DO HIGH DENSITY SYSTEMS REALLY PAY ? - EVALUATION OF HIGH DENSITY SYSTEMS FOR CLING PEACHES

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Abstract

An orchard of clingstone peaches (*Prunus persica* L. Batsch, cv Ross) was established at the Kearney Agricultural Center in Parlier, California, for evaluating the efficiency of three high density planting systems compared with the standard Open Vase system. The orchard contained four replicated plots of 0.8 ha each with each plot containing four different planting systems. Each planting system subplot was 0.2 ha. The four planting systems were: the "Cordon" system (2.4 x 4.0 m, with 4.8 m perpendicular drive rows at 24 m intervals, 919 trees/ha), the "KAC perpendicular V" system (2.0 x 5.5 m, 919 trees/ha), a "high density KAC-V" system (1.8 x 4.6 m, 1196 trees/ha) and the standard "Open Vase" system (6.1 x 5.5 m, 299 trees/ha). All system-specific costs and crop yields were recorded annually on each subplot for the first five years of the orchard. Cumulative yields were highest for the high density KAC-V system followed by KAC-V, Cordon and Open Vase. Cumulative costs were greatest for the high density V system followed by Cordon, KAC-V and Open Vase. The relative economic returns of the systems depended on the price received for the crops. With high crop prices, high density systems with high crop yields gave the best net returns but the relative advantages of high density systems decreased with low crop prices. This study indicates that the relative economic benefits of planting high density systems depends not only on crop yields and system establishment and maintenance costs, but also on the crop value.

1. Introduction

In the past 25 years, there have been sweeping changes in apple orchard training systems that have revolutionized the way apples are grown throughout most of the world. At the same time, the systems used in peach production have been relatively slow to change, especially in traditional production areas. In California, the large majority of orchards are still using the standard Open Vase system with 250 to 350 trees per hectare. Many of the changes that have occurred in apple systems have been facilitated by the development of a range of size controlling rootstocks and genetic differences in the growth habit of scion cultivars. Similar options are not yet available for peach; however, there have been numerous attempts at developing high density peach planting systems that are either designed to cope with, or take advantage of, the vigorous vegetative growth inherent in standard peach trees (Bargioni, *et al.*, 1985; Chalmers, *et al.*, 1978; DeJong, *et al.*, 1994; Erez, 1978; Hutton, *et al.*, 1987). Several of these systems appear to have mature production potentials equal to, or greater than, the standard system while providing the opportunity for higher yields earlier in the life of the orchard.

However, very little information is available on the economic efficiency of high density systems for peach under commercial production conditions in California. The purpose of this study was to compare the economic production efficiency of four orchard planting systems for peach under California production conditions and to evaluate the effect that variations in labor costs and fruit prices would have on the economic advantages or disadvantages of the various systems.

2. Materials and methods

In January 1990, a field research block of clingstone peaches (*Prunus persica* L. Batsch, cv Ross on Nemaguard rootstock) was established at the University of California Kearney Agricultural Center, Parlier, CA. This research block consisted of 4 replicated plots of 0.80 ha each with each plot containing four different training/planting systems. Each training system subplot was 0.20 ha. The four training/planting systems were the "Cordon" system (trees spaced 2.44 m in the row and 3.96 m between rows with 4.88 m wide perpendicular harvest drives spaced every 22 m down the rows, 919 trees/ha), the "Kearney Agricultural Center perpendicular V" (KAC-V) system (trees spaced 1.98 m in the row and 5.49 m between rows, 919 trees/ha), the "high-density perpendicular V" (Hi D KAC-V) system (trees spaced 1.83 m in the row and 4.57 m between rows, 1196 trees/ha) and the "Open Vase" system (trees spaced 6.10 m in the row and 5.49 m between rows, 299 trees/ha). Rows were oriented in a N-S direction.

The soil was a Hanford fine sandy loam. Prior to planting the soil was fumigated with dichloropropene (Telone II, 92%, at 374 ha^{-1}), deep ripped and leveled. In the first year after planting the field was furrow irrigated. After the first year a slight berm (~15 cm high) was thrown up in the tree rows and the area between the berms leveled. Subsequently the orchard was irrigated by periodic flooding of the area between berms. Irrigation was scheduled to maintain 100% replacement of evapotranspiration requirements. The row middles were tilled the first year and subsequently mowed to control the volunteer weed cover. A meter-wide weed-free strip was maintained down the tree rows with combinations of contact and pre-emergence herbicides as deemed appropriate. Insects and diseases were controlled with pheromone confusion techniques and commercially used pesticides as needed.

Trees were hand planted on January 9, 1990. Immediately after planting trees were headed to a height of ~0.5 m and tree wraps were placed on the lower 0.3 m of each tree.

Detailed descriptions of horticultural operations used for developing and maintaining the four systems are available elsewhere (DeJong, *et al.*, 1997). Tree pruning and fruit thinning operations varied depending on the systems. The KAC-V and Hi D KAC-V systems were generally developed as described by DeJong, *et al.* (1994). The standard Open Vase system was developed generally as recommended by Micke, *et al.* (1980).

Tree height in the three upright systems reached 4-5 m. The Cordon system was developed by initially training the trees to two vigorous, upright shoots and then tying these shoots horizontally down the tree to form Cordons approximately one meter from the soil surface. Branches emanating from the Cordon were then used to bear the crop in subsequent years. Due to difficulties in getting the trees to set fruit on the vigorous upright growth, the system was adjusted after the third year and a system of short, semi-permanent scaffolds extending into the alleyways was permitted to develop fruit-bearing shoots. Tree height was maintained at less than 2.5 m.

Yield data were collected by harvesting into bin trailers that had load cells built directly into the axles and hitch. Only marketable fruit were weighed in the yield data.

The time required to accomplish each mechanical orchard operation (i.e., spraying, mowing, brush shredding, etc.) was calculated by recording the times required to perform the operation on several rows of each system and then multiplying by the number of rows in each system subplot. Machine operators' times were multiplied by $8.50 to calculate labor costs associated with each operation.

Times required to accomplish each hand labor operation were calculated by monitoring the worker-hours spent in each system sub-plot for each operation. Crew sizes ranged from 2 to 16, depending on the task. The worker-hours required to accomplish each hand labor task were multiplied by $6.00 to calculate labor costs associated with each operation.

For convenience, the first year costs were accumulated from January until October 1990. In subsequent years costs were accumulated from October to October.

3. Results

System-specific costs (Fig. 1) during the first year were dominated by the initial establishment costs which included tree costs ($3.99 per tree), planting cost ($0.41 per tree by commercial contractor), initial pruning time ($6.00 per hour) and installation of tree protectors ($0.025 each plus labor). These costs per hectare were directly proportional to tree density since the commercial nursery and planter did not offer cost breaks for high density plantings. Tree training costs in the first year varied from zero in the Open Vase system to $800.63 per hectare for the Cordon system.

System-specific costs were minimal in the second year and in the subsequent three years the majority of costs were associated with pruning, fruit thinning and harvesting, regardless of system. The Cordon system generally had the highest summer pruning costs but the lowest dormant pruning costs. Fruit thinning and harvest costs were generally related to crop load. Cumulative expenses over the five years of this trial were consistently highest for the highest density system. Costs of establishing and maintaining the Cordon system were higher than the KAC-V system (at the same tree density) over the first two years. However, costs during later years were dominated by fruit thinning and harvest costs and the Cordon system had lighter crop loads and tended to be a little more efficient to harvest than the two "V" systems.

Of the four systems, the Hi D KAC-V system produced the highest annual yields except in the second year (Fig. 2). In 1991 the Cordon system out-produced the other three systems but then lagged behind the other two high density systems in subsequent years. The Open Vase system consistently had the lowest yields in all years but these were not significantly less than produced by the Cordon system in the fourth and fifth years.

Even though the Hi D KAC-V system produced the highest mean crop yields over the five year period (Fig. 2), the cumulative gross profit for the period was not substantially different than the standard KAC-V system (Fig. 3) because of the difference in annual costs associated with each system. Similarly, although the annual yield values of the Cordon system were substantially greater than the Open Vase system (Fig. 2), the Open Vase system was more profitable than the Cordon system (Fig. 3) because of the relatively high establishment and maintenance costs of the Cordon system.

4. Discussion

More specific information about establishment costs, maintenance and harvest costs, differences in yield components (fruit number and size) and physiological efficiency of the four systems will be presented in other papers. This discussion will focus on a comparison of the overall economic efficiencies of the four systems.

The yield results of this study corroborate the general expectation that higher density plantings produce higher yields early in the life of the orchard than lower density plantings (Jackson, 1985). However, it is also clear that differences in pruning and training practices can result in substantial differences in yield when trees are planted at the same tree density (comparison of KAC-V with Cordon in Fig. 2). From an economic point of view, clearly the cumulative estimates of gross profit over the five-year period are the most valuable. Interestingly, the cumulative gross profit of the highest and lowest yield systems were nearly identical after the third year (Fig. 3) while the Cordon system, which had the highest yields in the second year (Fig. 2), was economically the least efficient in the third and fourth years (Fig. 3). Although there were no significant differences in yield between the KAC-V and the Cordon system in the fifth year, there was still a significant economic difference between the two systems in that year (Fig. 3).

The data in Fig. 3 indicate that there are no significant differences in the profitability between the V systems planted at different densities or between the Cordon and the Open Vase systems. These data were based on calculations using the average price received for the crop over the four cropping years ($193.46 mt^{-1}) and labor prices of $6.00 and $8.50 per hour for hand labor and tractor drivers respectively. To evaluate how changes in crop price would affect the relative economic efficiencies of these systems, gross profits were recalculated using crop prices that were \$45.36 mt^{-1} higher and lower (Fig. 4).

Rising crop prices favored the V systems over the other two systems whereas decreasing crop prices closed the gap between the Open Vase system and the V systems and increased the favorability of the Open Vase system compared to the Cordon system (Fig. 4).

On the conservative side one could interpret the data presented in Fig. 3 to indicate that there appears to be little incentive for growers to plant the Hi D KAC-V system instead of the lower density KAC-V system or similarly the Cordon system instead of the Open Vase system. Alternatively, if one is predisposed to higher density systems the data in Fig. 3 could be used to indicate that there is little reason not to use these systems. Using a similar approach, one could interpret the data in Fig. 4 to indicate that there is little economic incentive to plant the V systems compared to the Open Vase system. However, it is clear from Fig. 4 that the higher yielding systems that do not have excessive maintenance costs offer a greater opportunity to take advantage of increased prices received for the crop. Clearly, understanding and controlling the costs involved in establishing and maintaining a particular orchard system can be as important as documenting yield when evaluating high density systems.

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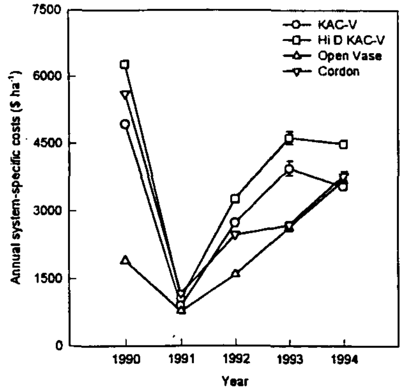

Fig. 1. Five-year summary of the annual system-specific costs (labor and materials costs) directly related to differences between the systems (trees, planting, pruning, thinning, harvest, etc.). Costs assessed on a ground area basis (land, irrigation, etc.) related to the establishment and maintenance of four peach systems were excluded. The symbols represent means "SE of four 0.2 ha plots per training system. See text for details about systems and costs.

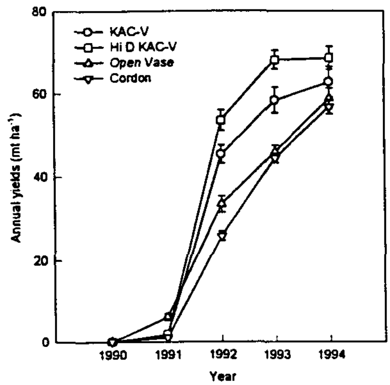

Fig. 2 - Summary of annual yields of four peach orchard systems during the first four years after planting. (Trees were planted January 1990.) Symbols represent means + SE of four 0.2 ha plots per training system. See text for details about systems.

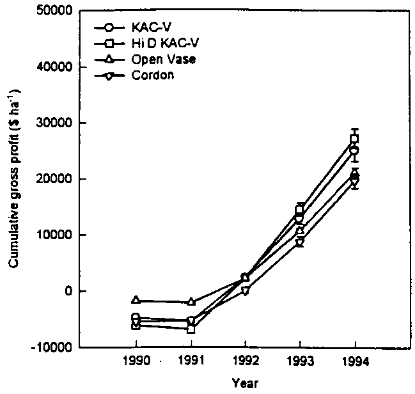

Fig. 3. Comparison of cumulative gross profit calculations [(crop yield x price ($193.46 mt^{-1}) - system specific costs) x interest rate (8%] for four orchard systems over the first five years after planting. Symbols represent means + SE, n = 4.

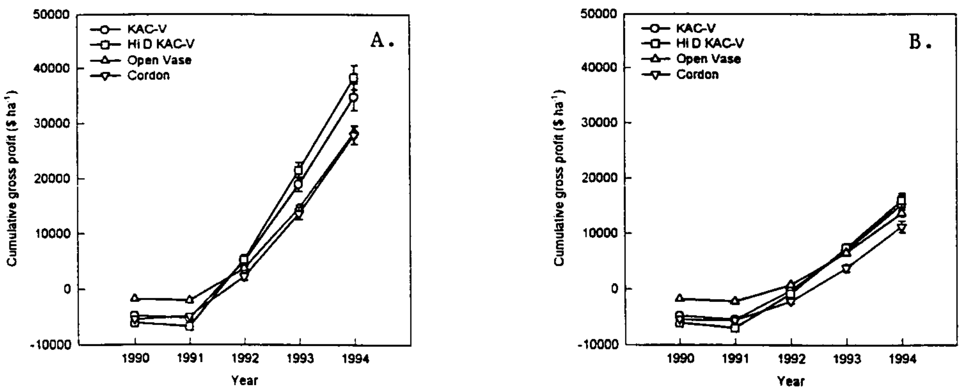

Fig. 4. - Comparison of cumulative gross profit calculations using A) higher crop prices ($238.82 mt^{-1}) and B) lower crop prices ($148.10) than used in Fig. 3. See Fig. 3 for details.