Experiences with Support Systems for the Tall Spindle Apple Planting System

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The support system in today’s modern orchard is an essential component. Fully dwarfing rootstocks used in the Tall Spindle and Vertical Axis planting systems induce early bearing so that the tree’s trunk and limbs cannot support the full weight of the fruit (Robinson, 2003). In addition, many of the newer rootstocks have brittle graft unions, which have a tendency to snap under any type of stress induced by wind and fruit weight. The pruning and training schemes for these systems have eliminated heading cuts on the leader so that these planting systems grow taller more quickly creating significant leverage on the tree and graft union. A sturdy support system capable of holding more than 35 tons of fruit per acre is necessary and takes the place of the trunk and scaffolds of older systems. Support systems must also be engineered to withstand the additional stresses caused by wind, snow and rain which can add another 871,000 lb. of force.

“Modern high-density planting systems such as the Tall Spindle can produce huge crops on small trees, which can create significant leverage on the tree and graft union. A sturdy support system capable of holding more than 35 tons of fruit per acre is necessary and takes the place of the trunk and scaffolds of older systems. Support systems must also be engineered to withstand the additional stresses caused by wind, snow and rain which can add another 871,000 lb. of force.”

Although economic analyses of orchard system profitability show that input costs including support systems, are a secondary profitability factor compared to yield and fruit quality (Robinson et al., 2007; Robinson and Hoying, 2003), apple producer’s usually try to build the least expensive support system possible by minimizing material costs. The capabilities of these support systems have always lagged behind the developments in horticulture, which has maximized early production and yield. Consequently, support systems have repeatedly failed over the years due to weaknesses in their materials and construction. Since fruit plantings are established for the long term, more than 20 years, mistakes made at establishment have long lasting effects and are very costly if not impossible to correct (Figure 1). In 2010 we established an apple planting at the Hudson Valley Lab funded by the Apple Research and Development Program to be used to study horticultural aspects of apple production. This approximately 1.5 acre planting consists of 21 rows, 1700 trees, and 20 different varieties and strains. One of the research objectives was to compare support systems for the Tall Spindle and Vertical Axis planting systems. Support systems were established in 2011 the year after planting.

Figure 1. 5-Wire support system withstands crop load, snow load, and other stresses.
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Materials and Methods

Five different support systems were installed in 2011, the year after planting. All of the support systems used pressure-treated 12-foot lodgepole pine posts spaced 30 feet apart in the row as a basis. Past experience has shown that greater distances between the posts have resulted in excessive leaning between the rows particularly with taller planting systems. The systems included 1) Single Stake Single High Wire, 2) 3-Wire Trellis, 3) 5-Wire Trellis, 4) 3-Wire with wire training aide 5) 3-Wire with bamboo training aide.

1) Single Stake Single High Wire has been the most common support system for high density systems in NY State and is most appropriate for the Vertical Axis system since the lower number of trees/acre results in lower investment in individual stakes (Figure 2). It provides excellent support and the 10 foot X ½ inch conduit or 1” bamboo provides optimum height support for plantings when the spacing between rows is 11’ to 14’. Shorter inline posts can be used since the individual stakes provide support to 9.5 feet above the ground. The system consists of a single wire attached to the inline posts approximately 7’ off the ground. Each individual stake is attached to the wire with a trellis clip or potato bag tie. The tree is initially fastened to the stake and then as the tree grows additional ties are made to the very top of the stake. This support system facilitates easier movement among trees and rows for harvest crews.

2) 3-Wire Trellis is a minimalist system consisting of 3 wires spaced evenly along the inline posts (Figure 3). The bottom wire is 24” above the ground and fastened on the windward side of the post with staples. The top wire is fastened with staples on the top of the post. A single staple is laid horizontally to prevent the highly tensioned wire from cutting into the post. The middle wire is spaced evenly between these two wires, and in our case 66” above the ground.

3) 5-Wire Trellis adds two more evenly spaced wires to the 3-Wire system (Figure 4). Wires are located at 24”, 45”, 66”, 87”, and 108” above the ground all fastened on the windward side of the post with staples.

4) 3-Wire with Soft Wire Training Aide championed by Finger Lakes Trellis and described in their catalogue dubbed “Stabilizer System”. This system uses soft wire to bridge the gaps between the top middle and bottom wires at each tree and is fastened using a crimping air tool. The soft wire is used as a training aide to fasten the leader to and “stabilize”
the leader’s vertical growth. The wire will also support fruit weight if the tree is tied just above fruit clusters. The vertical height of this system is limited by the length of the inline support posts (approximately 108” when using a 12 foot post or 84” when using a 10 foot post.

5) **3-Wire with Bamboo Training Aide** performs similarly to 3-Wire Stabilizer system except that the training aids are more rigid and is fastened to the upper and middle wire only using trellis clips or potato bag ties (Figure 5). The top of each bamboo stake reaches the optimum 10 feet in height by extending the bamboo splint 12” above the top wire. The bamboo stake used is very light-weight and measures 3/8” X 6 feet.

**Results**

Tree support system did not affect trunk circumference (a measure of tree vigor) of NY 1 and NY 2 after 3 years but did affect tree height (Table 1). The 3-Wire with bamboo splint system completely supported the growing leader of NY 1 and allowed it to grow significantly taller than any of the other supports for NY1 by the end of the 3rd leaf (Figure 6). There were obvious differences in growth between NY 1 and NY 2 when both were grown on M.9T337 rootstock. Trunk circumference was greater for NY 2 than NY1. Tree height in the third leaf was also greater for NY 2 than NY 1 confirming that NY 2 is more vigorous and more suitable for less vigorous rootstocks or rootstock strains than NY 1. The more vigorous NY 2 grew significantly taller with both the 3-Wire bamboo and 3-Wire stabilizer support than those with only wire support. The 3-Wire and the 5-Wire support systems did not support the leader nearly as well as the systems with upright training aids thus were shorter in height (Figure 3). Leaders leaned when there was too much space between wires and any fruit between the wires caused the leader to pull free from the wire necessitating re-tying. The 5-wire support system with wires spaced approximately 21 inches apart was significantly better than the 3-wire support systems spaced approximately 42 inches apart.

Yield in the third year was affected by support system (Table 2). Among the 5 varieties we tested, Golden Delicious, Striped Red Fuji, and NY 1 all had the highest yields with the 3Wire/Bamboo system in the 3rd leaf. However, among all varieties, yield and fruit size was not consistently best with any one system. The “Stabilizer System”, and the 5-wire systems tended to support more fruit than the 3-wire system, which correlated to tree height. Fruit size varied among variety and support system with no apparent clear advantages among support systems.

Although not directly compared with NY 1 and NY 2, the single conduit stake supported by a single high wire is the most stable support and affords similar growth to the bamboo and stabilizer support systems. The significant cost differences among the support systems must be taken into account when establishing a planting (Table 3).

**Discussion**

The technology to manage high density orchard support systems to withstand increasing crop load and the vagaries of the weather has been a learning experience for NY fruit growers. Some of the main lessons we have learned are:

1. Use pressure-treated or a rot-resisting wood species.

Lodgepole pine, Southern yellow pine, Locust, and Cedar are the best. All locally sourced posts should be debarked. Ensure that trellis posts are of sufficient diameter to withstand heavy crop loads, high winds, or snow loads. End posts and anchors should be 5-6 inches in diameter (smaller number is the diameter of the small end of the post and the larger number is the diameter of the big end of the post) and inline posts 4-5 inches in diameter. Some species of wood are more susceptible to breakage than oth-
ers particularly those that have a whorled branching pattern such as Red Pine. Other species such as Southern Yellow Pine and Lodgepole Pine have spiral branching pattern so that knots are intergrown and sound with few holes or dead knots in the timber leading to fewer weak spots. All posts should be pounded to a depth of 3 feet, which is below the frost line. Posts that are too shallow are subject to frost heaving and will need to be re-pounded annually and may fail with heavy rains and crop or snow providing stress.

2. Although staples are quick and efficient to install, there have been a multitude of failures associated with staples pulling out of the wood. A single staple pull can cause a whole row of trees to fall and if on a brittle rootstock snap at the graft union. Be sure and use at least 1 ¾ inch staples and double them at stress points such as where angle changes. Install them so that staple arms flare out rather than in. Although initial installation is more difficult and expensive, drilling holes through inline trellis posts ensure that installed wires will remain in place through heavy snow loads as in this case. For multiple wire systems only the top wire needs to be threaded through the posts.

3. Do not splice trellis wires if at all possible within the row. Splicing wires half way through a row with lead wire crimps can fail with excessive load or wind stress. If splicing is necessary use 2-3 crimps adjacent to one another rather than one. Use a high quality wire tightening device on each wire so that wires can be tightened and loosened as needed.

4. In our block, bamboo splints, individual steel stakes at each tree, and trellis “stabilization wires” were very good supporting 2nd and 3rd leaf trees and preventing leaders from breaking out. Three and five wire systems suffered the greatest leader breakout since the distances between the wires was too great to adequately support existing trunks and leaders. Trunks and leaders usually broke out at the wire they were attached to (Figure 7). We recommend a minimum of 5 wires no more than 21 inches apart starting at the top of the post. As trees age the bottom wires

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**Table 2. Yield and fruit weight comparisons among 4 support systems for 5 varieties.**

<table>
<thead>
<tr>
<th>Variety</th>
<th>Systems</th>
<th>Average # Fruit/Tree</th>
<th>Average Fruit Wt. (g)</th>
<th>Estimated Yield Bu/Acre</th>
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<tbody>
<tr>
<td>Royal Empire</td>
<td>3-Wire</td>
<td>13.5</td>
<td>168.4</td>
<td>144.3</td>
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<tr>
<td></td>
<td>5-Wire</td>
<td>18.1</td>
<td>174.5</td>
<td>200.4</td>
</tr>
<tr>
<td></td>
<td>3-Wire with Bamboo</td>
<td>17.7</td>
<td>168.7</td>
<td>189.5</td>
</tr>
<tr>
<td></td>
<td>3-Wire Stabilizer System</td>
<td>10.8</td>
<td>179.9</td>
<td>123.3</td>
</tr>
<tr>
<td>Gibson Golden Delicious</td>
<td>3-Wire</td>
<td>10.2</td>
<td>192.7</td>
<td>124.7</td>
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<td></td>
<td>5-Wire</td>
<td>8.7</td>
<td>186.6</td>
<td>103</td>
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<td></td>
<td>3-Wire with Bamboo</td>
<td>15.4</td>
<td>203</td>
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<td></td>
<td>3-Wire Stabilizer System</td>
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<td>197.2</td>
<td>150.2</td>
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<td>Striped Red Fuji</td>
<td>3-Wire</td>
<td>19.4</td>
<td>222</td>
<td>273.3</td>
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<tr>
<td></td>
<td>5-Wire</td>
<td>19.4</td>
<td>201.1</td>
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<td>205.9</td>
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<td>272.5</td>
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<td>NY 1</td>
<td>3-Wire</td>
<td>15.3</td>
<td>208.1</td>
<td>202</td>
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<td></td>
<td>5-Wire</td>
<td>17.8</td>
<td>205.6</td>
<td>232.2</td>
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<td>254.2</td>
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</table>

*The significant cost in purchasing the air tool, generator, and/or compressor to install wire clips is not included in this figure.

**Table 3. Cost of Support Systems**

<table>
<thead>
<tr>
<th>Systems</th>
<th>Posts</th>
<th>Wire &amp; Staples</th>
<th>Training Stakes</th>
<th>Installation Labor</th>
<th>Total</th>
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<td>3-Wire</td>
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<td>$205.50</td>
<td>$0.00</td>
<td>$367.00</td>
<td>$1,696.16</td>
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<tr>
<td>5-Wire</td>
<td>$1,123.66</td>
<td>$340.50</td>
<td>$0.00</td>
<td>$387.00</td>
<td>$1,851.16</td>
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<td>3-Wire plus Bamboo</td>
<td>$1,123.66</td>
<td>$205.50</td>
<td>$648.00</td>
<td>$495.00</td>
<td>$2,472.16</td>
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<tr>
<td>3-Wire plus Stabilizer</td>
<td>$1,123.66</td>
<td>$205.50</td>
<td>$211.20</td>
<td>$495.00</td>
<td>$2,035.36</td>
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<tr>
<td>1-Wire w/Conduit Stake</td>
<td>$1,123.66</td>
<td>$68.50</td>
<td>$2,420.00</td>
<td>$495.00</td>
<td>$4,107.16</td>
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</tbody>
</table>

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**Figure 7.** Trees broke under snow load at the 2nd wire in a 3-Wire support system when not attached to the 3rd wire

**Figure 8.** Trellis clips were economical and strong for attaching stakes to wire. They did not slip along the wire.
can be removed to facilitate easier movement around the tree for picking and pruning.

5. We found trellis clips (Figure 8) to be the best way to attach stakes to wire. They were very quick and easy to install, labor savings made up for the higher cost of the clip and they did not slide along the wire, keeping trees vertical even with heavy crops.

6. The strongest end post assembly is an equilateral triangle created by the end post, the trellis wire and the distance between them along the ground. The anchor should be driven not augured vertically into the soil.

7. Perform annual maintenance after harvest to replace broken and weakened posts, re-pound anchors and in-line posts that have leaned or heaved, check for and replace pulled staples especially those at stress points where wire changes direction, finally, readjust wire tension after harvest and crop has been removed.

**Literature Cited**

Hoying, S.A., Robinson, T.L., and DeMarree, A.M. 2012. Do high-density apple planting systems make sense? Presented at the Northwest Michigan Orchard and Vineyard Show [www.apples.msu.edu/presentations.htm](http://www.apples.msu.edu/presentations.htm)


