Effect of Training System and Rootstock on Growth and Productivity of 'Golden Russet® Bosc' Pear Trees

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Abstract

Interest in size controlling, precocious rootstocks has precipitated increased sales of trees grafted to the 'Old Home' x 'Farmingdale' (OHxF) series (Brooks selections). A replicated trial was established in a commercial orchard in Lake County to evaluate performance of 'Golden Russet® Bosc' on six rootstocks and five training systems. Trees grafted on OHxF 69, 97, 217, 333, and 513, and *P. betulaefolia* were planted in May 1993. Spacing was 5 x 3 m (797 trees/ha) for the central leader, three-leader, and parallel hedgerow (grower system) training systems. Spacing was 5 x 1.5 m (1,594 trees/ha) for the freestanding perpendicular fan and Tatura trellis systems. The Tatura was formed by heading single trees at planting, rather than double planting. Four systems received delayed heading, pinching of upright and narrow angle young shoots, selective limb tying and summer pruning. The parallel hedgerow was exclusively dormant pruned by the grower and received intensive limb tying through the season. Final height of free standing trees was approximately 4.5 – 4.7 m. Tatura trellis height was limited to 3 m to maximize sunlight penetration and avoid use of ladders. No fruit thinning was done prior to harvest. Trunk circumference and tree height were measured from 1994 – 1999. Yield per tree and fruit size were measured from 1996 – 1999 and yield per hectare, yield efficiency, and economic return calculated. The Tatura had the highest total gross cumulative returns per hectare. The most productive systems on a per tree basis, factoring in spacing, were the parallel hedgerow and central leader. The three-leader and perpendicular fan systems were least productive on a per hectare, and the perpendicular fan on a per tree basis. OHxF 69 was the most productive rootstock and OHxF 513 the least. The combination of Tatura trellis/OHxF 69 yielded the highest cumulative returns. Results indicate that the Tatura must be combined with the correct rootstock as productivity of training/rootstock combinations varied widely. Row spacing is critical since results would have differed if spacing had been adjusted for the shorter height of the trellis, thus increasing number of trees per hectare by one-third. Tatura returns were reduced in 1998 due to small fruit size, indicating fruit thinning is needed in heavy cropping years. Major drawbacks related to installing a Tatura trellis in California are cost of additional trees, cost of trellis installation, and risk of inadequate lateral shoot growth (as is a tendency with 'Bosc'). Major benefits include earlier cash flow, more efficient labor, reduced labor insurance costs, and improved pesticide deposition.

INTRODUCTION

Producers of orchard crops worldwide have shown great interest in increasing the rate of return on investment in new orchards. This has been accomplished by variously combining increased planting density, alternative training systems, and precocious, size-controlling rootstocks. Apple production systems have provided the model for many other fruit crops due to the commercial availability of size-controlling clonal rootstocks. This has enabled orchard tree densities to dramatically increase from about 222 to as many as 4,000 or more trees per hectare (Ferree and Carlson, 1987). Many of these rootstocks benefit from, or even require, support of a wire trellis for anchorage and to encourage early fruiting (Ferree and Carlson, 1987). Other fruit crops, e.g. cherry, peach, pear, have yet to benefit from true size-

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controlling rootstocks and must rely on training systems and other cultural practices to contain tree size and encourage fruiting, with varying success. Producers of European pear who desire to plant high-density orchards have relied heavily on Quince rootstocks on supported systems to achieve early production (Sansavini, 1982).

There has been very limited adoption of Quince clones in the Western U.S. due to susceptibility to fireblight and winter injury, relatively poor anchorage and poor graft compatibility with 'Bartlett' and 'Bosc', necessitating an interstem (Westwood, 1993). Growers have thus sought out available alternatives, most recently from the clonally propagated 'Old Home' x 'Farmingdale' Series from Oregon, selections of which are now extensively sold by U.S. nurseries. These rootstocks are listed as producing trees 60 to 100% the size of seedlings (Lombard and Westwood, 1987), depending on clone. There are virtually no long-term data, however, in commercial orchards in California for most available clones, particularly in conjunction with other orchard factors such as spacing and training system.

Beginning in 1993, a trial was established to assess the productivity of six then commercially available 'Old Home' x 'Farmingdale' (OHxF) clones as compared to a widely planted seedling, *P. betulaefolia* and Quince BA29/'Comice' interstem. At the same time, it was decided to test several training systems that had been shown to hasten and maintain productivity in other deciduous fruit crops (Baugher et al., 1996; van den Ende et al., 1987; DeJong et al., 1994). The goal was to discern if there was a rootstock/training system combination for pear production on the North Coast of California that could hasten yield, and hence rate of return on investment, as well as offer added benefits of better labor efficiency and improved fruit quality.

MATERIALS AND METHODS

Experimental Design

A replicated trial was established in a commercial pear orchard in Finley, Lake County, California. Cultivar was Golden Russet® Bosc (Carlton Nursery, Dayton, Oregon). The field was fumigated with methyl bromide in the fall prior to planting and a solid-set under tree irrigation system installed. The trial was a randomized complete block design, split-plot, with each treatment replicated five times. The main plots consisted of five training systems: central leader, 3-leader 'vase', parallel hedgerow (grower system), free standing perpendicular fan (based on the Kearney Ag. Center Perpendicular "V" for peaches), and the Tatura trellis. Spacing for the first three systems was 5 x 3 m and 5 x 1.5m for the latter two. Trees trained to the free standing fan and Tatura systems were formed by heading single trees at planting rather than double planting as in Australia (van den Ende et al., 1987). Sub-plots consisted of one tree each of nine rootstocks, each randomized within the plot. There were thus a total of five replicates of each training x roostock combination. Grafted trees of six of the combinations were planted in April 1993. The remaining three rootstocks were planted as seedlings and grafted due to unavailability of grafted trees from the nursery. These three were thus one year behind in growth and yield.

Training Systems and Cultural Practices

Four of the systems received delayed heading, pinching of upright and narrow angle young shoots, and selective limb tying in the spring to encourage formation of laterals and discourage apical dominance. Trees of these systems were also summer-pruned in mid- to late-June to enhance light penetration, promote fruit bud formation, and control vigor. The parallel hedgerow trees were managed by the grower and were exclusively dormant-pruned and received intensive limb tying through the season to form permanent lateral scaffolds. Final height of the central leader, 3-leader, perpendicular fan and parallel hedgerow systems was 4.4 – 4.7 m in 1999. Tatura trellis height was limited to approximately 3 m to maximize sunlight penetration and avoid use of ladders. No fruit thinning was done prior to harvest in order to avoid treatment variability.

Rootstocks

Rootstocks were chosen based on experimental promise and commercial availability. The six chosen 'Old Home' x 'Farmingdale' clones were 40, 69, 87, 97, 217, 333, and 513 (40 and 87 were planted as seedlings). Quince BA29 (with a 'Comice' interstem for compatibility) was the size-limiting control and *P. betulaefolia* the seedling control.

Data Collection and Analysis

Trunk circumference (10 cm above the graft union) and tree height were measured each winter from 1994-1999. Yield and number of fruit per tree were measured from 1996 – 1999. Yield per hectare (kg), fruit size (gms), yield efficiency (kg per cm^2), crop density (kg per m of tree height), and gross economic return using 100% packout ($ per ha) were calculated. Data is reported only for the six rootstocks planted as grafted trees (OHxF 69, 97, 217, 333, 513 and *P. betulaefolia*). Analysis was by ANOVA (SAS, Cary, NC).

RESULTS AND CONCLUSIONS

The Tatura trellis had the highest gross cumulative returns per hectare through 1999, 35% greater than any of the other training systems (Figure 1). Productivity, however, varied greatly according to rootstock, which indicates that the choice of rootstock may have great impact on the net return on investment. Only the Tatura x OHxF 69 combination yielded greater than 37 tons per hectare in the sixth season, the breakeven point generally considered necessary to pay back establishment costs (van den Ende, pers. comm.). Row spacing is also critical since results would have differed if spacing had been adjusted for the shorter height of the trellis, thus increasing the number of trees per hectare. Reduced Tatura returns in 1998 due to small fruit size (196 g/fruit) also indicates pre-harvest fruit thinning is needed in heavy cropping years. While benefits of the Tatura thus include earlier cash flow, more efficient labor and reduced related costs, and improved pesticide deposition, the extra cost of trees, cost of trellis installation, and risk of inadequate yields must be considered.

The parallel hedgerow system was the most efficient training system in 1999, although crop density per meter of tree height was similar for it and the Tatura trellis (Table 1). The emphasis of this system on building strong lateral scaffolds delayed bearing the first several years, but resulted in good yields in the 7^{th} leaf. Fruit size, however, was smaller compared to the other systems, resulting in lower calculated gross return.

Cumulative returns for the central leader system were about equal to the parallel hedgerow. While yield was lower in 1999, it produced more fruit in earlier years with equal or larger size. The three-leader vase and perpendicular "fan" were the least productive systems due to excessive pruning needed to shape them. The freestanding fan is thus an unacceptable substitute (at least for 'Bosc') for the Tatura trellis in this trial.

OHxF 69 has consistently been the most productive rootstock since the first harvest in 1996. It has produced the highest gross returns across all training systems. OHxF 97 and 217 are moderate producers although fruit size is slightly larger for OHxF 97. OHxF 333 and 513 are less acceptable choices thus far due to poorer yields and/or fruit size. *P. betulaefolia* performed surprisingly well on the Tatura system and produced the second highest cumulative returns of the rootstocks from 1996-1999.

Results in the coming years will determine the long-term productivity of each of the training systems and rootstocks.

Literature Cited

Baugher, T.A., Hogmire, H.W., Biggs, A.R., Lightner, G.W., Walter, S.I., Leach, D.W. and Winfield, J. 1996. Packout audits of apples from five orchard management systems. *HortTechnology*. 6(1):34-41.

DeJong, T M., Day, K.R., Doyle, J.F. and Johnson, R.S. 1994. The Kearney Agriculture Center Perpendicular "V" (KAC-V) orchard system for peaches and nectarines. *HortTechnology* 4:362-367.

Ferree, D.C. and Carlson, R.F. 1987. In: R.C. Rom and R.F. Carlson (eds.), Rootstocks for fruit crops. Wiley, New York, p. 107-143.

Lombard, P.B. and Westwood, M.N. 1987, p. 145-183.
Sansavini, S. 1982. Palmette and other pruning –Training systems for pear tress. In: T. van der Zwet and N.F. Childers (eds.). The Pear; Cultivars to Marketing. Horticultural Publications, Florida: 331-353
van den Ende, B., Chalmers, D.J. and Jerie, P.H. 1987. Latest developments in training and management of fruit crops on Tatura trellis. *Hortscience*, 22:561-572.
Westwood, M.N. 1993. Temperate Zone Pomology; Physiology and Culture. Timber Press, Portland.

Table

Table 1. Effect of training and rootstock on yield, fruit size and yield efficiency of 7 year old Golden Russet® Bosc pear trees, Lake County, California, 1999.

	Fruit per Tree (No.)	Fruit Weight per Tree (kg)	Fruit Size (g)	Yield (t/ha)	Trunt cross-section (cm^2)	Yield efficiency (kg/cm^2)	Tree Height (m)	Crop Density (kg/m)
ROOTSTOCK[1]								
OHxF 69	155 a	33.2 a	231.8 ab	37.0 a	98 bc	0.33 ab	4.2 bc	8.1 a
OHxF 97	104 b	24.8 ab	255.2 a	27.4 b	107 ab	0.23 c	4.5 ab	5.5 bc
OHxF 217	100 b	24.1 b	248.6 ab	26.7 b	93 cd	0.25 bc	4.4 b	5.5 bc
OHxF 333	138 ab	29.1 ab	218.3 b	32.1 ab	79 d	0.36 a	4.0 c	7.4 ab
OHxF 513	117 ab	24.5 ab	218.0 b	28.0 ab	93 cd	0.26 bc	4.2 bc	6.0 bc
P. betulaefolia	103 b	23.9 b	237.7 ab	26.0 b	115 a	0.20 c	4.8 a	5.0 c
TRAINING[1]								
Central leader	144 b	33.1 b	234.0 ab	29.8 b	106 a	0.32 b	4.8 a	6.9 bc
Three-leader	100 c	24.1 c	247.0 a	22.0 b	102 a	0.24 c	4.6 ab	5.4 c
Parallel hedgerow	220 a	44.7 a	207.1 b	40.0 a	110 a	0.42 a	4.7 ab	9.5 a
Free-standing “fan”	29 d	7.3 d	251.5 a	13.6 c	82 b	0.09 d	4.4 b	1.7 d
Tatura trellis	104 c	23.6 c	234.7 ab	42.2 a	88 b	0.28 bc	3.1 c	7.8 ab
ANOVA[2]								
Blocks	NS	NS	NS	NS	**	NS	**	NS
Training	***	***	***	***	***	***	***	***
Rootstock	***	**	**	**	***	***	***	***
Training x Rootstock	NS	NS	NS	NS	NS	NS	NS	NS

[1]Within columns, rootstock or training treatment means significantly different (Tukey-Kramer multiple range test, $P < 0.05$).
[2] *,**,*** Indicate significance at $P < 0.05$, 0.01, and 0.001 respectively. NS indicates not significant $P > 0.05$.

Figure

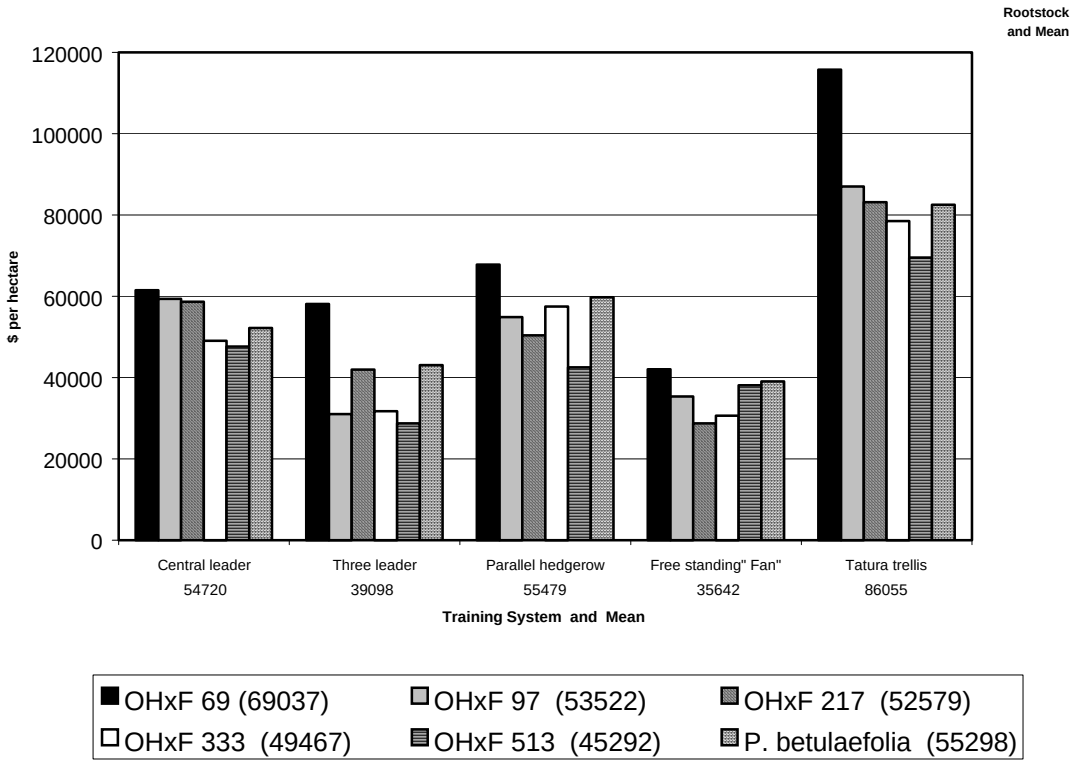

Fig. 1. Effect of training x rootstock combination on accumulated gross returns (based on 100% packout), 7 year old 'Golden Russet® Bosc' pear trees, Lake County, California, 1996 - 1999.