT 84108
- 20. Oakdell Nurseries P.O. Box 1147 Apopka, FL 32703
- 21. Oglesby Nursery, Inc. 3714 Southwest 52nd Ave. Hollywood, FL 33023
- 22. Phyton Technologies, Inc. 7327 Oak Ridge Hwy. Knoxville, TN 37921
- 23. Dr. Paul E. Read University of Minnesota St. Paul, MN 55108
- 24. Dr. Kenneth C. Sink, Jr. University of Michigan East Lansing, MI 48823
- 25. Dr. L.P. Stoltz
 University of Kentucky
 Lexington, KY 40546
- 26. Weston Nurseries, Inc. East Main Street Hopkinton, MA 01748
- 27. Weyerhaeuser Company Technology Center Tacoma, WA 98401
- 28. Dr. Richard H. Zimmerman
 U.S.D.A. Fruit Laboratory
 Beltsville Ag. Research CenterWest
 Beltsville, MD 20705

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