# COMPARISON OF HORNER 4, OHXF 87, AND OHXF 97 ROOTSTOCKS UNDER VARYING GROWING CONDITIONS AND CULTURAL PRACTICES IN LAKE COUNTY, CALIFORNIA

## (2022-2023 Progress Report)

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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 10-year, 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 (United Kingdom), BM 2000 (Australia), Fox 11 (Italy), Horner 4 (Oregon), OHxF 69 (Oregon, Mendocino Bartlett only), OHxF 87 (Oregon), Pyro-233 and Pyrodwarf (both Germany). 2014 was the tenth season of the 10-year trial and the final year of formal data collection. After ten years (2005 – 2014) Bartlett on the open pollinated OHxF[1] selection Horner 4 consistently had the largest fruit (197 grams average), yielded 41% or more than the next highest yielding rootstocks, and had similar yield efficiencies despite being nearly twice as large as other trees. For 'Golden Russet' Bosc, Horner 4 trees were largest and had the largest fruit in the final year of the trial, but lower yield efficiency than other rootstocks, suggesting it may be better suited to less vigorous Bartlett. There were very few, if any, root suckers. Horner 4 was also the least water stressed rootstock, most likely to attain baseline values of -6 - -8 bars mid-day stem water potential (MSWP), the suggested baseline for fully-watered trees (Shackel 2007). Increasing (positive) MSWP was significantly and positively correlated with fruit size, TCSA, and yield efficiency. Based on positive results, a series of four replicated trials was initiated in 2016 in the Kelseyville (Big Valley) growing area of Lake County, California to compare Horner 4 versus OHxF 87 and OHxF 97 rootstocks on a range of soil types and cultural practices. Three trials were interplanted between rows of mature 'Bartlett' trees and one trial installed in a replant site. After eight growing seasons (2016 - 2023) across all four trial sites, Horner 4 trees were significantly larger based on TCSA and height, had significantly more and larger fruit, and higher yields than OHxF rootstocks. OHxF 87 trees were smallest and had the least and smallest fruit, and lowest yields. Tree growth, productivity, fruit maturity data will continue in 2024.

## 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 (OHxF) (Brooks®)[1] series offers several potential options that are now becoming more widely planted. The two OHxF selections currently most offered by major wholesale nurseries are 97 and 87 (333 is generally sold to homeowners). 97 is a relatively large tree similar to Winter Nelis, though more precocious than *P. betulaefolia*. 87 is smaller but has been shown to produce small fruit in some locations. Data from California, and more recently Washington, has suggested that OHxF 69, 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; Reed 2011; Elkins, Bell and Einhorn 2012).

The North Central Regional Research Project NC-140 (*www.NC140.org*) is a federally (NIFA)-supported, multi-state rootstock project focused on perennial tree fruit crops. The goal of NC-140 is to disseminate information generated from long-term (generally 10 year) 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 growers and nurseries who can then select rootstocks suitable to their location and customer base. All Regional projects must be re-authorized every five years; the NC-140 2017-2022 continuing 5-year proposal accepted by the North Central Regional Association (NCRA) of State Agricultural Experiment Station Directors is available on the NC-140 website. California began participating in NC-140 for apples in 1995 and peaches in 2001 and began participating actively in pears in 2005.

In coordination with Oregon, Washington, New York, and Chihuahua, Mexico, three 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 then budded 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 NC-140 pear plantings are shown in Table 1. The 2005 NC-140 trials were the only **bearing *replicated*** rootstock trials in California. The ultimate objective of these, as with all NC-140 and other rootstock trials, was to select the best potential available candidates for future increased propagation and industry use. The information they have provided has already contributed to future nursery and grower planting decisions, particularly for new, high density planting systems.

After ten years (2005 – 2014) Bartlett on the open pollinated OHxF[1] selection Horner 4 consistently had the largest fruit (197 grams average), yielded 41% or more than the next highest yielding rootstocks, and had similar yield efficiencies despite being nearly twice as large as other trees. For 'Golden Russet' Bosc, Horner 4 trees were largest and had the largest fruit in the final year of the trial, but lower yield efficiency than other rootstocks, suggesting it may be better suited to less vigorous Bartlett. There were very few, if any, root suckers. Horner 4 was also the least water stressed rootstock, most likely to attain baseline values of -6 - -8 bars mid-day stem water potential (MSWP), the suggested baseline for fully-watered trees (Shackel 2007). Increasing (positive) MSWP was significantly and positively correlated with fruit size, TCSA, and yield efficiency.

The male parent of this series has now been shown to be Bartlett (Postman et al. 2013).

Based on positive results from 2005-2014, efforts were made to propagate a greater number of Horner 4 trees to test Horner 4 under varying grower conditions (soil type, nutritional challenges, microclimates), culminating in planting four replicated trials (all Bartlett scion) in the Big Valley (Finley-Kelseyville) growing area of Lake County in spring 2016. Comparison rootstocks were OHxF 97 (all four sites) and OHxF 87 (three sites).

## OBJECTIVES

- Early and consistent production;
- Vigor and production on a range of (heavier) soil types;
- Compatibility with organic production (two orchards)
- Usefulness as an interplant to replace the vigorous but non-precocious *P. betulaefolia* (being phased out by nurseries).

## PROCEDURES

*Trial locations and descriptions:* all Bartlett, sprinkler irrigated

1) D&S (conventional; omit 87); 12.5' x 12.5', interplanted; Cole clay loam, Still loam (stratified);
2) Henderson (organic); 12' x 6', interplanted; Cole clay loam;
3) Lone Pine (organic); 12' x 12', open ground, replanted; Cole clay loam;
4) Neck (conventional); 12.5' x 6', interplanted; Still loam, stratified; Landlow Variant silty clay loam.

Budded trees from hardwood cuttings were obtained from Sierra Gold Nursery (Yuba City, California) and planted April 4-27, 2016.

*Design:* Randomized complete block with five blocks consisting of 2-3 treatments x 5 tree plots (10-15 trees/block). Blocking configuration varies with location.

**Data Collection**

*Tree survival, growth and vigor (2016 - 2023):* Percent tree survival was determined. Tree height and cultivar trunk cross-sectional area (TCSA) 10 cm. above the graft union were measured at planting (baseline) and annually thereafter. Root suckers were counted from base of origin annually.

*Tree productivity (2019 – 2023*; *variable by orchard)*: Total number of fruit per tree were counted and weighed and average grams/fruit calculated. Yield efficiency was calculated.

*Fruit quality (2021 – 2023)*: Two fruit per tree (total 10 fruit per 5 replicate) were collected. Firmness (kg force) was measured on each side of the fruit using a stand firmness tester ("UC" type, 5/16 mm tip). Juice was obtained from the combined fruit sample and soluble solids (°Brix) were measured using a hand refractometer (ATC-1, Atago Co. Ltd., Tokyo, Japan).

**Data summarization and analysis**

Data was analyzed using ANOVA and means separated using Tukey HSD test, $p \leq 0.05$ (root suckers by Duncans MRT, $p \leq 0.10$) (Statgraphics Centurion XVII, StatPoint Technologies, Warrenton, VA).

**2021 - 2023 RESULTS (Tables 1-9)**

***Tree survival, growth, and vigor****:* Cumulatively across all four orchards through 2023, there were no survival differences (p = .13). Although numerically observed lower survival for OHxF 87 with 70% of tree survival, followed by OHxF 97 with 81% and Horner 4 with 82% (Table 1). Horner 4 trees showed a TCSA of 22.2 %, followed by OHxF 97 with 20.1% and then OHxF 87 with 19.2% (Table 1). The results of tree height were 325 cm for Horner 4, followed by OHxF 97 with 263 cm and then OHxF 87 with 212 cm (Table 1). For 2023, Horner 4 also presented the best performance for Crop Load (fruit no/tree), Fruit Size (g), Yield (kg/tree), and Yield (ton/ac) (Table 1). There were no differences in number of root suckers.

***Tree productivity***: (Table 2). Cumulatively across all four trial sites in 2022-2023, There were no differences in crop load (fruit no/tree) and Yield (kg/tree). But Horner 4 had significantly more (190 > 150 = 129 (size g/fruit), $p$ = .001).

***Cumulative 2016 - 2023 results for each location:***

*D&S (Horner 4 and OHxF 97 only)*: Horner 4 survival rate was significantly lower than for OHxF 97 (77 vs 96%, $p$ =.05) (Table 3). No difference was observed for plant height and TCSA (%). There were very few root suckers. In contrast to the other trial sites, OHxF97 bore very significantly more Crop Load (fruit no/tree), Fruit Size (g),

Yield (kg/tree), and Yield (ton/ac) compared to Horner 4 (Table 3).

*Henderson*: Horner 4 survival rate was significantly higher (88%, *p* =.002) than OHxF 87 (56%) and trended higher than OHxF 97 (44%) (Table 4). Horner 4 trees were significantly largest (21.6 ≥ OHxF 97 15.6 ≥ OHxF 87 7.6 $cm^2$ TCSA; 279 > OHxF 87 193 = OHxF 97 181 cm tall). For this location, Horner 4 presented a better performance for Crop Load (fruit no/tree), Yield (kg/tree), and Yield (ton/ac) compared to OHxF 97 and OHxF 87 (Table 4). There were very few or no root suckers (OHxF 97). Horner 4 fruit number trended higher (23 (Horner 4) vs 7 (OHxF 87), and 6 (OHxF 87), *p* = .002). There were no differences in fruit size, though higher fruit numbers resulted in a trend toward higher yield (4.7 (Horner 4) vs 1.5 for (OHxF 97) and 0.9 (OHxF 87) kg/tree (*p* = .08)). The yield efficiency resulted (3.1 (Horner 4) vs 1.0 for (OHxF 97) and 0.6 (OHxF 87) kg/tree (*p* = .001)).

*Lone Pine*: Horner 4 trees were very significantly taller than either OHxF 97 or 87 (381 > 292 >246 cm, respectively, p <.001). There were no root suckers differences (Table 5). There were significant differences among rootstocks. Horner 4 (126) had significantly more fruit than OHxF 87 (66), and numerically more than OHxF 97 (111) (*p* = .002). Horner 4 fruit size (182 g) trended larger versus OHxF 97 (145 g) and was significantly larger versus OHxF 87 (107 g) (*p* = .03).
Horner 4 and OHxF 97 yield were similar (23.7 and 16.7 kg/tree, respectively) and was significantly higher than OHxF 87 (7.3 kg/tree).

*Neck*: Survival was 100%. Horner 4 TCSA and 4 trees height was (48.7 $cm^2$, 362 cm tall (*p*<.001), followed by OHxF 97 with (31.9 $cm^2$, 263 cm tall (*p*<.001), and OHxF 87 with (22.9 $cm^2$, 212 cm tall (*p*<.001) (Table 6). There were no differences in root suckers.
Unable to harvest 2023.

***Fruit quality*** (Tables 7-9). In general, no differences were observed in the fruit firmness and soluble solids values between rootstocks and locations.

## DISCUSSION AND 2024 PLANS

This year (2023), the high volumes of rainfall and the groundwater recharge turned out to be excellent for the health of pear orchards, and the development of the trees. After eight growing seasons, cumulatively across all four trial sites, Horner 4 trees were largest with no differences in growth rate. Horner 4 trees had significantly more and larger fruit and highest yield, followed by OHxF 97, with no yield efficiency differences. OHxF 87 trees were least vigorous and bore least. For individual sites, Horner 4 trees were the largest (TCSA and/or height) in three of four orchards (Henderson, Lone Pine, Neck), and have grown to equal size as OHxF 97 trees in the fourth (D&S). OHxF 87 trees were consistently smallest. Horner 4 trees bore more fruit in two trials (Henderson and Neck) and larger fruit in two (Lone Pine and Neck). This combination resulted in statistically or numerically higher yields in three of the four

trials, with yield efficiency equal to OHxF97 despite its larger size. OHxF 97 has performed best in the D&S trial (no OHxF 87 comparison). OHxF 87 trees were least vigorous and bore least. Horner 4 fruit firmness and soluble solids trended lower, suggesting earlier maturity. Tree growth and productivity, and fruit maturity, measurements will continue in 2024 (Year 9).

## ACKNOWLEDGEMENTS

We thank: grower cooperators Dan Goff (G Bar G Orchards), David Mostin (Mostin Orchards), Greg Panella (Henderson Orchards), and David Weiss (Quercus Ranch) for contributing land, capital, labor, and advice to ensure success; 2021-2022 UC field staff Taylor Delbar, Cort Dunnington, Lynn Fraser, and Ryan Keiffer, and Juliana Wu for collecting data; Sierra Gold Nursery (Cliff Beumel (now with Agromillora California), Chuck Fleck, Reid Robinson), and Scully Packing and Mt. Konocti Growers for tree and fruit cold storage care. We thank California Pear Advisory Board and Pear Pest Management Research Fund for partial funding. Finally, I thank Rachel Elkins for the mentoring provided in my first and second years in this position.

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**Table 1:** Average cumulative effect of rootstock on number and size of fruit, tree yield and growth, root suckers, and tree survival of 1st to 7th leaf 'Bartlett' pear trees, D&S, Henderson, Lone Pine, and Neck Orchards combined, Kelseyville, Lake County, California, 2016-2023.

| Treatment[1] | Crop Load (fruit no/tree) | Fruit Size[3] (g) | Yield (kg/tree) | Yield (ton/ac) | Cumulative Yield Efficiency[6] ($kg/cm^2$) | 2022 TCSA ($cm^2$) | TCSA Increase (%) | 2023 Tree Height (cm) | Root Suckers[7] (no/tree) | Tree Survival (%) |
|---|---|---|---|---|---|---|---|---|---|---|
| Horner 4[4] | 48 | 190 a | 8.9 | 3.6 a | 39.1 a | 0.21 | 22.2 | 325 a | 1.0 | 82 |
| OHxF 87[5] | 34 | 129 b | 3.9 | 1.4 b | 22.4 c | 0.14 | 19.2 | 212 c | 0.9 | 70 |
| OHxF 97[4] | 51 | 150 b | 7.6 | 2.6 ab | 33.4 b | 0.18 | 20.1 | 263 b | 0.6 | 81 |
| ANOVA (*P* -value) [2] | | | | | | | | | | |
| Treatment | NS (0.42) | *** (<0.001) | NS (0.06) | ** (0.01) | *** (<0.001) | NS (0.16) | NS (0.49) | *** (<0.001) | NS (0.51) | NS (0.13) |
| Block | NS (0.46) | NS (0.72) | NS (0.54) | NS (0.49) | NS (0.19) | NS (0.83) | NS (0.91) | NS (0.21) | NS (0.69) | NS (0.45) |
| Treatment x Block | NS (0.66) | NS (0.14) | NS (0.84) | NS (0.67) | NS (0.77) | NS (0.97) | NS (0.15) | NS (0.72) | NS (0.15) | NS (0.62) |

[1] Within columns, 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.

[3] Average fruit size 2022 2023.

[4] Average of 4 plots.

[5] Average of 3 plots.

[6] Based on cumulative yield (2022-23) and final TCSA (2023).

[7] Root sucker data normalized, SQRT (root suckers+1.0) for *P* -values.

**Table 2:** Effect of rootstock on number and size of fruit, tree yield and growth, root suckers, and tree survival of 8-year-old (8th leaf) 'Bartlett' pear trees, D&S, Henderson, Lone Pine, and Neck Orchards combined, Kelseyville, Lake County, California, 2023.

| Treatment[1] | Crop Load (fruit no/tree) 8/28 & 31/2023 | Fruit Size (g) 8/28 & 31/2023 | Yield (kg/tree) 8/28 & 31/2023 | Yield (ton/acre) 8/28 & 31/2023 | Yield Efficiency (kg/tree) 11/2/2023 | Dormant TCSA ($cm^2$) 2023 | TCSA[3] Increase (%) 2022-2023 | Tree Height (cm) 11/2/2023 | Root Suckers (no/tree) 11/2/2023 | Tree Survival (%) 11/2/2023 |
|---|---|---|---|---|---|---|---|---|---|---|
| Horner 4[4] | 48 | 190 a | 8.9 | 3.6 a | 39.1 a | 0.21 | 22.2 | 325 a | 1.0 | 82 |
| OHxF 87[5] | 34 | 129 b | 3.9 | 1.4 b | 22.4 c | 0.14 | 19.2 | 212 c | 0.9 | 70 |
| OHxF 97[4] | 51 | 150 b | 7.6 | 2.6 ab | 33.4 b | 0.18 | 20.1 | 263 b | 0.6 | 81 |
| ANOVA (*P* -value) [2] | | | | | | | | | | |
| Treatment | NS (0.42) | *** (<0.001) | NS (0.06) | ** (0.01) | *** (<0.001) | NS (0.16) | NS (0.49) | *** (<0.001) | NS (0.51) | NS (0.13) |
| Block | NS (0.46) | NS (0.72) | NS (0.54) | NS (0.49) | NS (0.19) | NS (0.83) | NS (0.91) | NS (0.21) | NS (0.69) | NS (0.45) |
| Treatment x Block | NS (0.66) | NS (0.14) | NS (0.84) | NS (0.67) | NS (0.77) | NS (0.97) | NS (0.15) | NS (0.72) | NS (0.15) | NS (0.62) |

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

[2] *, **,** Indicates significance at $P \leq 0.05$, 0.01, and 0.0011 respectively. NS indicates not significant.

[3] Survival data normalized using SQRT (survival+1) for *P* -values.

[4] Average of 4 plots.

[5] Average of 3 plots.

**Table 3:** Effect of rootstock on number and size of fruit, tree yield and growth, root suckers, and tree survival of 8-year-old (8th leaf) 'Bartlett' pear trees, D&S Orchard, Kelseyville, Lake County, California, 2023.

| Treatment[1] | Crop Load (fruit no/tree) 8/28/2023 | Size (g.) 8/28/2023 | Yield (kg/tree) 8/28/2023 | Yield (ton/acre) 8/28/2023 | Dormant TCSA ($cm^2$) 11/2/2023 | Yield Efficiency ($kg/cm^2$) 2023 | TCSA Increase (%) 2022-2023 | Tree Height (cm) 11/2/2023 | Root Suckers[3] (no./tree) 11/2/2023 | Tree Survival (%) 11/2/2023 |
|---|---|---|---|---|---|---|---|---|---|---|
| Horner 4 | 10.1 b | 172 | 1.7 | 0.6 | 23.8 | 0.06 | 23.0 | 274 | 0.2 | 77 b |
| OHxF 97 | 21.0 a | 136 | 3.1 | 1.0 | 32.0 | 0.09 | 21.7 | 269 | 0.3 | 96 a |
| ANOVA (*P* -value) [2] | | | | | | | | | | |
| Treatment | * (0.03) | ** (0.002) | NS (0.07) | NS (0.07) | NS (0.23) | NS (0.14) | NS (0.75) | NS (0.67) | NS (0.59) | * (0.05) |
| Block | ** (0.003) | ** (0.01) | ** (0.01) | ** (0.01) | NS (0.34) | ** (0.01) | NS (0.22) | NS (0.48) | NS (0.49) | NS (0.34) |
| Treatment x Block | NS (0.41) | ~ [4] | NS (0.39) | NS (0.39) | NS (0.47) | NS (0.22) | NS (0.49) | NS (0.15) | NS (0.45) | NS (0.14) |

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

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

[3] Root sucker data normalized, SQRT (root suckers+1.0) for *P* -values.

[4] Not enough Horner 4 trees with fruit for interactions

Harvest date: 8/28/2022

**Table 4:** Effect of rootstock on number and size of fruit, tree yield and growth, root suckers, and tree survival of 8-year-old (8th leaf) 'Bartlett' pear trees, Henderson Orchard, Kelseyville, Lake County, California, 2023.

| Treatment[1] | Fruit No. (per tree) 8/28/2023 | Size (g.) 8/28/2023 | Yield (kg/tree) 8/28/2023 | Yield (ton/acre) 8/28/2023 | Dormant TCSA ($cm^2$) 11/2/2023 | Yield Efficiency ($kg/cm^2$) 2022 | TCSA Increase (%) 11/2/2023 | Tree Height (cm) 11/2/2023 | Root Suckers (no./tree) 11/2/2023 | Tree Survival (%) 11/2/2023 |
|---|---|---|---|---|---|---|---|---|---|---|
| Horner 4 | 23 a | 209 | 4.7 a | 3.1 a | 21.6 a | 0.20 a | 27.7 | 279 a | 0.3 | 88 a |
| OHxF 87 | 5 b | 169 | 0.9 b | 0.6 b | 10.9 b | 0.07 b | 33.3 | 181 b | 0.7 | 56 b |
| OHxF 97 | 7 b | 201 | 1.5 b | 1.0 b | 15.6 ab | 0.09 b | 31.2 | 193 b | 0.3 | 44 b |
| ANOVA (*P* -value) [2] | | | | | | | | | | |
| Treatment | ** (0.002) | NS (0.39) | *** (0.001) | *** (0.001) | *** (0.001) | *** (<0.001) | NS (0.72) | *** (<0.001) | NS (0.17) | ** (0.002) |
| Block | NS (0.53) | ** (0.002) | NS (0.62) | NS (0.62) | NS (0.59) | NS (0.25) | NS (0.54) | NS (0.89) | NS (0.25) | NS (0.08) |
| Treatment x Block | NS (0.55) | ***(0.001) | NS (0.62) | NS (0.62) | NS (0.69) | NS (0.33) | NS (0.68) | NS (0.33) | NS (0.15) | NS (0.60) |

[1] Within columns, treatment means significantly different (Tukey HSD, $P \leq 0.05$), fruit no. and yield by (Fisher's LSD, $P \leq 0.05$).

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

[3] Not enough Horner 4 trees with fruit for interactions

Harvest date - 8/28/203

**Table 5:** Effect of rootstock on number and size of fruit, tree yield and growth, root suckers, and tree survival of 8-year-old (8th leaf) 'Bartlett' pear trees, Lone Pine orchard, Kelseyville, Lake County, California, 2023.

| Treatment[1] | Crop Load (fruit/tree) 8/24/2022 | Size (g) 8/24/2022 | Yield (kg/tree) 8/24/2022 | Yield (ton/acre) 8/24/2022 | TCSA ($cm^2$) 11/29/2022 | Yield Efficiency ($kg/cm^2$) 2022 | TCSA Increase (%) 2020-2021 | Tree Height (cm) 11/29/2022 | Root Suckers[3] (no/tree) 11/29/2022 | Tree Survival (%) 11/29/2022 |
|---|---|---|---|---|---|---|---|---|---|---|
| Horner 4 | 126 a | 182 a | 23.7 a | 7.9 a | 60.1 a | 0.39 a | 13.2 | 381 a | 4.6 | 63 |
| OHxF 87 | 66 b | 107 c | 7.3 b | 2.4 b | 34.9 c | 0.22 b | 15.1 | 246 c | 2.4 | 55 |
| OHxF 97 | 111 ab | 145 b | 16.7 a | 5.6 a | 46.6 b | 0.33 a | 6.8 | 292 b | 1.9 | 84 |
| ANOVA (*P* -value) [2] | | | | | | | | | | |
| Treatment | ** (0.002) | *** (<0.001) | *** (<0.001) | *** (<0.001) | *** (<0.001) | *** (<0.001) | NS (0.06) | *** (<0.001) | NS (0.88) | NS (0.07) |
| Block | NS (0.21) | * (0.04) | ** (0.01) | ** (0.01) | *** (0.001) | NS (0.52) | NS (0.06) | NS (0.22) | NS (0.82) | ** (0.01) |
| Treatment x Block | ** (0.004) | NS (0.35) | *** (0.001) | *** (0.001) | * (0.02) | * (0.02) | NS (0.29) | * (0.03) | * (0.02) | NS (0.15) |

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

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

Harvest Date: 8/31/2023

**Table 6:** Effect of rootstock on number and size of fruit, tree yield and growth, root suckers, and tree survival of 8-year-old (8th leaf) 'Bartlett' pear trees, Neck orchard, Kelseyville, Lake County, California, 2023.

| Treatment[1] | Fruit No. (per tree) 8/12/2022 | fruit Size (g) 8/12/2022 | Yield (kg/tree) 8/12/2022 | Yield (ton/acre) 8/12/2022 | Dormant TCSA ($cm^2$) 12/29/2022 | TCSA Increase (%) 2021-2022 | Yield Efficiency ($kg/cm^2$) 2022 | Tree Height (cm) 12/29/2022 | Root Suckers[3] (no/tree) 12/29/2022 | Tree Survival (%) 12/29/2022 |
|---|---|---|---|---|---|---|---|---|---|---|
| Horner 4 | ~ | ~ | ~ | ~ | 48.7 a | 21.0 ab | ~ | 362 a | 1.03 | 100 |
| OHxF 87 | ~ | ~ | ~ | ~ | 22.9 c | 15.0 b | ~ | 212 c | 1.08 | 100 |
| OHxF 97 | ~ | ~ | ~ | ~ | 31.9 b | 23.4 a | ~ | 263 b | 1.02 | 100 |
| ANOVA (*P* -value) [2] | | | | | | | | | | |
| Treatment | ~ | ~ | ~ | ~ | *** (<0.001) | ** (0.01) | ~ | *** (0.001) | NS (0.20) | ~ |
| Block | ~ | ~ | ~ | ~ | *** (0.001) | NS (0.46) | ~ | NS (0.06) | NS (0.22) | ~ |
| Treatment x Block | ~ | ~ | ~ | ~ | ** (0.01) | ** (0.01) | ~ | ** (0.01) | ** (0.01) | ~ |

[1] Within columns, treatment means significantly different (Tukey HSD, $P \leq 0.05$), n=25.

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

[3] Root sucker data normalized, SQRT (root suckers+1.0) for *P* -values.

[4] Orchard not harvested.

**Table 7:** Effect of rootstock on fruit firmness and soluble solids of 8-year-old (8th leaf) 'Bartlett' pear trees, D&S Orchard, Kelseyville, Lake County, California, 2023.

| Treatment[1] | Firmness (kg force) 8/31/202 | Soluble Solids (°Brix) 8/31/2023 |
|---|---|---|
| Horner 4 | 9.1 | 14.8 |
| OHxF 97 | 8.8 | 15.7 |
| ANOVA (*P* -value) [2] | | |
| Treatment | NS (0.39) | NS (0.24) |
| Block | NS ( 0.22) | NS ( 0.24) |

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

[2] NS indicates not significant.

Harvested 8/28/23; tested 8/31/23.

**Table 8:** Effect of rootstock on fruit firmness and soluble solids of 8-year-old (8th leaf) 'Bartlett' pear trees, Henderson Orchard, Kelseyville, Lake County, California, 2023.

| Treatment[1] | Firmness (kg force) 9/1/2023 | Soluble Solids (°Brix) 9/1/2023 |
|---|---|---|
| Horner 4 | 8.3 b | 12.4 |
| OHxF 87 | 9.6 a | 12.0 |
| OHxF 97 | 9.0 ab | 12.4 |
| ANOVA (*P* -value) [2] | | |
| Treatment | * (0.04) | NS (0.65) |
| Block | NS (0.36) | NS (0.40) |

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

[2] NS indicates not significant.

Harvested 8/28/23; tested 9/1/23.

**Table 9:** Effect of rootstock on fruit firmness and soluble solids of 8-year-old (8th leaf) 'Bartlett' pear trees, Lone Pine Orchard, Kelseyville, Lake County, California, 2023.

| Treatment[1] | Firmness (kg force) 9/1/2023 | Soluble Solids (°Brix) 9/1/2023 |
|---|---|---|
| Horner 4 | 8.5 | 12.2 |
| OHxF 87 | 8.8 | 13.4 |
| OHxF 97 | 8.5 | 12.6 |
| ANOVA (*P* -value) [2] | | |
| Treatment | NS (0.68) | NS (0.06) |
| Block | NS (0.58) | NS (0.51) |

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

[2] NS indicates not significant.

Harvested 8/31/23; tested 9/1/23.