Tree Training and Planting Systems in Vermont Orchards

Pruning

Horticultural management of apple trees seeks to balance production of adequate vegetative wood to support the framework of the tree with fruiting wood to produce apples. At the same time, the tree must be pruned or trained to allow for penetration of sunlight to drive photosynthetic production, air for drying of leaf and fruit surface, and spray materials for crop protection and development. An open tree with good sunlight capture and minimal interior shading will produce more fruit and better fruit than a shaded, poorly managed tree. The shaping of individual trees is performed both with annual pruning and in choosing an appropriate architectural orchard system for the planting.

Apple trees, like many plants, produce auxin, a plant growth hormone, in their growing meristems, or shoot tips. Auxins flow linearly down a growing shoot and inhibit breaking of buds for a distance below the growing shoot tip. Growers manipulate auxin flow by either not cutting the primary vertical shoot in the tree (the central leader) to avoid excessively vigorous top growth, removing a vertical shoot but only by cutting back to a weaker shoot which can maintain the apical dominance provided by auxin flow, or by bending the leader to slow auxin flow without removing it. On horizontal branches, where lateral bud break is encouraged to generate fruiting wood, branches may be spread to an angle as low as 60° from the trunk to slow auxin flow. This allows the tip of the branch to continue to grow while maintaining good fruit production potential on strong lateral branches. Growers should therefore avoid heading cuts, where a portion of a branch is removed and auxin flow disturbed, but rather focus on whole branch thinning cuts which maintain the vegetative to fruiting wood potential within the tree.

Apple tree pruning should happen every year to every tree, such that excessive pruning is never required in the planting. Whenever possible, and especially in plantings over ten years of age, whole limbs should be removed from each tree to open the tree up to light and air penetration.

The following links will provide more in-depth information on apple pruning basics:

- Pruning and Training Apple Trees, Teryl Roper, University of Wisconsin
- Pruning Mature Apples and Pears, HYG-1150-93, Ohio State University
- Training and Pruning Apple Trees, Cornell Cooperation Extension Publication / Info Bulletin #112
- Common Pruning Mistakes, Caleb Torrice, Cornell Cooperative Extension
- Renovating Old Apple Trees, James Schupp, University of Maine
- Techniques for Training Young Apple Trees Jon Clements, University of Massachusetts

Orchard Architecture

In the past 50 years, orchard architecture has seen great changes due mostly to reduced tree size and research on training systems to maximize the performance and productivity of intensively grown trees. In Vermont one can find examples of the various orchard designs that have been planted during this time.

Orchard systems dictate the training practices used in the planting to address the basic horticultural principles discussed above. Orchard systems are often considered in the context of a puzzle of interlocking pieces, none of which dominate but all of which interact to guide the development of the planting. Orchard system components include: tree arrangement, tree quality, tree support, tree density, variety and rootstock, training and pruning, as well as external factors such as grower skill and equipment, site selection, marketing, and other concerns.

From the development of commercial orcharding through the 1950's, a typical Vermont orchard was planted to trees on vigorous seedling rootstock, spaced up to 40 feet apart in either direction, with individual trees reaching up to thirty feet tall. Labor requirements for these orchards were great; ladders were necessary for many tasks and spraying was very difficult, time consuming, and the extreme overhead reach needed resulted in excessive worker exposure to chemicals. Such trees also took up to 15 years to bear a full crop, and the interior shading of the large canopies resulted in many fruit not making packing grade due to poor size of color. Still, these large canopies, particularly by utilizing horizontal space, were able to produce large quantities of fruit per acre. Some of these orchards remain in commercial production today, and through regular management and good annual pruning are able to produce profitable crops. Still, the labor required to grow apples in such a system, and the potential for shading and off-grade fruit made smaller trees attractive to growers.

By the 1950's, size controlling rootstocks were being planted in Vermont, beginning with semistandard (Robusta 5, MM111) and semidwarf (MM106, M7) trees that were planted at higher densities than the old seedling orchards at 125-200 trees per acre. With these rootstocks and relatively tighter spacings growers would see increased precocity, with trees coming into production in 7-10 years. Other benefits included better fruit quality and improved yields during the early bearing period of the planting. The extensive use of albeit shorter ladders, and eventual shading of interiors at tree maturity and resulting decline in fruit quality forced growers to further adopt more intensive systems.

By the 1970's and 1980's the use of full dwarf or smaller semidwarf (M 9, M. 26) rootstocks was becoming standard, with orchards planted at densities of 200-500 trees per acre. Most of these orchard were supported with individual tree stakes, sometimes with irrigation. Weed-free herbicide strips were used to improve early tree growth, with orchard now reaching production in five years. Some orchards were maintained to allow nearly all work from the ground, without ladders. These 'pedestrian orchards', however, lost production to reduced tree height while maintaining roughly 16-foot spacings between rows, and at maturity canopy shading again becomes a problem. The cost to establish these orchards would be roughly $4000-8000 per acre today depending on trellising choices and other factors. Many orchards in Vermont are still successfully managed in this fashion.

Planting Density

The planning of a new orchard block can be more difficult than its actual planting. When planning an orchard block, one of the most crucial decisions the orchardist must make is the planting density of the new orchard block. Planting density, or the number of trees per acre, greatly effects orchard efficiency, productivity and the intensity of management needed to run the orchard.

Higher density orchards (500+ trees/acre) maximize productivity per acre while minimizing land waste. Lower density orchards (100-300 trees/acre) tend to produce less, but are cheaper to install at planting. Today, the majority of mature orchards in Vermont have densities between 200-500 trees per acre, but many growers are switching to higher density plantings in order to maximize production and precocity.
At whatever planting density is finally decided upon, a basic rule is to plant the trees so that, when they reach maturity the trees touch but do not crowd each other. Also, ensure that space is available for machinery to move freely through the orchard.

In order to achieve the ideal tree size for the planting density used, the rootstock/cultivar combination must be chosen carefully. Rootstocks which offer less size control (M.111, M.7a and G.30) are usually better for orchard blocks planted at lower densities (100 to 300 trees/acre), and do well with a central leader system. The more size-controlling the rootstock (M.26, M.9 and Bud. 9), the better adapted it is to higher density planting systems (500 +trees/acre). The more dwarfing the rootstock, the more likely it will need staking or trellising to support growth. These support systems can greatly increase the initial cost of planting. Many different training systems may be used with higher density plantings, such as Vertical Axis, Slender Spindle, and Tall Spindle.

The growth habit, precocity and vigor of the cultivar will also effect the mature size of the tree. The mature size of different cultivars on the same clonal rootstock can vary by as much as 40% (table 1). When cultivars with different degrees of vigor are planted within the same block, adjustments must be made in rootstocks used and/or in planting distance. Additional variations in mature tree size can be caused by geographical location, soil fertility, available water, light intensity, in-row spacing and grower management. Your nursery catalog or Extension Service can provide the appropriate recommendations for determining the growth habit of trees.

Intensive High Density Systems

More intensive orchard plantings have been studied since the 1960's with the Slender Spindle system developed in Holland and Vertical Axe, developed in France in the 1980's. All of these systems are modifications of the basic central leader system, with primary changes in trellis design, tree spacing, and shoot manipulation being the main differences. The development of smaller equipment, including narrow orchard tractors and taller tower sprayers, has further pushed the implementation of intensive orchard systems. Growers began to realize that a tree's photosynthetic energy could produce either wood or fruit, and that trellises could replace much of the structural function of strong trunks. Tightly planted trees with no large limbs, consisting almost entirely of very productive 2-3 year-old fruiting wood borne on the central leader could yield significant quantities of high-quality fruit with excellent light penetration into the canopy. Extensive multi-year research in New York, including work in Champlain Valley orchards, has shown the potential of intensive, high density (1000-1200 trees per acre) plantings in Vermont. Costs associated with establishing these plantings, including trellises, is around $15,000 per acre, but early returns of a few hundred bushels per acre in year two and up to 1000 bushels per acre by year five quickly pay off the high investment required. Highly intensive systems such as these may not be for every grower now, but they will be a major component of the orchard industry in years to come.

Cornell Orchard System Training Fact Sheets:

- Tall Spindle System: Planting, Pruning, and Training
- Vertical Axis System: Planting, Pruning, and Training
- Slender Pyramid System: Planting, Pruning, and Training
- Slender Axis System: Planting, Pruning, and Training

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