propagated *R. vaseyi*, we remove the terminal on cuttings as soon as they are established in our potting medium. These "tipped" cuttings branch heavily. As with *R. prinophyllum*, the parent plant for the microcuttings was different than that for the macrocuttings and seed. The microcutting clone may exhibit a high degree of apical dominance or it is possible that basal branching is a later characteristic to develop. Further study will observe the long-term growth pattern of the micropropagated plants.

From a commercial standpoint, it is clear that micropropagation provides a viable source of plant material with the possible benefits of increased and faster rooting, vigorous growth, and heavy basal branching. Because some growth characteristics such as basal branching may be largely under genetic control, propagators should be aware that careful consideration must be given to source plants before isolation.

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We feel that the rapid growth occurs because: 1) 10 weeks are added to the growing season, 2) the copper-treated containers control root growth, eliminating or greatly reducing the need to root prune when plants are upcanned, and 3) the best cultural practices are maintained.

The advantages of OPS are rapid growth during the first year of production and, following transplanting, the ability to profitability produce difficult-to-transplant species (such as bur oak and black gum), and production efficiency. Production efficiency is increased because whips are produced in one year, rather than in three to five years. For instance, whip orders for fall, 1991 or spring, 1992 could be taken as late as March 1991. Therefore, a producer need sow only as many seeds or plant as many rooted microcuttings as they have orders for, rather than speculating on market conditions three to five years in advance. Two additional advantages are: increased crop uniformity (especially with tissue-cultured material) and the potential to offer plant material grown to customers' specifications.

1990 SPECIES TRIAL

During 1990, we grew 20 species and cultivars under OPS conditions. With three exceptions, *Koelreuteria paniculata, Amelanchier,* and *Betula nigra*, where repeated rabbit browsing kept plants short, growth was excellent (Table 1). The advantage of extending the growing season by 10 weeks is clear. For example, with red oak, the most growth and greatest increase in dollar value occurred during August (Table 2). Without the 10-week greenhouse period, plants would have reached this growth potential in late October; well after the first fall freezes.

CHALLENGES TO OPS

The Ohio Production System is ideally suited for species produced from seeds as well as species which also tend to be difficult to transplant and difficult to produce asexually. A problem with seed produced species is yearly variation in seed quality (both genetic and physiological) and quantity. Variation in seed quantity is caused by alternate bearing habit, common to many woody species. The only way to insure adequate supplies of consistent high quality seed is to establish and manage seed orchards or to purchase seed produced in seed orchards where the mother trees or clones have been tested for genetic superiority. Seed propagated crops can be uniform with respect to phenotype while still being genetically diverse.

Table 1. Percent of plants in given size categories at three times during the growing season and number of plants produced during the 1990 growing season. Plant heights are given in cm and ft.

		Percent of plants in given size class						
Species	Date	<60 cm <2 ft	61-91 2-3	92-122 3-4	123-152 4-5	153-183 5-6	184-244 6-8	No plants in study
Acer rubrum 'October Glory'	8/1	0	30	2	21	66	11	47
	8/21	0	0	0	0	4	96	
	9/21	0	0	0	0	4	96	
A. rubrum 'Red Sunset'	8/1	0	0	0	16	50	34	48
	8/29	0	0	0	0	0	100	
	9/21	0	0	0	0	0	100	
A saccharum	8/1	42	28	42	4	2	0	50
	8/30	7	18	28	22	22	2	
	9/21	5	7	19	28	21	20	
Betula platyphylla 'Whitespire'	8/1	0	0	20	75	5	0	18
	8/30	0	0	6	0	17	78	
	9/21	0	0	5	0	5	90	
Cercis canadensis	8/1	13	31	21	13	13	6	15
	8/30	0	0	0	7	67	27	
	9/21	0	0	0	0	13	87	
Fraxinus americana	8/1	45	35	17	3	0	0	50
	8/30	26	54	14	6	0	0	
	9/21	26	52	16	6	0	0	
Larix decidua	8/1	25	60	15	0	0	0	19
	8/30	0	37	53	10	0	0	
	9/21	5	17	28	44	6	0	
Liquidambar styraciflua	8/1	0	56	48	0	0	0	27
	8/30	0	0	0	15	74	11	
	9/21	0	0	0	7	22	71	
Malus × *zumi*	8/1	20	20	60	0	0	0	39
	8/30	15	0	5	27	54	0	
	9/21	13	2	3	12	18	52	
Malus 'Snowdrift'	8/1	47	19	31	3	0	0	36
	8/30	39	8	31	14	8	0	
	9/21	25	8	11	22	31	3	
Nyssa sylvatica	8/1	4	17	50	28	1	0 4	239
	8/29	2	0 4	7	27	50	14	
	9/21	3	0	1	3	39	54	
Quercus alba	8/1	100	0	0	0	0	0	5
	8/29	100	0	0	0	0	0	
	9/21	74	13	10	3	0	0	
A coccinea	8/1	94	6	0	0	0	0	39
	8/29	80	10	10	0	0	0	
	9/28	74	13	10	3	0	0	
Q. macrocarpa	8/1	46	49	4	0	0	0	78
	8/29	10	33	35	19	3	0	
	9/21	10	12	26	36	14	3	
Q palustris	8/1	57	43	0	0	0	0	96
	8/29	28	44	25	1	0	0	
	9/21	24	36	30	8	2	0	

Table 1. ***Continued***

Species	Date	Percent of plants in given size class						No plants in study
		<60 cm <2 ft	61-91 2-3	92-122 3-4	123-152 4-5	153-183 5-6	184-244 6-8	
Q rubra	8/1	10	16	38	29	7	0 3	289
	8/29	4	6	13	21	23	34	
	9/21	4	3	5	10	30	48	
Q shumardii	8/1	12	30	32	18	8	0	48
	8/29	6	4	27	23	25	15	
	9/28	4	2	6	10	19	58	
Q velutina	8/1	60	36	4	0	0	0	20
	8/29	40	30	20	10	0	0	
	9/21	20	24	32	16	4	4	
Taxodium distichum	8/1	2	13	84	0	0	0	55
	8/30	2	2	15	78	5	0	
	9/21	0	0	2	24	72	2	
Tilia cordata 'Greenspire'	8/1	0	0	0	13	47	40	40
	8/30	0	0	0	0	0	100	
	9/21	0	0	0	0	0	100	

Table 2. Value (in dollars) for various sized *Quercus rubra* (red oak) whips and value of 100 red oak whips at three times during the 1990 growing season. Dollar values, for unbranched whips, were calculated by multiplying the percent of plants in a given size category by the price per whip.

Size category	<60 cm <2 ft	61-91 2-3	92-122 3-4	123-152 4-5	153-183 5-6	184-244 6-8	
Whip price ($)	0 00	1 00	1 70	5 40	7 50	8 75	
DATE							TOTAL
8/1	0 00	16 00	27 20	156 60	52 50	0 00	252 30
8/24	0 00	6 00	22 10	113 40	172 50	297 50	614 50
9/21	0 00	3 00	8 50	54 00	225 00	358 75	649 25

Reliable seed supplies can be insured by learning how to even out the natural alternate bearing habit or by developing storage techniques so that seed from plentiful years, especially seed of species that produce recalcitrant seed, can be stored for use during years of light seed production.

Finally, before OPS can become profitable, a marketing plan must be developed. Whips produced under OPS conditions are similar, but not identical to, field-grown whips. An OPS grower must either adjust production practices so that OPS whips more closely resemble field-grown whips, or develop a marketing strategy which promotes OPS-grown material as an alternative, and in some aspects (such as transplantability) a superior alternative to field grown whips. The author feels the most successful way to market OPS grown material is as a superior alternative to field-grown whips.

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