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 was the standard NC-140 configuration of randomized complete block (RCB) with 10 single tree replicates. Rootstocks included 708-36 (OR), BM2000 (Australia), Fox 11 (Italy), Horner 4 (Oregon), OHxF69 (Oregon) (Mendocino Bartlett only), OHxF87 (Oregon), Pyro-233 and Pyrodwarf (both Germany). The Sacramento trial was abandoned after 2009, and the final trial data presented in the 2010 report. Survival rate in Mendocino County ranges from 60-100%, with Fox 11 having the most losses. In 2011, Bartlett yields increased 38% from 2010. Horner 4 had the largest and most fruit, yielded the most, and had comparable yield efficiencies to most rootstocks. 708-36 had the least number of fruit. OHxF 87 had the smallest fruit, and Pyrodwarf the highest yield efficiency. For Bosc, Horner 4 had the largest fruit and highest yield, Fox 11 the least number of fruit and lowest yield, and 708-36 the smallest fruit. 708-36 had the highest soluble solids and Horner 4 the lowest. 2011 was the seventh season of the 10 year trial; data collection will continue through 2014. A 5-year report (2005-2009) summarizing California (Mendocino and Sacramento), Washington, New York, Nova Scotia, Canada and Chihuahua, Mexico was presented and published.

INTRODUCTION AND OBJECTIVES

There are very few commercially viable size controlling rootstocks for pear. Quince rootstock is widely used in Europe interstemmed with Old Home or Beurre Hardy, but is only being employed in the U.S. as a rootstock for Comice due to its incompatibility with other cultivars. The Old Home x Farmingdale (Brooks®) series offers several potential options that have only recently been re-explored. The two OHxF selections currently most offered by major wholesale nurseries are 97 and 87 (333 is generally sold to homeowners). 97 is a large tree similar to Winter Nelis, though more precocious than *P. betulaefolia*). 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 limited commercial availability, may also be promising, particularly for Bosc, but is difficult to propagate by hardwood cuttings (Elkins and DeJong, 2002, Elkins et al., 2008, Elkins and DeJong, 2011).

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. Researchers share progress and results at the annual meeting and via the NC-140 website. Each state representative submits an annual report which is distributed at the meeting and then compiled into a national report for USDA and posted on the NC-140 website for public use. Data is also shared with nurseries and growers who can then 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, Sacramento County, (Bartlett, 9' x 15' spacing). Rootstock liners were propagated by Meadow Lake Nursery, McMinnville, Oregon. They were then grafted and grown by Fowler Nurseries, Inc., 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 available candidates for future increased propagation and industry use. The information they are providing will contribute to future 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). The 2011 continuing objective was 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.

PROCEDURES

Trials were planted in Talmage (Ukiah Valley), Mendocino County, California in April 2005. Design was randomized complete block, with 10 single tree replicates per rootstock. Data collection and calculation from 2005-2011 included number of flower clusters (2005-2010), number of fruit, tree height, trunk cross sectional area (TCSA), yield, yield efficiency, number of root suckers, and % survival. 2010 and 2011 data at the Talmage site also included firmness (kg) and soluble solids (°Brix).

RESULTS AND DISCUSSION

2005 Bartlett Pear Rootstock Planting

2011 results (Tables 2-3)

No trees were lost in 2011. Overall fruiting increased by 28% and tree yield by 38% from 2010. Fruit size decreased by 6%, with fruit generally remaining small (less than 200 grams) due to another late growing season. The large crop was reflected in the high yield efficiencies. Horner 4 had the largest fruit, most fruit, highest yield and yield efficiencies comparable to most of the other rootstocks. 708-36 had the least number of fruit and lowest yield. OHxF 87 had the smallest fruit. TCSA increased 16% compared to 2010, with Horner 4 being the largest and 708-36 the smallest trees. Overall, yield efficiency increased 19%, with Pyrodwarf and Fox 11 having the greatest and OHxF 69 the lowest. There were few root suckers and no significant differences in fruit firmness or soluble solids (although Horner 4 had the lowest soluble solids in 2010).

2005-2011 cumulative results (Table 4)

Tree survival – Trees were lost only in the first two years. Biggest losses were with Pyro 2-33 (3) and Fox 11 (2). There have been no losses of BM2000, Horner 4, and OHxF 87.

Tree size and vigor – Horner 4 trees are nearly twice as large as others. 708-36 trees are the smallest; the others are equal in size.

Cumulative yield and yield efficiency – Horner 4 has yielded nearly twice as much as the next highest yielding rootstocks, Pyrodwarf and BM2000. 708-36 has yielded the lowest and all others have yielded equally. There are slightly less differences in yield efficiency, with Pyrodwarf having the highest. Despite its vigor, Horner 4 has had statistically equal efficiency to most other rootstocks due to its high yields. OHxF 69 has had the lowest efficiency, indicating poor yield. This is in contrast with past results with 'Golden Russet' Bosc (Elkins and DeJong, 2011) and data from other locations (Auvil, 2005). OHxF 69 trees have expressed poor vigor, bark cracking, and dieback of as-yet undefined origin at this location. Lack of juvenility, a known characteristic attributed to some clonal rootstocks, is one possible cause being currently being addressed by industry-supported research. OHxF 69 liners readily flower soon after planting in the nursery, suggesting lack of juvenility, which may in turn, reduce grafted tree vigor.

Fruit size – Average fruit size has been relatively small (<200 grams). This is partly due to recent very late growing seasons which have reduced growing time. Most of these rootstocks have also been selected for lower vigor and fruit thinning may be required to enable large fruit in some cases. Horner 4 has the largest fruit thus far, while OHxF 69, OHxF 87, and Pyrodwarf had the smallest.

Root suckers – There have been very few root suckers at this location. Only Fox 11 has had more than 2 per tree, although both BM2000 and OHxF 69 have had more than 1. This contrasts with profuse suckering of Pyrodwarf in Wenatchee, Washington.

2005 'Golden Russet' Bosc Pear Rootstock Planting

2011 results (Tables 5-6)

Overall survival is less than in the Bartlett trial with no changes in 2011. The number of fruit increased by 239%, and yield by 191% from 2010. Overall fruit size decreased by 6%, the norm due to the long, cold spring which delayed fruit growth. Only TCSA differed significantly; Horner 4 had the largest TCSA and OHxF 87 and 708-36 the smallest. There were very few root suckers, even less than in 2010. Soluble solids were highest for 708-36 and lowest for Horner 4.

2005-2011 cumulative results (Table 7)

Tree survival – Horner 4 is the only selection with 100% survival, although there were no statistical differences among rootstocks.

Tree size and vigor – As with Bartlett, Horner 4 trees are the largest, but there is less difference among selections than for Bartlett. This may be related to the relatively low crop load on the Bosc versus Bartlett trees. Pyrodwarf and Pyro 2-33 are the smallest trees, and OHxF 87 is also quite small.

Cumulative yield and yield efficiency – Overall yields have been about half those of Bartlett. OHxF 87 has had the highest and nearly double the yield efficiency of most other rootstocks. OHxF 69 was not included in the Bosc trial so cultivar performance cannot be compared with Bartlett.

Fruit size – There have been no differences among rootstocks. Average fruit size has been very low, suggesting overall low vigor and late seasonal development.

Root suckers – There have been no difference among rootstocks, however, Horner 4 averaged more than 1 per tree.

WORK PLANNED FOR 2012 – Cumulative 5-year results were presented at the XI International Pear Symposium in Neuguen, Argentina and published in *Acta* Horticulturae 909 in December 2011. Data collection and rootstock evaluation will continue through 2014. Procedures will again follow guidelines established by the NC140 Technical Committee.

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Table 1: Locations and included rootstocks, NC140 pear rootstock trials, Oregon and Washington, 2005 and 2006 plantings.

Rootstock	Origin	2005 MCAREC[1] Anjou	2005 Cashmere Anjou	2005 Tonasket Bosc	2005 Yakima Bartlett	2006 MCAREC Anjou	2006 Cashmere Anjou	2006 Tonasket Bosc	2006 Yakima Bartlett
28-119	France	x							
Pyriam (OH-11)	France					x	x	x	x
P-2532	France					x	x	x	x
Bet 2291	China					x	x	x	x
BM 2000	Australia	x	x	x	x				
BU-2	Germany	x	x						
BU-3	Germany		x						
Fox 11	Italy	x	x		x	x	x	x	
Horner 4	Hood River, OR	x	x	x	x	x	x	x	x
OHxF 69	Oregon								x
OHxF 87	Oregon	x	x	x	x	x	x	x	x
Pyro 2-33	Germany	x		x					
Pyrodwarf	Germany	x	x	x	x				

[1] Mid-Columbia Agricultural Research and Extension Center, Hood River, Oregon

Table 2: Effects of 2005 NC-140 rootstock planting on number and size of fruit, tree yield, tree growth, root suckers, and tree survival among 6-year-old (7th leaf) Bartlett pear trees, Talmage, Mendocino County, California, 2011.

	No. Fruit 9/3-5/11	Fruit Size 9/3-5/11 (g/fruit)	Yield 9/3-5/11 (kg/tree)	TCSA 10/20/11 (cm^2)	Yield Efficiency (kg/cm^2)	Tree Height 10/20/11 (cm)	Root Suckers 10/20/11 (no./tree)	Tree Survival 9/3/11 (%/10 trees)
ROOTSTOCK[1]								
708-36	84 b	159 ab	12.1 c	19.3 c	0.61 ab	217 c	0.1	90
BM 2000	120 b	177 ab	21.0 b	29.2 b	0.74 ab	269 ab	0.3	100
Horner 4	194 a	193 a	37.0 a	52.4 a	0.71 ab	285 a	0.0	100
Fox 11	125 b	176 ab	21.6 b	27.1 bc	0.81 ab	250 abc	0.9	80
OHxF 69	100 b	162 ab	15.6 bc	27.5 bc	0.56 b	240 bc	0.0	90
OHxF 87	104 b	154 b	15.6 bc	21.8 bc	0.71 ab	230 c	0.0	100
Pyrodwarf	131b	161 ab	20.7 b	24.1 bc	0.87 a	243 bc	0.0	90
Pyro 2-33	114 b	172 ab	19.2 bc	25.6 bc	0.74 ab	238 bc	0.0	70
ANOVA[2]								
Rootstock	***	*	***	***	*	***	NS	
Block	NS	NS	*	*	NS	*	NS	

[1] Within columns, rootstock treatment means significantly different (Tukey HSD test, $P \leq 0.05$). Root sucker data normalized using SQRT (root sucker+0.5) for p-value.

[2] *, **, *** Indicate significance at $P \leq 0.05$, 0.01, and 0.001 respectively. NS indicates not significant $P > 0.05$.

Table 3: Effects of 2005 NC-140 rootstock planting on firmness and Brix among 6-year-old (7th leaf) Bartlett pear trees, Talmage, California, 2011.

	Pressure (kg) 9/3 & 6/11	Brix (degrees) 9/3 & 6/11
ROOTSTOCK[1]		
708-36	7.1	13.2
BM 2000	7.1	12.6
Horner 4	7.1	12.6
Fox 11	7.3	13.0
OHxF 69	7.2	13.0
OHxF 87	7.0	13.9
Pyrodwarf	7.1	13.4
Pyro 2-33	7.1	13.2
ANOVA[2]		
Rootstock	NS	NS
Block	NS	NS

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

Table 4: Cumulative effects of 2005 NC-140 rootstock planting on tree survival, trunk cross-sectional area, tree yield, average fruit size, yield efficiency and root suckers of 7th leaf Bartlett pear trees, Talmage, Mendocino County, California, 2005-2011.

	Tree Survival (%)	2011 TCSA (cm^2)	Average Cumulative Yield (kg)	Average Fruit Size (g)	Average Cumulative Yield Efficiency[3] (kg/cm^2)	Root Suckers (Cum. no./tree)
ROOTSTOCK[1]						
708-36	90 ab	19.3 c	26.7 c	160 ab	1.36 bc	0.0 b
BM 2000	100 a	29.2 b	46.3 b	168 ab	1.60 abc	1.4 ab
Horner 4	100 a	52.4 a	82.4 a	185 a	1.58 abc	0.1 b
Fox 11	80 ab	27.1 bc	42.4 bc	177 ab	1.58 abc	2.3 a
OHxF 69	90 ab	27.5 bc	34.8 bc	156 b	1.23 c	1.9 ab
OHxF 87	100 a	21.8 bc	38.5 bc	159 b	1.79 ab	0.3 ab
Pyrodwarf	90 ab	24.1 bc	45.8 b	157 b	1.92 a	0.0 b
Pyro 2-33	70 b	25.6 bc	40.4 bc	182 ab	1.56 abc	0.0 b
ANOVA[2]						
Rootstock	NS	***	***	*	**	**
Block	NS	*	***	NS	NS	NS

[1] Within columns, rootstock treatment means significantly different (Tukey HSD test, P≤0.05). Root sucker data normalized using SQRT (root suckers+0.5) for P-value; Duncan test for multiple range.

[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 (2005-11) and final TCSA (2011).

Table 5: Effects of 2005 NC-140 rootstock planting on number and size of fruit, tree yield, tree growth, root suckers, and tree survival among 6-year-old (7th leaf) 'Golden Russet' Bosc pear trees, Talmage, Mendocino County, California, 2011.

	No. Fruit 9/29/11	Fruit Size 9/29/11 (g/fruit)	Tree Yield 9/29/11 (kg/tree)	TCSA 10/20/11 (cm^2)	Yield Efficiency (kg/cm^2)	Tree Height 10/20/11 (cm)	Root Suckers 10/20/11 (no./tree)	Tree Survival 9/29/11 (%/10 trees)
ROOTSTOCK[1]								
708-36	97.4	145	14.2	30.0 b	0.41	260	0.0	80
BM 2000	98.3	168	16.7	34.6 ab	0.52	268	0.0	70
Horner 4	103.9	190	18.1	46.5 a	0.39	277	0.2	100
Fox 11	83.3	172	13.9	35.7 ab	0.41	267	0.0	60
OHxF 87	113.2	147	16.9	29.8 b	0.55	250	0.0	80
Pyrodwarf	113.9	155	17.6	36.2 ab	0.49	268	0.0	90
Pyro 2-33	106.5	157	16.8	32.9 ab	0.52	266	0.0	80
ANOVA[2]								
Rootstock	NS	NS	NS	*	NS	NS	NS	
Block	*	NS	*	NS	NS	NS	NS	

[1] Within columns, rootstock treatment means not significantly different (Tukey HSD test, $P \leq 0.05$). Root sucker data normalized using SQRT (root suckers+0.5) for P-value.

[2] *, **, *** Indicate significance at $P \leq 0.05$, 0.01, and 0.001 respectively. NS indicates not significant $P > 0.05$

Table 6: Effects of 2005 NC-140 rootstock planting on firmness, Brix and rating among 6-year-old (7^{th} leaf) 'Golden Russet' Bosc pear trees, Talmage, California, 2011.

	Pressure (kg) 9/29/11	Brix (degrees) 9/29/11
ROOTSTOCK[1]		
708-36	6.4	15.0 a
BM 2000	6.4	14.0 ab
Horner 4	5.9	12.9 b
Fox 11	6.4	14.4 ab
OHxF 87	5.9	14.3 ab
Pyrodwarf	7.0	14.7 ab
Pyro 2-33	6.4	14.6 ab
ANOVA[2]		
Rootstock	NS	*
Block	*	NS

[1] Within columns, rootstock treatment means significantly different (Tukey HSD test, $P \leq 0.05$)

[2] * Indicates significance at $P \leq 0.05$. NS indicates not significant $P > 0.05$.

Table 7: Cumulative effects of 2005 NC-140 rootstock planting on tree survival, trunk cross-sectional area, tree yield, average fruit size, yield efficiency and root suckers of 7th leaf 'Golden Russet' Bosc pear trees, Talmage, Mendocino County, California, 2005-2011.

	Tree Survival (%)	2011 TCSA (cm^2)	Average Cumulative Yield (kg)	Average Fruit Size (g)	Average Cumulative Yield Efficiency[3] (kg/cm^2)	Root Suckers (Cum. no./tree)
ROOTSTOCK[1]						
708-36	80	28.8 bc	25.5 ab	114	0.77 ab	0.19
BM 2000	70	35.6 ab	19.6 ab	89	0.60 b	0.40
Fox 11	60	35.8 ab	21.6 ab	121	0.60 b	0.00
Horner 4	100	46.5 a	26.0 ab	120	0.55 b	1.20
OHxF 87	80	29.4 bc	32.7 a	121	1.05 a	0.03
Pyrodwarf	90	17.3 c	17.3 b	123	0.48 b	0.00
Pyro 2-33	80	17.6 c	16.4 b	104	0.52 b	0.00
ANOVA[2]						
Rootstock	NS	***	*	NS	***	NS
Block	NS	*	NS	NS	NS	NS

[1] Within columns, rootstock treatment means significantly different (Tukey HSD test, $P \leq 0.05$). Root sucker data normalized using SQRT (root suckers+0.5) for P-value.

[2] *, **, *** Indicate significance at $P \leq 0.05$, 0.01, and 0.001 respectively. NS indicates not significant.