Evaluation of Potential New, Size Controlling Rootstocks for European Pears

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ABSTRACT

The Multi-state Research Project NC-140, "Improving Economic and Environmental Sustainability in Tree Fruit Production Through Changes in Rootstock Use", was established in the late 1980s. The first multi-state pear trial was established in 1987 and subsequent ones in 2004-2006. Three trials were planted in California in April 2005: Bartlett in Mendocino (loam) and Sacramento (clay) Counties and 'Golden Russet' Bosc in Mendocino County (loam). Trial design in California is the standard NC-140 configuration of randomized complete block (RCB) with 10 single tree replicates. Rootstocks include 708-36 (OR), BM2000 (Australia), Fox 11 (Italy), Horner 4 (Oregon), OHxF69 (Oregon) (Mendocino Bartlett only), and OHxF87 (Oregon), Pyro-233 and Pyrodwarf (both Germany). The Sacramento trial was abandoned after 2009, thus no data is presented herein. Survival rate in Mendocino County ranges from 60-100%, with Fox 11 having the most losses. For Bartletts, 2010 flower clusters and yields increased 28 and 87% from 2009, respectively. Horner-4 yielded the most and 708-36 the least. For Bosc, OHxF 87 had the most flower clusters, number of fruit, and highest yield, and Pyro 2-33 the fewest flowers, least number of fruit and lowest yield. 2010 was the sixth season of the 10 year trial; data will be collected in 2011 and a 5-year report (2005-2009) covering California (Mendocino and Sacramento), Washington, New York, Nova Scotia, Canada and Chihuahua, Mexico is being completed.

INTRODUCTION

There are very few commercially viable size controlling rootstocks for pears. Quince rootstock is widely used in Europe, but has only been successfully employed in the U.S. as a rootstock for Comice. The Old Home x Farmingdale (Brooks®) series offers several potential options that have only recently been re-explored. The two OHxF selections most offered by major wholesale nurseries are 97 and 87 (333 is generally sold to homeowners). 97 is a large tree (though more precocious than *P. betulaefolia*), similar to Winter Nelis. 87 is a smaller tree, but has been shown to produce small fruit in some locations. Data from California, and more recently Washington, has suggested that OHxF69, which has yet to become widely commercially available, may also be promising, particularly for Bosc (Elkins and DeJong, 2002, Elkins et al., 2008).

The NC-140 Regional Rootstock Research Project (*www.NC-140.org*) is a federally-supported, multi-state project for perennial fruit and nut crops. The goal is to disseminate information generated from long-term trials throughout the U.S. Each participating state (as well as Canada and Mexico) establishes and evaluates similar ("uniform") trials using the same rootstocks and similar plot design so that regional differences can be determined. Progress and results are shared at an annual meeting and via the NC-140 website. Each state submits an annual report which is distributed at the meeting which are then compiled into a national report for USDA. Data is also shared with nurseries and growers who can select rootstocks suitable to their location and customer base. California has long participated in NC-140 for apples and peaches and began participating actively in pears in 2005.

In coordination with Oregon, Washington, and New York, three new NC-140 trials were established in California in spring 2005, two in Talmage, Mendocino County (Bartlett and Golden Russet Bosc (5' x 10' spacing), and one in Courtland (9' x 15' spacing). Trees were grown by Fowler Nurseries, Inc. in Newcastle, California. The Courtland trial was abandoned after 2009, leaving the two Mendocino

County trials in place. Rootstock and cultivar selections for the existing 2005 California and Northwest NC-140 pear plantings are shown in Table 1.

The NC-140 trials are currently the **only bearing *replicated*** rootstock trials in California and the Talmage Bartlett trial is the only one planted in 2005 that includes OHxF69.

The ultimate objective of the trial, as for all NC-140 trials, is to select the best potential candidates for future increased propagation and industry use. The information they provide will contribute to planting decisions, particularly for new, high density planting systems (the Talmage trial is planted at 871 trees per acre and is on very fertile soil). 2009 and 2010 continuing objectives were to evaluate rootstocks for size, vigor, growth habit, productivity, compatibility with major varieties, susceptibility to diseases and pests, propensity to sucker, etc. with the ultimate goal of finding potential precocious, size-controlling rootstocks for pear orchards in northern California.

MATERIALS AND METHODS

Trials were planted in Mendocino County, California in April 2005. Design was randomized complete block, with 10 single tree replicates per rootstock. Data collection and calculation from 2005-2010 included number of flower clusters, number of fruit, tree height, trunk cross sectional area (TCSA), yield, yield efficiency, number of root suckers, and % survival. 2010 data at the Talmage site also included °Brix and firmness (kg).

RESULTS AND DISCUSSION

2005 Bartlett Pear Rootstock Planting

1) North Coast - Talmage, Mendocino County, Cole loam (Tables 2-5)

The rootstock regrowth of one OHxF 69 tree that died back in 2009 fruited, suggesting a high level of precocity. Overall, 2010 flowering increased by 28%, fruiting by 99%, and tree yield by 87% compared to 2009. Fruit size decreased by 2% and fruit was generally small (less than 200 grams), typical for the season due to cold spring weather which delayed fruit development. Horner 4 and BM 2000 had the most flower clusters, and Horner 4 the most fruit and nearly twice the average yield of other rootstocks. 708-36 and Pyro 2-33 had the least number of flower clusters, and 708-36 the least number of fruit. TCSA increased 30%, with Horner 4 having the largest and 708-36 the smallest TCSA. Horner 4 yield was highest and 708-36 lowest. High yield efficiencies reflected relatively small tree size and heavy crop load. Overall yield efficiency increased 67%, with Pyrodwarf and BM 2000 having the highest and OHxF 69 the lowest. Interestingly, Horner 4 yield efficiency was relatively high (0.68 kg/cm^2) given its vigor (42.6 cm^2 TCSA). 708-36 fruit was the firmest and among the sweetest, while Horner 4 fruit was the softest and least sweet, perhaps due to its greater vigor.

Compared to cumulative 2005-2009 yields, 2010 yields increased appreciably for BM2000 (68%), Pyro 2-33 (44%), Horner 4 (39%), Pyrodwarf (38%), and. Fox 11 (37.5%). OHxF69 had a modest increase (21%) and OHxF87 (1.7%) and 708-36 (-32%) yields stayed static or actually declined. 2011 yields will provide insight into whether stagnating or declining yields are due to 1) reaching full crop load potential, 2) declining vigor or health, or 3) weather-related phenology effects during bloom and early fruit set. Average fruit size has been equal for all rootstocks, hence it is difficult thus far to implicate fruit size, leaving number of fruit as the major discernible factor.

2005 'Golden Russet' Bosc Pear Rootstock Planting

1) North Coast-Talmage, Mendocino County; Pinole-Yokayo-Redvine sandy loam (Tables 3-9)

Survival is less than in the Bartlett trial. One BM 2000 tree died in 2010. Yields have thus far been much less than Bartlett yields. Flower clusters increased by 55%, number of fruit by 202%, and yield by 196% compared to 2009. The only significant difference in 2010 was in yield efficiency (although individual TCSA and yield averages were equal). Efficiencies were low overall but OHxF87 was the most efficient and Horner 4 the least. There were no significant differences among rootstocks for firmness, °Brix, or russeting.

WORK PLANNED FOR 2011 - Data collection and rootstock evaluation will continue from 2011-2014. Procedures will continue to follow the guidelines established by the NC-140 Technical Committee. A 5-year summary of results from the Bartlett and Bosc trials in California, Chihuahua (Mexico), New York, and Washington (Tonasket) was presented at the ISHS International Pear Symposium in Neuquen, Patagonia, Argentina in November 2010 and is being summarized for publication.

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Table 1: Current locations and included rootstocks, NC-140 pear rootstock trials, California, Oregon and Washington, 2005 plantings.

Rootstock	Origin	2005 Talmage Bartlett	2005 Talmage Bosc	2005 MCAREC[1] Anjou	2005 Cashmere Anjou	2005 Tonasket Bosc
28-119	France			x		
708-36	UK	x	x	x		
BM 2000	Australia	x	x	x	x	x
BU-2	Germany			x	x	
BU-3	Germany				x	
Fox 11	Italy	x	x	x	x	
Horner 4	Hood River, OR	x	x	x	x	x
OHxF 69	Oregon	x				
OHxF 87	Oregon	x	x	x	x	x
Pyro 2-33	Germany	x	x	x		x
Pyrodwarf	Germany	x	x	x	x	x

[1] Mid-Columbia Agricultural Research and Extension Center, Hood River, Oregon
[2] abandoned due to fire blight

Table 2: Cumulative effects of 2005 NC-140 rootstock planting on average fruit size, trunk cross sectional area, size, tree yield, yield efficiency, root suckers and tree survival of 5th leaf Bartlett pear trees, Talmage, California, 2005-2009.

	Average Fruit Size (g/fruit)	Average Cumulative Yield (kg/tree)	2009 TCSA (cm^2)	Average Cumulative Yield Efficiency[3] (kg/cm^2)	Root Suckers (cumulative no./tree)	Tree Survival (%)
ROOTSTOCK[1]						
708-36	161	8.3 bc	14.0 c	0.57 ab	0.0 b	90 ab
BM 2000	162	6.2 c	17.6 bc	0.34 b	0.1 ab	100 a
Horner-4	190	16.9 a	34.0 a	0.49 ab	0.0 b	100 a
Fox 11	185	8.0 bc	17.1 bc	0.48 ab	0.2 a	80 bc
OHxF 69	141	8.5 bc	20.9 b	0.34 b	0.1 ab	100 a
OHxF 87	164	11.4 b	16.9 bc	0.68 a	0.0 b	100 a
Pyrodwarf	161	9.6 bc	16.6 c	0.56 ab	0.0 b	90 ab
Pyro 2-33	183	7.6 bc	16.1 c	0.45 ab	0.0 b	70 c
ANOVA[2]						
Rootstock	NS	***	***	***	*	***
Block	NS	***	*	*	NS	***

[1] Within columns, rootstock treatment means significantly different (Tukey HSD test, $P<0.05$). Duncan multiple range test for SQRT (root suckers+1).
[2] *, **, *** Indicate significance at $P<0.05$, 0.01, and 0.001 respectively. NS indicates not significant $P>0.05$.
[3] Based on cumulative yield (2005-09) and final TCSA (2009).

Table 3: Effects of 2005 NC-140 rootstock planting on flower clusters, number and size of fruit, trunk cross sectional area, yield, yield efficiency, tree height, root suckers, and tree survival among 4-year-old (5th leaf) Bartlett pear trees, Talmage, California, 2009.

	Flower Clusters 4/22/09 (no./tree)	No. Fruit 8/20/09	Fruit Size 8/20/09 (g/fruit)	Yield 8/20/09 (kg/tree)	TCSA 11/12/09 (cm^2)	Yield Efficiency (kg/cm^2)	Tree Height 11/12/09 (cm)	Root Suckers 11/12/09 (no./tree)	Tree Survival 11/12/09 (%/10 trees)
ROOTSTOCK[1]									
708-36	104	48 ab	144 b	7.7 b	14.0 c	0.42	239 bc	0.0	90
BM 2000	110	30 b	174 ab	5.3 b	17.6 bc	0.29	265 ab	0.2	100
Horner-4	143	74 a	187 a	13.8 a	34.0 a	0.40	289 a	0.0	100
Fox 11	90	44 b	164 ab	7.2 b	17.6 bc	0.34	253 bc	0.2	80
OHxF 69	158	48 ab	154 b	7.4 b	20.4 b	0.30	233 bc	0.0	100
OHxF 87	142	54 ab	154 b	8.3 b	16.9 bc	0.50	238 bc	0.0	100
Pyrodwarf	120	46 ab	155 b	7.1 b	16.9 bc	0.35	246 bc	0.0	90
Pyro 2-33	136	38 b	167 ab	6.3 b	13.6 c	0.28	225 c	0.1	70
ANOVA[2]									
Rootstock	NS	**	**	***	***	NS	***	NS	
Block	NS	*	NS	*	NS	NS	NS	NS	

[1] Within columns, rootstock treatment means significantly different (Tukey HSD test, $P \leq 0.05$).
[2] *, **, *** Indicate significance at $P \leq 0.05$, 0.01, and 0.001 respectively. NS indicates not significant $P > 0.05$.

Table 4: Effects of 2005 NC-140 rootstock planting on flower clusters, number and size of fruit, yield, truck cross-sectional area, yield efficiency, tree height, root suckers, and tree survival among 5 year-old (6th leaf) Bartlett pear trees, Talmage, California, 2010.

	Flower Clusters 4/22/10 (no./tree)	No. Fruit 8/29/10	Fruit Size 8/29/10 (g/fruit)	Yield 8/29/10 (kg/tree)	TCSA 11/03/10 (cm^2)	Yield Efficiency (kg/cm^2)	Tree Height[3] 11/05/10 (cm)	Root Suckers 11/03/10 (no./tree)	Tree Survival 8/29/10 (%/10 trees)
ROOTSTOCK[1]									
708-36	111 b	50 c	158	6.3 d	15.8 d	0.41 bc	226 c	0.1	90
BM 2000	204 a	117 b	168	19.2 b	25.1 bc	0.76 a	264 ab	0.6	100
Horner-4	233 a	170 a	169	28.0 a	42.6 a	0.68 ab	269 a	0.1	100
Fox 11	146 ab	82 bc	161	12.8 bcd	21.5 bcd	0.59 abc	250 abc	0.7	80
OHxF 69	154 ab	74 bc	133	10.7 cd	28.7 b	0.33 c	246 abc	1.1	90
OHxF 87	162 ab	77 bc	154	11.6 cd	19.7 cd	0.61 abc	230 c	0.2	100
Pyrodwarf	169 ab	110 b	142	15.5 bc	20.9 bcd	0.78 a	245 abc	0.0	90
Pyro 2-33	103 b	78 bc	193	13.6 bcd	21.8 bcd	0.65 abc	239 bc	0.0	70
ANOVA[2]									
Rootstock	***	***	NS	***	***	***	***	NS	
Block	NS	**	NS	**	**	NS	NS	NS	

[1] Within columns, rootstock treatment means significantly different (Tukey HSD test, $P \leq 0.05$).
[2] *, **, *** Indicate significance at $P \leq 0.05$, 0.01, and 0.001 respectively. NS indicates not significant $P > 0.05$.

Table 5: Effects of 2005 NC-140 rootstock planting on fruit firmness and sugar among 5-year-old

(6th leaf) Bartlett pear trees, Talmage, California, 2010.

	Firmness (lb) 8/30/10	Brix (degrees) 8/30/10
ROOTSTOCK[1]		
708-36	20.5 a	14.3 ab
BM 2000	17.9 bc	13.3 bc
Horner-4	17.2 c	12.9 c
Fox 11	19.1 ab	13.5 bc
OHxF 69	19.1 abc	13.6 bc
OHxF 87	18.2 bc	15.1 a
Pyrodwarf	18.8 abc	14.5 ab
Pyro 2-33	18.6 abc	14.1 abc
ANOVA[2]		
Rootstock	***	***
Block	*	NS

[1] Within columns, rootstock treatment means significantly different (Tukey HSD test, P≤0.05).
[2] *, **, *** Indicate significance at P≤0.05, 0.01, and 0.001 respectively. NS indicates not significant P>0.05

Table 6: Cumulative effects of 2005 NC-140 rootstock planting on average fruit size, trunk cross sectional area, size, tree yield, yield efficiency, root suckers and tree survival of 5th leaf 'Golden Russet' Bosc pear trees, Talmage, California, 2005-2009.

	Average Fruit Size (g/fruit)	Average Cumulative Yield (kg/tree)	2009 TCSA (cm^2)	Average Cumulative Yield Efficiency[3] (kg/cm^2)	Root Suckers (cumulative no./tree)	Tree Survival (%)
ROOTSTOCK[1]						
708-36	160	3.7 ab	18.6	0.21 ab	0.2	80 abc
BM 2000	80	0.7 b	16.3	0.02 b	0.2	70 bc
Horner-4	142	3.5 ab	23.2	0.14 b	0.7	100 a
Fox 11	149	2.7 ab	18.1	0.11 b	0.2	62 c
OHxF 87	165	6.9 a	18.2	0.36 a	0.1	80 abc
Pyrodwarf	167	2.8 ab	18.5	0.15 b	0.0	90 ab
Pyro 2-33	126	1.9 b	16.6	0.11 b	0.0	84 ab
ANOVA[2]						
Rootstock	NS	*	NS	***	NS	***
Block	NS	NS	NS	NS	NS	***

[1] Within columns, rootstock treatment means significantly different (Tukey HSD test, P≤0.05).
[2] *, **, *** Indicate significance at P≤0.05, 0.01, and 0.001 respectively. NS indicates not significant

Table 7: Effects of 2005 NC-140 rootstock planting on flower clusters, number and size of fruit, trunk cross sectional area, yield, yield efficiency, tree height, root suckers, and tree survival among 4-year-old (5th leaf) Bosc pear trees, Talmage, California, 2009.

	Flower Clusters 4/22/09 (no./tree)	No. Fruit 9/10/09	Fruit Size 9/10/09 (g/fruit)	Tree Yield 9/10/09 (kg/tree)	TCSA 11/12/09 (cm^2)	Yield Efficiency (kg/cm^2)	Tree Height 11/12/09 (cm)	Root Suckers 11/12/09 (no./tree)	Tree Survival 11/12/09 (%/10 trees)
ROOTSTOCK[1]									
708-36	31 ab	11 ab	194 ab	2.2 ab	16.9	0.15 ab	273	0.0	80
BM 2000	17 b	2 b	221 a	0.5 b	15.7	0.04 b	293	0.1	70
Horner-4	24 ab	14 ab	190 ab	2.7 ab	23.2	0.20 b	308	0.5	100
Fox 11	7 b	2 b	192 ab	0.5 b	17.0	0.05 b	287	0.1	60
OHxF 87	48 a	21 a	186 ab	4.0 a	17.9	0.27 a	245	0.0	80
Pyrodwarf	21 ab	11 ab	189 ab	2.0 ab	19.1	0.11 b	274	0.0	90
Pyro 2-33	21 ab	8 ab	183 b	1.5 ab	16.5	0.11 b	291	0.0	80
ANOVA[2]									
Rootstock	**	**	*	**	NS	**	NS	NS	
Block	NS	NS	*	NS	*	NS	NS	NS	

[1] Within columns, rootstock treatment means significantly different (Tukey HSD test, $P \leq 0.05$).
[2] *, **, *** Indicate significance at $P \leq 0.05$, 0.01, and 0.001 respectively. NS indicates not significant $P > 0.05$

Table 8: Effects of 2005 NC-140 rootstock planting on flower clusters, number and size of fruit, yield, truck cross-sectional area, yield efficiency, tree height, root suckers, and tree survival among 5-year-old (6th leaf) Bosc pear trees, Talmage, California, 2010.

	Flower Clusters 4/23/10 (no./tree)	No. Fruit 9/15/10	Fruit Size 9/15/10 (g/fruit)	Tree Yield 9/15/10 (kg/tree)	TCSA 11/03/10 (cm^2)	Yield Efficiency[3] (kg/cm^2)	Tree Height 11/05/10 (cm)	Root Suckers 11/03/10 (no./tree)	Tree Survival 9/15/10 (%/10 trees)
ROOTSTOCK[1]									
708-36	51	41	147	7.8	24.9	0.27 ab	260 ab	0.0	80
BM 2000	27	20	185	3.5	29.3	0.14 ab	284 a	0.2	60
Horner-4	24	23	193	4.4	36.8	0.12 b	285 a	0.1	100
Fox 11	43	33	152	5.6	28.5	0.16 ab	285 a	0.1	60
OHxF 87	58	45	186	8.8	25.4	0.31 a	247 b	0.0	80
Pyrodwarf	38	31	182	5.9	28.7	0.20 ab	272 ab	0.0	90
Pyro 2-33	22	23	163	3.5	25.2	0.14 ab	268 ab	0.0	80
ANOVA[2]									
Rootstock	NS	NS	NS	NS	NS	*	**	NS	
Block	NS	NS	*	NS	NS	NS	*	NS	

[1] Within columns, rootstock treatment means not significantly different (Tukey HSD test, $P \leq 0.05$).
[2] *, **, *** Indicate significance at $P \leq 0.05$, 0.01, and 0.001 respectively. NS indicates not significant $P > 0.05$.

[3] Tukey HSD test, $P \leq 0.10$

Table 9: Effects of 2005 NC-140 rootstock planting on fruit firmness, sugar and rating among 5-year-old (6th leaf) Bosc pear trees, Talmage, California, 2010.

	Firmness (lb) 9/16/10	Brix (degrees) 9/16/10	Rating (Russeting) 9/16/10
ROOTSTOCK[1]			
708-36	17.4	11.7	2.4
BM 2000	16.8	14.3	2.4
Horner-4	17.4	13.8	2.5
Fox 11	17.7	10.8	2.4
OHxF 87	17.9	14.8	3.3
Pyrodwarf	18.3	14.5	2.5
Pyro 2-33	19.2	12.3	2.2
ANOVA[2]			
Rootstock	NS	NS	NS
Block	***	NS	NS

[1] Within columns, rootstock treatment means significantly different (Tukey HSD test, $P \leq 0.05$)
[2] NS indicates not significant $P > 0.05$.