CALIFORNIA 2012 ANNUAL REPORT OF NC-140 COOPERATIVE REGIONAL PROJECT

PROJECT: **NC-140, California**

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Objective 1. ROOTSTOCK – ENVIRONMENT INTERACTIONS

PROGRESS OF THE WORK AND PRINCIPAL – ACCOMPLISHMENTS

2009 Redhaven Peach Rootstock Planting

The trees grew very well and produced a good crop in 2012. No trees died during the year and only two (one Krymsk 1 and one *P. americana*) showed moderate signs of incompatibility. There was very little suckering in the orchard, only *Prunus americana* had a noticeable problem (data not shown). Based on trunk circumference measurements, the rootstocks separated into three size categories. These are listed in order of tree size in Table 1. The first three are the most dwarfing. The next five are statistically identical and would be considered semi-dwarfing. The last eight are all standard sized trees. Therefore, there are eight rootstocks that are all smaller than Lovell. Mirobac had small fruit but the other dwarfing and semi-dwarfing rootstocks all had fruit weight statistically equal to Lovell. Five of the rootstocks (Krymsk 1, Controller 5, HBOK 32, HBOK 10 and Penta) also had greater yield efficiency than Lovell. *P. americana* did not perform as well in 2012, compared to the year before, with noticeably smaller fruit. KV010-127 continued to look promising with large fruit both years. Among the more vigorous rootstocks, Atlas looked particularly interesting in 2012. It had the greatest yield and largest fruit of all the rootstocks in the trial.

Table 1. 2009 NC-140 Redhaven peach rootstock trial – 2012 trunk circumference, yield, fruit weight and yield efficiency measurements.

Rootstock	10/12 Trunk Circumference (cm)	2011 Yield (kg/tree)	2012 Yield (kg/tree)	2011 Fruit Weight (g)	2012 Fruit Weight (g)	2012 Yield Efficiency (kg/cm^2)
Prunus americana	25.9 d	20.2 j	36.2 i	221 a	188 e-f	.67 b-f
Krymsk 1	27.2 d	27.5 ij	47.8 hi	209 a-c	192 c-e	.82 a
Controller 5	29.7 d	34.0 g-i	49.6 hi	188 c-e	182 ef	.70 a-d
Mirobac	34.6 c	45.8 d-g	62.8 gh	179 e	172 f	.67 b-f
HBOK 32	35.8 c	44.2 e-g	78.9 d-g	181 e	187 d-f	.78 ab
HBOK 10	36.7 c	49.0 c-f	80.8 c-f	187 de	197 b-e	.75 a-c
Penta	36.6 c	42.1 f-h	73.2 fg	206 a-d	209 a-c	.69 a-e
Tetra	37.3 c	29.2 h-j	74.1 e-g	184 de	201 b-e	.67 b-f
KV010-127	44.4 b	58.3 a-c	96.5 bc	216 ab	213 ab	.62 d-g
Krymsk 86	46.3 ab	61.0 a-c	95.8 bc	182 e	207 a-c	.58 e-g
KV010-123	46.8 ab	62.5 a-c	98.3 b	189 c-e	200 b-e	.57 e-g
Viking	46.7 ab	57.6 a-d	95.3 b	192 c-e	203 b-d	.56 e-g
Atlas	47.9 ab	69.4 a	118.6 a	188 c-e	226 a	.66 c-f
Guardian	48.0 ab	55.5 b-e	91.6 b-e	196 b-e	202 b-d	.51 g
Lovell	48.2 ab	65.0 ab	100.0 b	175 e	197 b-e	.54 fg
Brights Hybrid 5	48.8 a	67.7 ab	100.1 b	182 e	203 b-d	.54 fg

Related Rootstock Work

The peach rootstock breeding program includes a large number of selections from a wide array of crosses. In 2001, several of these with O'Henry peach grafted on top looked to be extremely promising. The trees ranged in size from very dwarfing to semi dwarfing and all had excellent fruit size. More than 20 of these have been identified and were planted in a large replicated trial in 2003, 2004 and 2005. Controller 5 and 9 were released under patent in 2004. Controller 7, 8 and 9.5 were patented in 2012. Controller 6 has recently been submitted to the patent office.

2005 Bartlett Pear Rootstock Planting (Tables 2 to 4)

North Coast - Talmage, Mendocino County, Cole loam

There was no change in survival this year and trees were about 20% larger. Number of fruit decreased 26%, offset by a modest 8% increase in fruit size, though average size was less than 200 grams for most rootstocks, suggesting relatively low vigor of most stocks in this high density (5 x 10) planting. Tree yield decreased by 20%, and yield deficiency 34% compared to 2011, commensurate with statewide average. Horner 4 continued to have the largest and most fruit, greatest yield, largest trunk circumference, and yield efficiencies equal to the other rootstocks. 708-36 had the smallest fruit and were the smallest trees. BM2000 and Fox 11 had the most root suckers. There were fruit quality differences in 2012. 708-36 had the firmest fruit and Horner 4 the softest, while OHxF 69 had the highest sugars.

Cumulatively from 2005-2012, there were no differences in tree survival. Horner 4 trees were the largest, followed by BM2000, while 708-36, OHxF87, and Pyrodwarf trees were the smallest. Horner 4 also had the greatest cumulative yield (over twice that of any other rootstock), the largest fruit, and, surprisingly, yield efficiency statistically equal to OHxF87 and Pyrodwarf. OHxF69 had the lowest yield efficiency.

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 7-year-old (8th leaf) 'Bartlett' pear trees, Talmage, California, 2012.

	No. Fruit 8/21/2012 (no./tree)	Fruit Size 8/21/2012 (g/fruit)	Yield 8/21/2012 (kg/tree)	TCSA 10/12/2012 (cm^2)	Yield Efficiency 10/12/2012 (kg/cm^2)	Tree Height 10/12/2012 (cm)	Root Suckers 10/12/2012 (no./tree)	Tree Survival 8/21/2012 (%/10 trees)
ROOTSTOCK[1]								
708-36	70 b	158 b	10.5 b	21.6 d	0.46	221 c	0.1 ab	90
BM 200	95 b	196 ab	18.2 b	37.2 b	0.50	254 ab	1.4 a	100
Horner-4	159 a	204 a	32.1 a	58.3 a	0.55	261 a	0.1 b	100
Fox 11	73 b	183 ab	13.0 b	32.2 bc	0.41	239 abc	0.8 a	80
OHxF69	81 b	181 ab	14.4 b	34.0 bc	0.41	232 bc	0.0 b	90
OHxF 87	77 b	168 ab	12.6 b	26.5 cd	0.48	228 c	0.0 b	100
Pyrodwarf	89 b	179 ab	15.7 b	29.5 bcd	0.54	236 abc	0.2 ab	90
Pyro 2-33	76 b	198 ab	13.8 b	31.2 bc	0.45	236 abc	0.0 b	70
ANOVA[2]								
Rootstock (P-value)	***(<0.001)	**(0.01)	***(<0.001)	***(<0.001)	NS (0.37)	***(<0.001)	*(0.05)	-----
Block (P-value)	NS (0.44)	* (0.03)	NS (0.75)	* (0.03)	NS (0.82)	* (0.02)	NS (0.16)	-----

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

[2] *, **, *** Indicate significance at P≤0.05, 0.01, and 0.001 respectively. NS indicates not significant P<0.05.
[3] Within columns, rootstock treatments means significantly different (Duncan P<0.05).

Table 3. Effects of 2005 NC-140 rootstock planting on firmness and soluble solids among 7-year-old (8th leaf) 'Bartlett' pear trees, Talmage, California, 2012.

	Firmness 8/30-31/2012 (Kg of force)	Brix 8/30-31/2012 (degrees)
ROOTSTOCK[1]		
708-36	7.9 a	15.1 ab
BM 2000	7.3 ab	13.7 b
Horner-4	6.9 b	13.7 b
Fox 11	7.4 ab	15.2 a
OHxF 69	7.7 ab	15.6 a
OHxF 87	7.4 ab	15.0 ab
Pyrodwarf	7.6 ab	15.6 a
Pyro 2-33	7.6 ab	14.0 ab
ANOVA[2]		
Rootstock	* (0.03)	** (0.01)
Block	** (0.01)	NS (0.63)

[1] Within columns, rootstock treatment means significantly different (Tukey HSD test, P≤0.05 [firmness] and 0.10 [brix]).

[2] *, ** Indicate significance at P≤0.05 and 0.01 respectively. NS indicates no significant P>0.05.

Table 4. Cumulative effects (2005-2012) of 2005 NC-140 rootstock planting on tree survival, trunk cross-sectional area, tree yield, average fruit size, yield efficiency, and root suckers of 7-year-old (8th leaf) Bartlett pear trees, Talmage, Mendocino County. California.

	Tree Survival (%)	2012 TCSA (cm2)	Average Cumulative Yield (kg)	Average Fruit Size (g)	Average Cumulative Yield Efficiency[3] (kg/cm2)	Root Suckers (Cum. No./tree)
ROOTSTOCK[1]						
708-36	90	21.6 e	37.2 c	159 c	1.68 ab	0.3 ab
BM 2000	100	37.2 b	64.5 b	173 abc	1.75 ab	2.7 ab
Horner-4	100	58.3 a	114.4 a	189 a	1.97 a	0.2 ab
Fox 11	80	32.2 bc	55.5 bc	178 abc	1.75 ab	3.1 a
OHxF 69	90	34.0 bc	49.2 bc	157 c	1.40 b	1.9 ab
OHxF 87	100	26.5 cd	51.2 bc	161 c	1.95 a	0.3 ab
Pyrodwarf	90	29.5 cde	61.5 b	162 bc	2.11 a	0.0 b
Pyro 2-33	70	31.2 bc	54.2 bc	185 ab	1.71 ab	0.0 b
ANOVA[2]						
Rootstock	NS (0.28)	***(<0.001)	***(<0.001)	***(<0.001)	**(0.003)	**(0.005)
Block	NS (0.56)	**(0.03)	**(0.002)	**(0.005)	NS (0.10)	NS (0.27)

[1] Within columns, rootstock treatment means significantly different (Tukey HSD test, P≤0.05). Root sucker data normalized SQRT (root sucker +0.5) for P<0.05); 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 (2005-12) and final TCSA (2012).

2005 'Golden Russet' 'Bosc' Pear Rootstock Planting (Tables 5-7)

North Coast - Talmage, Mendocino County, Cole loam

Average survival is less than in the 'Bartlett' trial, but with no changes in 2012 and no differences among rootstocks. Tree size increased nearly 30% but fruit number and yield decreased by 49% compared to 2011, a 56% decrease in yield efficiency. This was a much greater decrease than for 'Bartlett', suggesting the typical alternating bearing pattern of 'Bosc'. Though fruit size increased by 2%, this was not nearly enough to mitigate reduced yield. Only fruit size, trunk cross sectional area, and tree height differed significantly. Horner 4 trees were the largest and 708-36, OHxF 87 and Pyro 2-33 trees the smallest. There were no yield or yield efficiency differences, although there was a trend ($p = 0.15$) toward Horner 4 having the lowest yield efficiency. There were few root suckers but more than in past years. Unlike in 2011, there were significant differences in firmness or soluble solids, with OHxF 87 having the firmest fruit and Horner 4 the lowest sugars.

Cumulatively from 2005-2012, only trunk cross-sectional area and yield efficiency differed significantly. Horner 4 trees were the largest and had the lowest yield efficiency, while OHxF 87 trees were among the smallest, and had the highest yield efficiency.

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 7-year-old (8th leaf), "Golden Russet" 'Bosc' pear trees, Talmage, California, 2012.

	No. Fruit 9/13/2012 (no./tree)	Fruit Size 9/13/2012 (g/fruit)	Yield 9/13/2012 (kg/tree)	TCSA 10/12/2012 (cm^2)	Yield Efficiency 10/12/2012 (kg/cm^2)	Tree Height 10/12/2012 (cm)	Root Suckers[3] 10/12/2012 (no./tree)	Tree Survival 9/13/2012 (%/10 trees)
ROOTSTOCK[1]								
708-36	57	141 c	7.8	34.5 b	0.24	245 ab	0.2	80
BM 2000	42	193 a	8.1	48.8 ab	0.18	253 ab	0.7	70
Horner-4	42	173 ab	7.2	62.0 a	0.13	260 a	0.2	100
Fox 11	50	183 ab	8.7	48.6 ab	0.20	248 ab	0.0	60
OHxF 87	55	149 bc	8.2	37.9 b	0.23	228 b	0.0	80
Pyrodwarf	54	163 abc	8.7	46.4 ab	0.20	241 ab	0.0	90
Pyro 2-33	59	157 bc	9.2	42.4 b	0.23	233 b	0.0	80
ANOVA[2]								
Rootstock (P-value)	NS (0.68)	***(<0.001)	NS (0.94)	**(0.002)	NS (0.15)	**(0.003)	NS (0.17)	-----
Block (P-value)	NS (0.44)	** (0.003)	NS (0.41)	**(0.02)	NS (0.29)	NS (0.32)	NS (0.78)	-----

[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 $P < 0.05$.

[3] Root sucker data normalized SQRT (root sucker +0.5) for P-value.

Table 6. Effects of 2005 NC-140 rootstock planting on firmness and soluble solids among 7-year-old (8th leaf) "Golden Russet" 'Bosc' pear trees, Talmage, California, 2012.

	Firmness 9/14/2012 (kg of force)	Brix 9/14/2012 (degrees)
ROOTSTOCK[1]		
708-36	7.7 ab	14.3 ab
BM 2000	7.9 ab	14.6 ab
Horner-4	7.5 b	14.0 b
Fox 11	7.3 b	14.4 ab
OHxF 87	8.9 a	15.6 a
Pyrodwarf	7.7 ab	15.6 a
Pyro 2-33	7.0 b	15.3 ab
ANOVA[2]		
Rootstock (P-value)	** (0.01)	** (0.01)
Block (P-value)	*** (0.001)	NS (0.04)

[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 7. Cumulative effects (2005-2012) of 2005 NC-140 rootstock planting on tree survival, trunk cross-sectional area, tree yield, average fruit size, yield efficiency, and root suckers of 7-year-old (8th leaf) "Golden Russet" 'Bosc' pear trees, Talmage, Mendocino County, California.

	Tree Survival (%)	2012 TCSA (cm^2)	Average Cumulative Yield (kg)	Average Fruit Size[5] (g)	Average Cumulative Yield Efficiency[4] (kg/cm^2)	Root Suckers[3] (Cum. No./tree)
ROOTSTOCK[1]						
708-36	80	34.5 b	27.1	150	0.75 ab	0.4
BM 2000	70	48.8 ab	15.6	140	0.36 bc	1.5
Horner-4	100	62.0 a	19.5	169	0.33 c	1.5
Fox 11	60	48.6 ab	22.4	157	0.45 abc	0.3
OHxF 87	80	37.9 b	32.6	171	0.80 a	0.0
Pyrodwarf	90	46.4 ab	23.1	172	0.51 abc	0.0
Pyro 2-33	80	42.4 b	17.9	147	0.44 abc	0.0
ANOVA[2]						
Rootstock (P-value)	NS (0.41)	** (0.002)	NS (0.21)	NS (0.35)	*** (0.001)	NS (0.50)
Block (P-value)	NS (0.43)	** (0.01)	NS (0.71)	NS (0.12)	NS (0.97)	NS (0.51)

[1] Within columns, rootstock treatment means significantly different (Tukey HSD test, P≤0.05).

[2] **, *** Indicate significance at P≤0.01, and 0.001 respectively. NS indicates not significant P<0.05.

[3] Root sucker data normalized SQRT (root sucker +0.5) for P<0.05.

[4] Based on cumulative yield (2005-12) and final TCSA (2012).

[5] Average fruit size based on fruiting years – 2008 to 2012.

Presentations and Field Days

Bell, R. and R. Elkins. Current state of pear rootstock research: progress and priorities. American Society for Horticultural Science Pomology Working Group Workshop, Rootstocks: Challenges and Progress, August 2, 2012, Miami, Florida.

Elkins, R. Evaluation of potential new size controlling rootstocks for European pear (two presentations). 2012 Sacramento River District Pear Research Meeting, February 2, 2012, Walnut Grove, California and 2012 North Coast Pear Research Meeting, February 16, 2012, Lakeport, California.

Elkins, R. Spring Irrigation and Field Meeting. May 20, 2012, Talmage, Mendocino County, California.

Relevant Publications

Bell, R. L., R. B. Elkins, and T. Einhorn. 2012. Current state of pear rootstock research progress and priorities (abstract). *HortScience* 47(9) Supplement: S100.

Elkins, R. 2011. Evaluation of potential new size controlling rootstocks for European pear. 2011 California Pear Research Report, California Pear Advisory Board, Sacramento, California, p. 104-113.

Elkins, R., R. Bell, and T. Einhorn. 2012. Needs assessment for future US pear rootstock research directives based on the current state of pear production and rootstock research. *Journal of the American Pomological Society* 66(3):153-163.

Elkins, R.B., S. Castagnoli, C. Embree, R. Parra-Quezada, T.L. Robinson, T.J. Smith and C.A. Ingels. 2011. Evaluation of potential rootstocks to improve pear tree precocity and productivity. *Acta Hort*. 909 (1): 183-194.

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2010 Benton Cherry Rootstock and Training Systems Planting

The trial was in its third growing season in 2012. It includes Benton trees trained to Tall Spindle/Axe (TSA) and KGB systems on Gisela 3, 5, and 6 rootstocks, and UFO on Gisela 3, 5, 6, and 12. The trial design, location, site characteristics and general orchard management practices were described in previous reports.

System-appropriate tree training operations were performed during spring and summer 2010. Budbreak and shoot elongation were not as extensive as desired in 2010, due apparently to damage sustained during an October 2009 freeze event at the nursery. A decision was taken to “restart” trees prior to budbreak in 2011 by: heading all lateral shoots on TSA trees and uprights on UFO trees to a

single basal vegetative bud (TSA terminal shoots were not headed); heading all shoots on KGB trees to a 3-4 inch stub (leaving 3-4 vegetative buds); and applying Promalin (1:3 with white latex paint at green tip stage) to vegetative buds on TSA trees and UFO trees where shoots did not emerge/develop as desired in 2010.

Appropriate follow-up pruning and training activities were performed through the 2011and 2012 growing seasons, and have generally resulted in well-structured trees with a range of vigor expected from the respective rootstocks (Gi12>Gi6>Gi5>Gi3).

Considerable tree mortality has occurred in the trial, with the heaviest losses among Gi3-rooted trees (Table 8). Phytophthora root rot and/or bacterial canker are suspected as possible causes of tree death but these have not been clinically confirmed.

Key 2012 vegetative growth parameters evaluated in January, flower abundance in April, and fruit production in June are presented in Table 9. Very little fruit was produced this year, and much of that produced was damaged by birds. As such, only fruit numbers are reported here.

Table 8. Percent tree mortality by rootstock, California NC-140 Benton cherry trial.

Rootstock	2010	2011	2012	Total
Gi3 (n=72)	*4.2*	*19.4*	*4.2*	*27.7*
Gi5 (n=72)	*0.0*	*6.9*	*4.2*	*11.1*
Gi6 (n=72)	*0.0*	*8.3*	*6.9*	*15.3*
Gi12 (n=12)	*0.0*	*4.2*	*4.2*	*8.3*

Table 9. Measures of vegetative and reproductive development in 2012 by rootstock and training system (Gi12 has a single training system).

		January		April			June
Training system	Rootstock	No. shoots/tree	Mean shoot length (cm)	No. Flowering spurs/tree	No. shoot-borne flowers/tree	No. flowering shoots/tree	No. fruit/tree
KGB	Gi3	29.3[x]	34.5 b	7.3	3.8 a	2.5 a	1.0
	Gi5	29.4	48.4 a	2.0	1.3 b	0.9 b	0.5
	Gi6	34.3	44.4 a	1.8	0.4 b	0.42 b	0.4
	P[y]	*0.21*	*<0.01*	*0.37*	*<0.01*	*<0.01*	*0.51*
TSA	Gi3	34.8	36.5 c	15.5	153.3	33.4	12.1
	Gi5	41.1	48.6 b	13.33	137.0	35.0	19.8
	Gi6	40.8	60.6 a	12.00	136.4	30.6	23.0
	P	*0.02*	*<0.01*	*0.76*	*0.98*	*0.19*	*0.34*
UFO	Gi3	12.8 a	57.8 c	14.4 a	49.3 a	8.3 a	4.6 a
	Gi5	10.6 b	79.3 b	7.4 b	31.9 b	7.1 a	1.4 bc
	Gi6	11.8 b	91.5 b	16.5 a	30.4 b	5.7 b	3.1 ab
	Gi12	10.3 b	109.1 a	5.7 b	11.8 c	3.7 c	0.33 c
	P	*0.03*	*<0.01*	*<0.01*	*<0.01*	*<0.01*	*<0.01*

[x] Means in the same column and training system with different letters differ by Duncan's Multiple Range Test at P = 0.05.

[y] Pr > F, Analysis of variance by GLM Procedure, Statistical Analysis Systems (SAS Institute, Cary, NC).

WORK PLANNED FOR 2013 - Data collection and rootstock evaluation for the peach, pear, and cherry trials will continue in 2013. Procedures will again follow guidelines established by the NC140 Technical Committee.