More Productive and Profitable Peach Planting Systems

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Peach trees in NY State have a relatively short productive life (15 years), and low production levels compared to other peach producing areas with warmer climates. Our research has shown that high-density peach orchards can be successfully managed at densities of 400-600 trees/acre. These systems are much more productive and profitable than traditional low-density systems. Peach growers in NY should plant higher densities per acre to be competitive with peach growers in more southern climates.

Although pruning and training systems for apple planting systems have changed rapidly in the last 10 years, schemes for training and pruning peaches have been slow to change. The Open Center or Vase is still the most dominant system in use today in New York. This system's requirement for ground level production, strong annual pruning, and wide plant spacing has limited both early and mature production. New York's marginal climate for peach production has also limited the productivity and profitability of NY peach orchards. Winter damage, the main cause of Cytospora canker disease, is primarily responsible for a peach orchard's average lifespan of only 15 years in New York.

Experience with apple planting systems has shown that higher planting densities, and specialized pruning and training strategies have a huge effect on orchard productivity and profitability (Robinson et al., 2007). The renewed interest in peaches as an alternate crop for apples in recent years offered us the opportunity to investigate new pruning and training methods for peaches appropriate for New York. A planting systems trial was established in NY in 1999 with the objective of improving productivity and profitability in the NY peach industry. Six peach training systems [Open Center (155 trees/acre, Quad-V (218 trees/acre), Tri-V (366 trees/acre), Perpendicular-V (641 trees/acre), Central Leader (444 trees/acre) and Fusetto (779 trees/acre)] on three varieties [Allstar (yellow peach), Blushingstar (white peach) and Flavortop (nectarine)] all on Bailey rootstock were compared in a replicated field trial planted in 1999 at Olcott, New York (Table 1).

In this article we will describe the training procedures for establishing new high density peach plantings and compare their performance in our trial.

Open Center System

The Open Center (OC) or Vase system is the most common planting system used in the Northeast today. The OC requires the establishment of a significant support structure consisting of trunk and scaffolds. In order to achieve this goal, this system must start branching close to the ground, be widely spreading and not be allowed to grow more than eight feet tall. The low tree number at planting and aggressive pruning required to fill the abundant space, limits early cropping. Also, at

Figure 1. Perpendicular-V peach tree with two columnarized scaffold branches

TABLE 1

Six orchard planting systems evaluated in the New York peach systems trial.

System Name	Scaffold Arrangement	Tree Density /Acre	Tree Spacing (ft)	Initial Tree Heading Height (in)
Open Center	4 scaffold branches with 4 bifurcations.	155	14 X 20	24
Quad-V	4 scaffold branches without bifurcation and with renewal pruning.	218	10 X 20	18
Tri-V	3 scaffold branches without bifurcation and with renewal pruning.	366	7 X 17	18
Perpendicular-V	2 scaffold branches without bifurcation and with renewal pruning.	641	4 X 17	18
Central Leader	Central trunk with permanent lower tier of 4 branches.	444	7 X 14	40
Fusetto	Central trunk with no permanent lower tier branches.	778	4 X 14	40

maturity, this aggressive pruning provides abundant new fruiting shoots most of which must be removed. All growers are familiar with this traditional style of pruning and many pruning plans have been published (Funt et al., 1982; Lamb and Edgerton, 1983), so methods for pruning and training this system will not be discussed here.

V Systems

The V systems are modifications of the Open Center system that allow for higher densities. In our trial, we compared three densities of the V: the Perpendicular-V (two permanent upright scaffolds), (Figuure 1) the Tri-V (three permanent upright scaffolds) and the Quad V (four permanent upright scaffolds) systems. The Quad-V system had a tree density of 218 trees per acre and was spaced 10 feet in-row with 20-foot rows. The Tri-V system had a tree density of 366 trees per acre and was spaced seven feet in-row and 17 feet between rows. The Perpendicular-V system had a tree density of 650 trees per acre and was spaced four feet in-row and 17 feet between rows. The V systems use more upright scaffolds and

TABLE 2

Pruning and Training Plan for Establishing the Perpendicular-V Peach Training System

Year	Operation
First Leaf	
Before Planting	Trees should have abundant buds along the length of the trunk and should be 1/2-5/8 inch diameter. Trees without side branches are ideal. Seedling rootstocks such as Lovell or Bailey are appropriate for this planting system. Plant block so that tree rows run North/South.
At Planting	Before planting soak tree roots in water to hydrate the root system. Plant trees with graft union slightly below soil line. If tree has sufficient buds below 18 inches then head trees 18 inches above the soil line. Stub any remaining side shoots making sure to leave 1 or 2 live buds at the base of each shoot.
Soon after Planting	Apply 2-3 gallons of water with 20-20-20 starter solution to each tree immediately after planting to settle soil and promote rapid tree growth.
Early-summer	Control all secondary pests especially oriental fruit moth and peach tree borer. Apply 1/4 pound Calcium nitrate per tree. Hang soap bars or fence block to prevent deer feeding.
Mid-summer	Pinch back shoots with upright crotch angles and those oriented along the tree row.
Second Leaf	
At Bloom	Prune coinciding with bloom of mature peach trees and when dry and no rain is in the forecast for several days. Select two scaffolds approximately 12-15 inches above the soil line each facing toward opposite row middles. These scaffolds should be about the same vigor and have flat crotch angles. Select ones that are separated along the trunk by approximately 3 inches if possible. Remove all other shoots. Tip scaffolds lightly if needed to balance length of each arm. If appropriate scaffolds are not available, select the best available scaffold even if it is oriented along the tree row. Redirect growth back toward the tree row by choosing a side shoot facing in that direction. The result after pruning should be a tree with a basic Y shape.
Early-summer	Pinch back or remove all shoots that are excessively large along each scaffold arm. Remove all shoots that are growing upright on the inside of the Y arms with a flush cut. Control all secondary pests – insects, diseases, weeds, and mammals.
Mid-summer	Repeat early-summer training.
Third Leaf	
At Bloom	Continue to establish the Y-framework by stubbing back all lateral limbs along each scaffold that are more than 1/2 the diameter of main scaffold close to where it originates leaving a small side shoot or 2-3 live buds. Every shoot that is upright and on the inside of the Y-frame should be completely removed. Stub back up to 50% of all side shoots along each arm to 2-3 buds. The remaining shoots should be evenly spaced along each Y arm and about 6 inches apart. Trees should be encouraged to carry a crop in the 3rd leaf if they have grown well. Remove all apparent cankers.
Fruit Set-Pit Hardening	Fruit should be hand thinned 8 inches apart before pit hardening.
Mid-summer	Prune out all upright shoots along the inside of the Y-arms. Stub back all shoots that are too vigorous for their position to 2-3 buds. Remove all cankers.
2 weeks before harvest	Repeat Mid-summer.
Fourth Leaf	
At Bloom	Continue to establish the Y-framework by stubbing back any shoot that is more than 1/3 the diameter of main scaffold to a side shoot or leaving 2-3 live buds. Completely remove every shoots that is large, upright and on the inside of the Y-frame. Bench cut each scaffold arm at approximately 10 feet above the ground to a side shoot. Use bench cut to encourage spreading of upright varieties. Upright growth should be encouraged for spreading trees. Remove all apparent cankers. Stub back approximately 50% of the number of remaining side shoots to 2-3 buds to provide next year's fruiting wood. The remaining shoots should be evenly spaced along each Y arm and about 6 inches apart.
Before Pit hardening	Space peaches 6-8 inches apart on each shoot depending on cultivar and fruit size required.
Mid-Summer	Remove all vigorous and upright shoots in the interior of the Y framework.
2 weeks before harvest	Repeat Mid-summer.
Fifth to Twentieth Leaf	
At Peach Bloom	Remove shoots on the center of Y especially in the upper part of tree to keep the center of the Y open and to keep shoots in lower part of canopy adequately illuminated with sunlight to maintain active growth and continued fruitfulness. Manage cankers by removal or by canker surgery to keep scaffold arms and trunk intact. Continue to cut permanent scaffold arms to a lateral shoot at approximately 12 feet in height keeping tops very narrow and in line with trunks. Continue to annually renew at least 50% of shoots by stubbing back to 2-3 buds and spacing approximately 12 inches apart.
Before Pit hardening	Thin peaches appropriate to variety and desired fruit size (usually 6-8 inches apart on each shoot).
Mid-summer	Remove vigorous and upright interior shoot growth to keep interior of Y open to allow adequate illumination of lower part of canopy.
2 weeks before harvest	Repeat Mid-summer pruning.

are taller than the OC System. With the Perpendicular V, one scaffold is trained to each side of the row thus creating an open V down the row. With the Quad V, two scaffolds are trained to each side of the row while with the Tri-V, alternate trees down the row have two scaffolds trained on one side and one on the other side. In our trial all of the V systems were headed strongly at planting to develop strong upright scaffold growth 20 degrees from the vertical. Permanent scaffold arms were created with renewable fruiting wood along the length of each arm. The scaffolds were trained up and over the tractor alley leaving a six-foot open gap between adjacent rows. All upright shoots along the arms are permanently removed with flush cuts ensuring that canker will not develop at the site of the cut.

After scaffold establishment, we used renewal pruning along the scaffold limbs to generate new fruiting wood. More than 50% of the shoots from each arm were removed annually during dormant pruning to assure new fruiting wood for the following season depending on potential crop and number of shoots available. To keep sufficient light in the lower portion of trees, summer pruning the interior of the tree was required to keep strong fruiting wood in the bottom of the tree. As these orchard systems age, there is increased risk of weak and shaded wood, canker development and smaller fruit size. Tops were cut back annually to stiffen scaffolds, remove excess crop and keep tree height at 12 feet. In mature orchards main scaffolds are sometimes strapped together to maintain their integrity. These systems require ladders for pruning, thinning and picking while the OC system does not. Simplified training plans for V-shaped systems are included in Table 2.

Central Leader Systems

Our trial included two densities of central leader trees. The Central Leader (CL) system had a tree density of 444 trees per acre and was spaced 7 X 14 feet while the Fusetto (Slender Spindle) system, which is a high-density version of the CL system, had a tree density of 778 trees per acre and was spaced 4 X 14 feet. The CL system had a permanent lower tier of scaffold branches and renewable branches above the lower scaffolds, while the Fusetto had no permanent scaffolds and all limbs were renewable. Severe limb renewal was required because of the very close in-row spacing. All the fruit was produced on renewable shoots originating along the central leader. Shoots were separated along the leader with a portion always in the renewal phase.

Our experience with the central leader systems showed that it is necessary to aggressively remove competitive shoots when developing the tree to promote a strong leader. Weak apical dominance and heavy crop loads on weak nonstructural shoots in the tree top help to limit vigor and tree height. Pruning and training plans are combined for CL systems in Table 3.

Results and Discussion

The less severe initial pruning of the two central leader systems resulted in the highest yields in the second year and weaker shoot growth compared to the OC and V systems. However, this early yield advantage was quickly lost by the third year when the V systems completed formation of their initial tree structure and began fruiting (Table 4). In the third year through the eighth year the perpendicular V was the highest yielding system.

Cumulative yield over 8 years was largely a function of tree density. Increasing density gave greater canopy volume, which improved both early and mature yields compared to the traditional OC. The V systems had higher cumulative yield than the central leader systems at similar densities (Table 4). However, both the V and the Central Leader systems had much greater yield than the traditional OC system. This indicates that there is significant potential improvement in peach yields in NY State by changing to one of these high-density systems.

Fruit size was negatively related to tree planting density. Thus, fruit size was significantly smaller with the high-density systems than the OC system (Table 5). Nevertheless, fruit size was still very good with these systems. In contrast, fruit color was better with the V and Central leader systems than with the OC system (Table 5). This was likely due to improved light distribution within the canopy in the narrow profile high-density systems.

When yield and fruit pack-out were converted to crop value, the high density systems had a much higher crop value than the traditional OC system (Table 5). The Perpendicular-V System had the highest crop value in our trial but not the highest density. The Fusetto had the highest tree density but its cumulative crop value was less than the Perpendicular V and the Tri-V systems.

We estimated the lifetime profitability of the different systems by projecting yield from year 8 to year 15 and calculating the net present value of the profitability. There was a positive curvilinear relationship with tree density up to a density of 500-600 trees/acre (Figure 2). Above this density profitability was not improved except with the nectarine (Flavortop) which was not well adapted to NY growing conditions as evidenced by the low yield compared to the yellow and the white peach. The most profitable system was the Perpendicular V followed by the Tri-V systems. Even though establishment costs of the OC and the Quad-V were lower due to reduced tree numbers, the savings in tree cost was not enough to compensate for the greater yields of the Perpendicular-V or the Tri-V systems. This is similar to results from California (Day et al., 2005); however, the slower tree development and lower vigor of trees in NY resulted in the Perpendicular-V being the most profitable system without the excessive shoot growth problems of CA.

The Central leader and Fusetto have been the systems of choice in Eastern Canada (Miles and Guarnaccia, 1999). Their research showed that the central

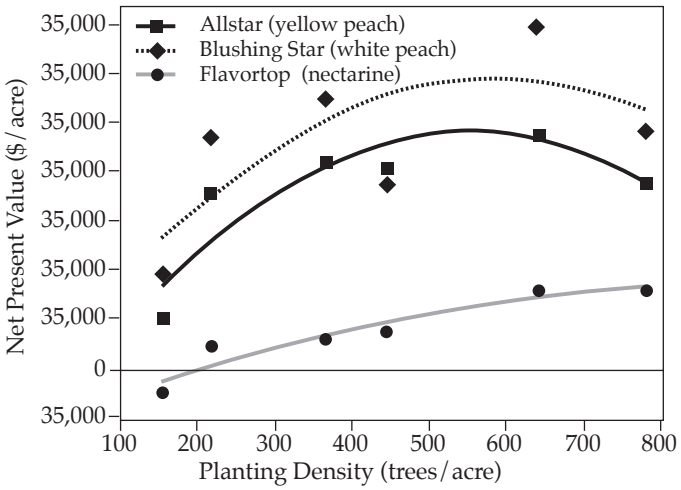

Figure 2. Effect of tree density on profitability (Net Present Value $/acre)for two peaches and a nectarine variety using a Net Present Value analysis of profit over a 15 year orchard life.

TABLE 3

Pruning and Training Plan for Establishing Central Leader and Fusetto Peach Training Systems

Year	Operation
First Leaf	
Before Planting	Trees should be good quality with an excellent root system and abundant buds or shoots along the length of the trunk. Seedling rootstocks such as Lovell or Bailey are appropriate for this planting system. Plant block so that tree rows run North/South.
At Planting	Before planting soak tree roots in water to hydrate the root system. Plant trees with graft union slightly below soil line. Head trees 40 inches above the soil line. Remove all shoots below 18 inches above the soil level. Stub all remaining lateral shoots leaving at least 2 live buds on each shoot.
Soon after Planting	Apply 2-3 gallons of water with 20-20-20 starter solution to each tree immediately after planting to settle soil and promote rapid tree growth
Early-summer	Control all secondary pests especially oriental fruit moth and peach tree borers which directly affect tree growth. Apply 1/4 pound Calcium nitrate per tree. Hang soap or fence block to deter deer feeding.
Second Leaf Fusetto	
At Bloom	Prune coinciding with bloom of mature peach trees and when dry and forecast is free of rain for several days. Remove all narrow-angled shoots from the trunk and those that are more than 1/2 the diameter of the trunk where they originate. Thin shoots so that they are approximately 4 inches apart. Remove all short weak shoots especially those with flowers. Identify the best shoot for a leader and remove all competing shoots. Single all remaining shoots wherever there is a forked shoot.
Early-summer	Thin peaches by hand to a light crop load (8-10 inch spacing) that will not negatively impact shoot growth. Upright shoots should be removed or pinched back. Peaches are not strongly apically dominant so encourage leaders to grow strongly by removing any new competitive shoots. Keep Oriental fruit moth and lesser and greater peach tree borer under complete control.
Mid-summer	Repeat early-summer training.
Second Leaf Central Leader	
At Bloom	Prune coinciding with bloom of mature peach trees and when dry and forecast is free of rain for several days. Select 3 or 4 lower scaffold limbs 18-30 inches above the soil line with good crotch angles and equally spaced around the tree. Scaffolds should be 3 inches apart on the leader rather than directly opposite each other. Ideally these scaffolds should be no more than 1/2 the diameter of the trunk where they originate. Also select a strong upright shoot near the top of the tree as the leader. Remove all shoots that compete with the leader and short weak shoots with flowers. Single all remaining shoots wherever there is a forked shoot
Summer	Same as Fusetto.
Third Leaf Fusetto	
At Bloom	Select a vigorous upright shoot in the top of the tree as the leader and remove all competitive shoots several inches below to encourage apical dominance. Remove all cankered limbs and those with narrow crotch angles. Renew any limbs that are too large for the plant spacing by shortening back to near the point of origin leaving 2-3 live buds at the base of the shoot. Manage crop load through selective stubbing of fruiting shoots along the leader. Stub back up to 50% of all side shoots leaving 2-3 buds to grow into a renewal shoot. The remaining shoots should be evenly spaced along the leader ideally 6-8 inches apart.
Fruit Set-Pit hardening	Fruit should be hand thinned 6-8 inches apart before pit hardening depending on variety and desired fruit size.
Mid-summer	Remove upright and overly vigorous shoots along the Leader. Stub back all shoots that are too vigorous for their position to 2-3 buds. Remove all cankers.
2 weeks before harvest	Repeat Mid-summer pruning.
Third leaf Central Leader	
At Bloom	Select a vigorous upright shoot in the top center of the tree as the leader. Remove all competitive shoots within 6 inches of this shoot. Remove all cankers. Simplify each bottom scaffold by removing strong lateral or upright shoots leaving only fruiting twigs. Redirect scaffold branch growth into appropriate positions around the tree by cutting back to a lateral shoot pointed in the right direction. Stub back 50% of lateral shoots along the leader to 2-3 buds to develop renewal shoots as next year's fruiting wood.
Summer	Same as Fusetto
Fourth Leaf Fusetto	
At Bloom	Select a vigorous upright shoot in the top center of the tree as the leader and remove all competitive shoots 12 inches below to encourage apical dominance. Remove all cankered limbs and those with narrow crotch angles. Renew any limbs that are too large for the plant spacing by shortening back to near the point of origin leaving 2-3 live buds at the base of the shoot. Manage crop load through selective stubbing of fruiting shoots along the leader. Stub back up to 50% of all side shoots leaving 2-3 buds to grow into a renewal shoot. The remaining shoots should be evenly spaced along the leader ideally 6-8 inches apart. Stubbed back shoots will provide fruiting wood for next year's crop.
Before Pit hardening	Thin fruitlets to appropriate levels depending on cultivar and market needs to achieve necessary fruit size. Likely fruits will be spaced 6-8 inches apart on each shoot.
Fourth Leaf Central Leader	
At Bloom	Select a vigorous upright shoot in the top center of the tree as the leader and remove all competitive shoots 12 inches below to encourage apical dominance. Remove all cankered limbs and those with narrow crotch angles. Simplify each bottom scaffold by removing strong lateral or upright shoots leaving only fruiting twigs. Redirect and limit scaffold branch length into appropriate positions around the tree by cutting back to a lateral shoot pointed in the right direction. Thin remaining fruiting twigs along the leader by stubbing back 1/2 of lateral shoots along the leader to 2-3 buds to develop renewal shoots as next year's fruiting wood.

TABLE 3 CONTINUED ON NEXT PAGE

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Pruning and Training Plan for Establishing Central Leader and Fusetto Peach Training Systems

Year	Operation
Fifth to Twentieth Leaf Fusetto	
At Bloom	Maintain good light distribution throughout the tree by renewing any limb along the leader that is larger than 1 inch diameter. Prune more aggressively in the top of the tree to improve light exposure of bottom shoots to maintain continued fruitfulness. Remove excess fruiting twigs in the tree top to maintain the central leader and prevent leader breakage from over cropping. Cut back central leader to a side shoot at approximately 12 feet in height. Continue to renew shoots by stubbing back several larger lateral branches to 2-3 buds and spacing fruiting twigs approximately 10-12 inches apart. This will ensure sufficient renewal shoots for next years crop.
Before Pit hardening	Thin fruitlets to appropriate levels depending on cultivar and market needs to achieve necessary fruit size. Likely fruits will be spaced 6-8 inches apart on each shoot.
Mid-summer	Summer prune if necessary.
Fifth to Twentieth Leaf Central Leader	
At Bloom	Maintain good light distribution throughout the tree by limb renewal pruning of all lateral limbs except for the permanent scaffolds. Prune more aggressively in the top of the tree to improve light exposure of bottom scaffolds to maintain continued fruitfulness. Remove all excess fruiting wood in the tree top to maintain the central leader and prevent leader breakage from over cropping. Trees should be approximately 12 feet in height with very narrow tops. Continue to renew shoots on the lower scaffolds and on the leader by stubbing back several larger lateral branches to 2-3 buds and spacing fruiting twigs approximately 12 inches apart. This will ensure sufficient renewal shoots for next years crop.
Summer	Same as Fusetto

TABLE 4

The average fruit yield (bushels/acre) of 3 varieties for 6 planting systems over 8 years.

Planting System	Density	2000	2001	2002	2003	2004	2005	2006	Cumulative
Open Center	156	0.4	20.4	95.1	180.7	230.8	164.5	288.2	980
Quad-V	218	0.3	28.6	118.7	220.7	324.5	275.6	291.3	1260
Tri-V	366	0.8	50.5	178.9	374.1	483.8	331.3	444.3	1864
Perpendicular-V	641	2.2	150.2	270.6	430.1	627.3	306.8	418.3	2206
Central Leader	444	9.0	110.4	202.6	273.2	375.2	224.4	295.4	1490
Fusetto	778	19.2	120.7	208.7	354.9	463.9	224.8	299.3	1692

leader tree form provided improved production efficiencies particularly in labor costs. In addition, orchard workers could understand pruning concepts better since it mirrored what was being done in apples. However, in our trials, the V systems had greater yield and greater profitability than the Central Leader systems. In addition, the upright growth habit of peach caused many scaffolds to be too upright, and crotch angle management was much more difficult than in the V-shaped canopy systems which naturally trended upright. Tight crotch angles in the CL resulted in canker formation on the main trunk resulting in tree girdling and loss. The tight stacking of fruiting branches, one on top of another, along the central leader made it more difficult to maintain good light distribution throughout the canopy resulting in weaker and smaller shoots, invasion sites for canker, and smaller and more poorly colored fruit.

Although there was a negative effect of the highest density systems on fruit size, the additional yield and early bearing of these systems make them significantly more profitable than the traditional OC system or the Central Leader systems. Our recent data (not shown) indicates that smaller fruit size is inherent to the high density planting systems and is not improved with more aggressive thinning. The role of competition among trees in high-density orchards for nutrients, water and light as density increases needs to be investigated. There may be other factors important in fruit size reduction including changes in the quantity and/or quality of the leaf surface as affected by crop load.

Table 5

Effect of 6 Orchard Planting Systems on Fruit Size and Color and Farm Gate Crop Value for the first 6 Years.

System	Tree Density/Acre	Av. Fruit Size (g)	Fruit Red Color (%) (2004)	Cumulative Farm Gate Crop Value/acre ($)**
Open Center	156	182.4 a*	46.3 b	6,057 d
Quad-V	218	179.7 a	61.5 a	9,987 c
Tri-V	366	172.0 b	56.7 a	11,572 b
Perpendicular-V	641	160.9 c	61.4 a	15,667 a
Central Leader	444	170.1 b	61.9 a	11,568 b
Slender Spindle	778	168.1 b	60.2 a	14,658 a
LSD $p \leq 0.05$		6.7	5.9	3,539

*Means followed by the same letter are not significantly different. ($p \leq 0.05$, $n=9$)
** Excludes picking, storage and packing costs.

Conclusions

It is clear that peach trees in NY State can be successfully managed at high densities and that these systems are much more productive and profitable than traditional systems. Given the relatively short life/low production levels of peach orchards in NY (15 years), it is critical that fruit growers in NY fruit growers plant densities between 400-600 trees per acre to be competitive with peach growers in

more southern climates, which have higher production and longer orchard life.

References

Day, K.R., DeJong T.M., and Johnson, R.S. 2005. Orchard-system configurations increase efficiency, improve profits in peaches and nectarines. *California Agriculture* Apr-Jun:75-79.

Funt, R.C., Ferree, D.C, and Hill, R.G. 1982. Training and Pruning Fruit Trees. OSU CES Bull. 528. pp.13-17.

Lamb, R.C. and Edgerton, L.J. 1983. Peach growing. NYSAES Info. Bull. 44. 16 pp

Miles, N.W. and Guarnaccia, R. 1999. High density peach production in Ontario. *NY Fruit Quarterly* Vol. 7(4):1-5.

Robinson, T.L, Hoying, S.A. and Andersen, R.L. 2007. Performance of 6 high density peach training systems in the Northeast. *Acta Hort* 732:421-428

Robinson, T.L., Hoying, S.A., DeMarree, A.M., Iungerman, K. and Fargione, M. 2007. The evolution towards more competitive apple orchard systems in New York. *New York Fruit Quarterly* 15(1):3-9.

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