Performance of Sweet Cherry Cultivars on Several Clonally-Propagated Understocks[1]

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Abstract

Clonal selections of *Prunus avium* L., *Prunus mahaleb* L., and *P. avium* x *P. mahaleb* (M x M) were compared during an 11-year period with mazzard seedling or mazzard F 12/1 as understocks for *Prunus avium* cvs Napoleon, Bing, Lambert, Corum, Chinook, or Sam. There were no obviously incompatible combinations but certain stocks produced smaller trees than others. Trees on *P. mahaleb* 193701 and 163091 were slightly smaller at age 10 than controls, but the difference varied with site and cultivar. Trees on M x M 14 were 1/3 to 1/2 the size of controls after 11 years. Trees on OCR-2 were the same size as control trees but were more precocious. Trees on M x M 39, were dwarf and precocious but did not remain productive.

Garner (5) recently reviewed ten papers on dwarfing rootstocks for sweet cherry. He suggested that there is considerable evidence of scion dominance by sweet cherry over a wide range of cherry species. In assessing future prospects he said, "... a dwarfing influence and ease of vegetative propagation are the priorities. Hybridization clearly offers immense opportunities of combining the desirable features of graft compatability, growth and form, ready propagation and resistance to disease." Howe (8) compared seedlings of *P. avium* L. with seedlings of *P. mahaleb* L. as rootstocks for 17 sweet cherry cultivars, including 'Napoleon.' He concluded that *P. avium* L. is more satisfactory than *P. mahaleb* L. With 'Napoleon' there was no difference in tree size due to rootstock. Coe (2), based on a 14-year study with 'Bing' in Utah, concluded that *P. mahaleb* L. was superior to *P. avium* L. and 'Stockton Morello' in vigor, size, hardiness, survival and yield. Haas (7) reported that *P. mahaleb* L. seedlings as rootstocks were incompatable with the cvs tested and gave high tree losses. *P. avium L.* interstocks caused no disturbance at the graft union and did not retard growth. *P. mahaleb* L. interstocks retarded growth, but the trees were short-lived. Brase and Way (1) considered both seedlings of *P. avium L.* and *P. mahaleb* L. as standard rootstocks because cherry varieties growing on them made strong growth and large trees. They reported dwarfing and precocious fruiting on seedlings of *P. fruticosa* Pall. Cummins (4) more recently reported that eight clones of *P. fruticosa* Pall. originally selected by Brase dwarfed sweet cherry cultivars Windsor, Emperor Francis, and Schmidt's Bigarrea at Geneva, New York and at Oppenheim/Rhein, Germany. All trees bloomed and set fruit in the second season in the orchard. Very heavy cropping and very limited growth were characteristic in subsequent years. Their marginal anchorage and considerable suckering were considered to be minor disadvantages. Research with nonsuckering, easily rooted clonal selections of *P. fruticosa* Pall. is proceeding. Larson (9) compared F-12/1 and seedling *P. avium* L. from New York with seedling *P. mahaleb* L. from 2 sources as rootstocks and *P. cerasus* L. cvs Kansas Sweet, Northstar, Montmorency and Redrich and interstocks for Bing and Chinook. After 5 years in the orchard, 'Bing'/'Montmorency' graft unions appeared to be discontinuous and 'Chinook' overgrew 'Red-

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rich.' *P. avium* L. from New York and P. mahaleb L. 900 seedlings gave smaller trees than f 12/1 and *P. mahaleb* L. 4. 'Northstar' and 'Redrich' gave smaller trees than 'Kansas Sweet' and 'Montmorency.' Ryugo and Micke (10) found that 'Vladimir,' and *P. cerasus* L. clone originally from Russia, was a suitable dwarfing rootstock for 'Rainier.' 'Vladimir' has a moderate tendency to sucker. Tydemon and Garner (11) found that a *P. avium* L. clone E.M. 4/158 was distinctly dwarfing but somewhat difficult to multiply vegetatively. Hybrids of *P. avium* L. x *P. pseudo-cerasus* Lind. were very easy to propagate and selected clones induced compact early-cropping trees. One such hybrid, named 'Colt' by the East Malling Research Station, is currently being propagated for trials in the U.S. and Europe. Garner (6) reported that cvs 'Early Rivers' and 'Merton Heart' yielded well on *P. dropmoreana,* remained half the size of trees on F/12/1 and did not sucker. This report summarizes results from trials established in growers' orchards in 1965 and 1966 in an attempt to find rootstocks which would produce smaller and/or more precocious cherry trees.

Materials and Methods

Rootstocks propagated from softwood cuttings under mist by A. N. Roberts, O.S.U., were of the following clones: *P. mahaleb* P.I., 194098, 193701, 163091, 193695; OCR-2, OCR-3, F 12/1. Rootstocks propagated by hardwood cuttings by Lyle Brooks, 2515 Gales Way, Forest Grove, OR 97116, were clones: M x M 1, 14, 18, 39, and F 12/1; Stockton Morello. The principal scion cultivars were Napoleon, Bing, and Lambert. Pollinizer cultivars were Corum, Chinook, and Sam. Since an unidentified black seedling was mistaken for 'Corum,' these trees were regrafted in the field when the first fruits appeared.

In 3 plots, frame stock of F 12/1, OCR-1, or M x M 1 were included to provide resistance to bacterial canker incited by *Pseudomonas syringae* van Hall. These were limb-grafted in the orchard. A randomized-block design was employed in most plots but, due to the small number of stocks of most kinds, most replicates were far from complete. Tree mortality further reduced the possibility for statistical analysis of the data.

The M x M clonal rootstocks were selected from 30,000 open-pollinated seedlings of *P. mahaleb* from McGill & Son Nursery by Lyle Brooks. The seedlings selected were presumed to be *P. avium* x *P. mahaleb* because of their relatively upright growth habit and leaves larger than *P. mahaleb. Prunus avium,* cv F 12/1, originated at East Malling, England. *Prunus cerasus,* cv Stockton Morello, originated in California. *P. avium,* cv OCR-1, was selected by A. N. Roberts, and OCR-2 by J. Milbrath. *P. mahaleb,* clones P.I. 193701, 163091, were provided by the U.S.D.A. Div. of Plant Exploration.

Plots were located in the Willamette Valley of western Oregon, an area with 75-100 cm of winter rainfall and acid soils, The Dalles-Mosier area with 45-55 cm of rainfall and sandy soils and Union County, an area with rich loam soils, colder winters and 40-50 cm of rainfall. The Walker orchard is a non-irrigated hillside site near Salem on Aiken soil which is an acid silty clay loam generally low in phosphorus and potassium. The Willard orchard is non-irrigated on a clay bench soil with limited drainage near the Willamette River without irrigation. The Wilson orchard near Mosier is on an irrigated sandy soil. The Cooper-Doak orchard near The Dalles is on an irrigated sandy loam soil. The Nims orchard, near Cove, is on a rocky knoll with shallow soil and has occasionally been irrigated. The Hug orchard, near Elgin, is on a medium loam and is not irrigated. All of the orchards are cultivated except the Walker orchard where herbicides and a flail mower have been used in the past 4 years. Recently, the Walker and Willard orchards have been harvested mechanically.

Trunk diameter was usually measured annually about 15 cm above the ground and converted to cross-sectional area before performing other calculations. The relative bloom density was estimated visually. In 1971, yields were obtained in the Walker, Willard, and Cooper orchards, and estimated in the Hug orchard. In 1973, yields were estimated visually except in two cases where the method of Chaplin et al. (2) was used. Mean fruit weight was calculated from the weight of 30 or 50 fruit picked at random from each tree at harvest time. All trees in a given plot were sampled on the same day. Soluble solids was determined on a mixed sample of juice from the fruit used to determine size.

In 1971 and 1972 all of the trees were indexed on Shirofugen for necrotic ring spot virus.

Samples of mid-terminal leaves taken in August, 1970 were analyzed for P, K, Ca, Mg, Mn, Zn, Fe, B using a Jarrell-Ash emission spectrograph and for N using a micro Kjeldahl technique.

Certain data for rootstock-scion combinations present in sufficient numbers were subjected to analysis of variance and means were compared using the L.S.D.

Results and Discussion

M x M 14. At the Willard site, trees on M x M 14 roots with interstocks were consistenly so dwarf that they were removed in 1973 at the grower's request. They were also deficient in potassium (Table 1). At Walker's they were attacked by the western peach tree borer but survived, and in 1976, were less than half the size of trees on P. avium seedlings and other non-dwarfing stocks (Table 2). Trees budded directly on M x M 14 roots at Walker's and Cooper's were also dwarfed. A few of them at Cooper's which appeared to have scion rooted were not as dwarfed as the others. Trees on M x M 14 grew slowly from the time of planting. At Walker's, some of the weaker trees did not crop as regularly as controls. Young trees on M x M 14 tended to have more bloom than those of F 12/1 (Table 3). Of 53 trees planted in 1965 on M x M 14, 47 survived. Of 67 F 12/1 rooted trees, 62 survived. Trees on M x M 14 generally had lower yields and productive efficiency than on other rootstocks (Table 4). Even though trees on M x M 14 were unsatisfactory at Willard's and were attractive to borers at Walker's, this stock is of interest because of its dwarfing characteristic. Trees on M x M 14 performed reasonably well at 3 of 4 test sites, Walker's, Wilson's, and Cooper's. If a frame stock is used with M x M 14, it should be a vigorous one such as F 12/1. It would probably not be satisfactory on clayey soils.

Table 1. Potassium content % D. W. in mid-August 1970 of 'Napoleon' sweet cherry leaves, on certain root and trunk stocks. Values are means of 6 or more trees at the Willard site.

Root stock	F 12/1	Trunkstock M x M 1	OCR-1
M x M 14	1.27	1.08	1.21
M x M 18	1.81	1.71	1.72
P. avium L. sdlg.	2.01	2.06	2.04
F 12/1	1.94	1.65	1.70

M x M 39. There were only 2 trees directly on M x M 39 which were kept to maturity, one Bing and one Napoleon, both at Cooper's. Both trees were dwarf and bore excessively heavy crops at an early age. They developed a peculiar brittleness of wood, assumed a drooping growth habit, and nearly stopped growing. Although they were very productive

Table 2. Mean cross-sectional area (cm^2) in 1976 of trunks of 11 year-old sweet cherry trees on certain root and trunk stocks.

Site and cv.	Rootstock	Trunkstock F 12/1	Trunkstock M x M 1	Trunkstock OCR-1
Walker				
'Napoleon'	M x M 14[a]	162	154	117
	M x M 18	400	485	362
Walker			*P. avium* L. sdlg.	
	P. avium L. sdlg.		370	
'Corum'	M x M 14		104	
	M x M 18		271	
			(scion worked direct)	
Cooper	*P. avium* L. sdlg.		642	
'Napoleon'	F 12/1		456	
plus 'Bing'	M x M 14		357	
	M x M 18		691	

[a]L.S.D. 35. Trunk stock not significant.

Table 3. Percent of sweet cherry trees planted in 1965 with light, medium or heavy bloom in 1972 on certain rootstocks. Data from the Wilson and Cooper orchards and 'Bing' and 'Napoleon' cultivars were combined.

Rootstock	Bloom rating light	Bloom rating medium	Bloom rating heavy	No. of trees observed
P. avium L. sdlg.	29	50	21	14
F 12/1	37	47	16	19
M x M 14	0	44	56	16
M x M 18	21	52	27	33
M x M 39	0	0	100	2

Table 4. Yield in 1971 in Kg and productive efficiency (Kg cherries per cm^2 trunk cross-sectional area) of 6 or 7-year-old sweet cherry trees, on certain root and trunkstocks in 1971.

	Trunkstock F 12/1		Trunkstock M x M 1		Trunkstock OCR-1	
Rootstock	Yield	effic.	Yield	effic.	Yield	effic.
	Walker orchard, 1965 planting, 'Napoleon'					
M x M 14	21.8	0.29	12.2	0.25	10.9	0.19
M x M 18	22.7	0.20	66.7	0.38	40.8	0.27
	Willard orchard, 1966 planting, 'Napoleon'					
M x M 14	4.1	0.098	3.6	0.136	8.0	0.380
M x M 18	8.9	0.078	7.7	0.115	5.0	0.066
P. avium L. sdlg.	10.0	0.068	9.1	0.073	8.8	0.070
F 12/1	12.9	0.076	11.8	0.107	4.9	0.048

in 1971 (Table 5) their weak, drooping habit and small fruit size made them unsuitable. Except with M x M 39, fruit size did not vary appreciably between rootstocks in the M x M series. Ungrafted, M x M 39 has an extremely drooping growth habit. At Walker's, 4 trees on M x M 39 roots with M x M 1 or seedling trunk stocks began to show a drooping growth habit, less pronounced than trees directly on M x M 39, after about 8 years in the orchard. They overgrew graft union.

We conclude that this stock would not have commercial value.

OCR-2. Trees on OCR-2, except at the Hug orchard, were not much smaller than controls (Table 6), but they were precocious (Tables 7, 8). 'Lambert' trees on OCR-2 at Hug's bore heavy crops in the fifth and sixth year after which yield and growth rate declined. Fruit size and soluble solids were reduced in 1971 as a result of excess cropping (Table 8). In December, 1972 the trunks of OCR-2 rooted trees at Hug's were injured by cold on the southwest side. The other trees in the trial were not injured. By 1976 they were smaller than the other trees but still alive and bearing in proportion to their size. OCR-2 rooted trees at Nims grew slowly as did all of the other trees and did not show signs of over-cropping. 'Napoleon' on OCR-2 at Wilson's did not set excessively heavy crops and the fruit was not small. Almost all of the trees on OCR-2 gave a mild reaction for *Prunus* ring spot virus. Although OCR-2 would not be satisfactory for 'Lambert,' due to excessive fruit set, it does appear promising for 'Napoleon' and perhaps other cultivars. We are testing it in a new experiment. Some virus-negative OCR-2 wood is available.

Mahaleb clones. Trees on Mahaleb 193701 were slightly smaller than controls. 'Napoleon' on 163091 at Wilson's was less than half the size of con-

Table 5. Yield, Productive efficiency and fruit size (gms per fruit) of 7 year old sweet cherries in 1971 at the Cooper Orchard, Wasco County.

Cultivar	Rootstock	Av. total wt. in Kg/tree	Productive efficiency in Kg/cm²	Av. wt. per cherry in grams
Napoleon	M x M 18	24.0	0.10	5.0
Napoleon	M x M 39	29.0	0.30	4.5
Bing	M x M 14	8.6	0.08	8.5
Bing	M x M 18	22.2	0.11	8.5
Bing	M x M 39	51.7	0.37	—

Table 6. Mean cross-sectional area in cm² in 1976 of sweet cherry trees on certain rootstocks, 1966 plantings, disregarding cultivars.

Rootstock	Orchard		
	Wilson	Nims	Hug
OCR-2	568 (14[a])	180 (6)	262 (6)
193701	391 (3)	195 (5)	360 (3)
163091	268 (6[b])	177 (5)	373 (7)
F 12/1	830 (1)	208 (3)	398 (1)
P. avium L. sdlg.	656 (5)	—	—

[a]Number of trees in parentheses.
[b]L.S.D. OCR-2 vs. 163091 at Wilson's 117, Nims n.s., Hug's 128.

trols but 'Lambert' on this stock at Nim's and Hug's was nearly the same size as controls. At Wilson's, trees leaned with the wind and developed dark grey trunks with sun scald injury. They were precocious, but fruit weight and soluble solids were much less than controls (Table 8).

Mahaleb 163091 does not appear to be satisfactory for commercial use as a dwarfing rootstock. As with 163091, 193701 was not consistently dwarfing between sites and cultivars. These stocks were exposed to poorer soil and moisture conditions in the Wilson and Nims sites than would often be encountered. As at Hug's, the mahaleb clones would probably be satisfactory non-dwarfing understocks for average or better soils.

Trunk stocks. Trees with trunk stocks M x M 1 and OCR-1 appeared to be smaller than trees with F 12/1 trunk stocks (Table 2) but the differences were not significant. An exception was trees with M x M 18 roots and M x M 1 trunks.

If a trunk stock was desired to further reduce the vigor of trees on a dwarfing rootstock, OCR-1 or M x M 1 might be satisfactory. These trunks have withstood mechanical shaking for harvesting in the past two or three seasons.

Only the most obvious differences between understocks were observable in these trials because there were so few trees of any given combination per test site and because of the large variability within some of the plots. Since much variability in tree performance associated with rootstocks was observed, further research, especially with hybrids of *P. avium* x *P. mahaleb*, might discover other rootstock clones of interest.

Table 7. Percent of sweet cherry trees planted in 1966 with light, medium or heavy bloom in 1971 on certain rootstock. Data from the Wilson, Nims, and Hug orchards and cultivars 'Lambert' and 'Napoleon' were combined.

Rootstock	Bloom rating light	medium	heavy	No. of trees observed
OCR-2	4	38	58	26
193701	25	33	42	12
163091	24	43	33	21
F 12/1	33	50	17	6

Table 8. Visual estimate of yield per tree, weight per fruit and percent soluble solids of sweet cherries, on certain rootstocks.

Rootstock	Yield estimate Kg/tree	Fruit weight grams	Soluble solids percent
	1971, Hug orchard, cv 'Lambert'		
OCR-2	64	4	13
193701	24	6	15
163091	15	6	17
F 12/1	11	5	17
	1972, Wilson orchard, cv 'Napoleon'		
OCR-2	20	7	15
OCR-3	1	6	16
193701	11	6	15
163091	12	3	13

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Compact Sweet Cherries[1]

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Many breeding programs throughout the world have the objective of developing compact sweet cherry varieties. The advantages of them are precosity, efficiency of picking, smaller size than standards and a thick canopy of leaves which shields the fruit from sun and rain. Several compact varieties are being tested commercially and may soon be widely grown. This article describes the origin and growth habit of a number of compact varieties and selections.

The term 'compact' is used in the title of this report but other words have also been used to describe varieties with restricting growth habit. Compact varieties sometimes refers to those originating from induced mutations; spur varieties, those originating from natural mutations. Genetic dwarfs occur in most seedling populations but are of little interest because of extreme stunting, sterility and leaves which are rugose and chlorotic. Brachytic (3) and dwarf are other terms which have been used.

Breeders have used several approaches to obtain compact cherries, the most successful involving irradiation to induce mutations artificially. Programs using this technique are active or being considered in several European countries and in North America. Several varieties have been developed using mutation breeding, and other selected mutants have been used for conventional breeding. Induced cherry mutants have been unstable in the past but advances in methodology should reduce or eliminate this problem.

Conventional cherry breeding methods (2) have also been used. The genetic variability of *Prunus avium* and related species is considerable and compact seedlings have been selected, however, no compact varieties have been developed this way. Seedlings have the advantage of allowing

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