



College of Agriculture,
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Cooperative Extension Service

Promoting Branching on High-Density Dwarf Fruit Trees

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Developing the early framework of dwarf fruit trees is essential to the future success of high-density orchards. Having trees with sturdy trunks and numerous branches in place when they are young goes a long way towards maximizing the mature cropping potential. Beginning with fully feathered nursery trees is a general recommendation for tall spindle and other similar apple training systems. However, this ideal can go unrealized. Where 10 to 15 feathers are preferred, growers must often contend with either nursery whips or trees having only three to four long laterals. Branch promoting techniques are necessary to fill in these spaces with productive limbs to balance vegetative growth with early fruiting capacity.

The rapid growth of young trees is a prime factor in inhibiting lateral branch formation. Because they are less fruitful, most of their energy is used vegetatively. Under ideal conditions, juvenile trees in a high density setting can reach the tops of trellises and almost completely fill their narrow growing space by the end of the

first or second year. While certainly advantageous, as larger trees often bear more fruit at an earlier age, it can also lead to inconsistent branch development at desired locations. Rapid vegetative growth encourages apical dominance, a condition whereby the top-most buds in the upper segment of dominant limbs suppresses bud break and lateral shoot elongation further down the tree. Branch promoting methods work to circumvent apical dominance mainly by eliminating, inhibiting, or reducing and replacing the hormonal signals within the plant which lead to its manifestation.

Some fruit trees naturally branch less regularly than others and especially benefit from branch-inducing practices. Pears and sweet cherries are well known for developing long unbranched sections on trunks and scaffolds. Certain apple cultivars, primarily tip bearers and those that have a spur type growth habit, often do not form an ideal structure when they are young. Lateral branches may fill in these bare spaces once trees begin

fruiting and their growth settles down, but cumulative cropping potential is lost by this early structural absence. Distribution of fruit on the tree and worker harvest efficiency are negatively impacted when numerous bare spots are present. The effectiveness of pesticide sprays are also reduced; unfilled canopy sections permit spray droplets to pass through, increasing drift to non-target areas.

Numerous tactics (Table 1) are available to growers wanting to promote branch growth and create a desired tree structure, some are more practical for high density orchards than others. These include remedial methods like heading, weak leader renewal, notching or scoring, bud removal, or proactive applications of plant growth regulators, as well as combinations of each. Techniques such as bagging, snaking, or bending the leader have performed satisfactorily, but are more resource and labor intensive, thus limiting their suitability for larger growers. All are time sensitive and work best when performed on young trees, i.e. within the first couple of years before crop loads become heavy. Once trees mature, these tactics are much less effective.

Heading

Heading the leader (Figure 1) during pruning removes a portion of last year's growth, including any weak later-season shoots or spurs that developed near the tip. Apically dominant terminal buds are eliminated during the process, releasing axillary (lateral) buds from their inhibited state. The degree of branching response depends on the amount of leader removed; in general, shoot length and number increases with progressively

more severe cuts. Regrowth immediately below the cut is rapid and most of the new branches will have sharp crotch angles. Removing the second through fourth buds near the tip by hand, leaving only the topmost one, will eliminate the need to remedially prune out competing leaders. Proactive spreading of young shoots with clothespins, toothpicks or wedges is best accomplished during the early growing season, starting when they are 3-5 inches long. Clothespins are kept in place until the shoots lignify and their angle is "set", at least two weeks, and are then removed to prevent girdling the leader. Toothpicks will eventually rot away and do not require removal.



(Figure 1)

Heading is one of the simplest, oldest, and most well-know branching methods, but is also one of the least useful for already limbed or "feathered" nursery trees, especially when early fruit yields are important. Headed and heavily pruned trees come into full production

at least a year later compared to lightly pruned trees. Minor trimming of broken branches and removal of competitive limbs at planting following a high density training plan will not adversely affect flower formation and is necessary for health and balance. Heading at five feet above the ground is permitted on nursery trees received as unbranched "whips". They will begin bearing fruit later than feathered trees anyway, heading them at planting will not negatively affect their overall productivity.



(Figure 2)

Weak leader renewal

Weak leader renewal (Figure 2) is a variation on heading whereby an overly vigorous leader is removed while pruning with a heading cut just above a slightly weaker lateral. The lateral branch is then tied up to a trellis wire or support post as the "new" leader. Shoot development is stimulated because the weaker terminal buds exert less apical dominance on basal buds. Unfortunately, like heading,

weak leader renewal negatively affects early crop production (though less so) and is only appropriate when heavy yields the following years are not important.

Bagging

Bagging (Figure 3) uses clear plastic tubing, similar to Italian bread loaf bags, to cover unbranched sections of last year's leader growth. A greenhouse effect is created which encourages earlier lateral bud development before apical growth can inhibit shoot initiation. The bags are cut to length (30-32 inches max) and placed on the tree 4-6 weeks prior to anticipated bud break and the ends closed tightly with a clothespin, rubber band, or tape. Bags are removed when laterals are roughly 1-2 inches long (usually around bloom); if left on longer, the tender green shoot tissue can quickly overheat and die. Spraying a branch-promoting growth regulator along with an anti-desiccant 3-5 days after bag removal will stimulate further shoot



(Figure 3)

elongation and limit minor wilting. Clear polyethylene tubing useable for bagging is available in rolls from shipping and packaging suppliers. Rolls of 4-6 inch widths and 2-3 MIL (1 MIL = 1/1,000 of an inch) thicknesses are sufficient and durable enough to last the 8-10 weeks that bags are on the trees.

Snaking

Snaking (Figure 4) of vigorous leader growth is performed in the early spring, beginning soon after planting and then throughout the growing season, or whenever time permits. The leader is bent over and secured to a support post at a 45° angle. The distance between each bend varies, but once every 18 inches of new growth is generally recommended. A zig-zag trunk is created, inducing lateral branching during the current and following years, primarily at the bends. Once the leader reaches the desired height it is bent downward (at or below horizontal) across the post or trellis wire to promote



(Figure 4)

spur formation. Care is necessary to prevent breakage if snaking is practiced during dormancy; some apple cultivars have more brittle wood than others. Cold temperatures also increase brittleness and it is not advisable to practice snaking when conditions are near freezing.



(Figure 5)

Bending

Bending (Figure 5) is another technique useful to slow overly vigorous leader growth and is an alternative to snaking. The leader is bent downward below horizontal in the early spring prior to budbreak until its direction is nearly reversed. Terminal elongation and bud growth on the underside of the curve is inhibited while lateral branching near the apex is enhanced. Left in place, the old leader will act as a weakened fruiting limb while a new shoot will serve as its replacement. Alternatively, untying the leader once laterals are 1-2 inches long and bending it in the other direction will induce branching on the opposite side. When development is roughly uniform

on both sides, the leader is tied upright and allowed to resume normal growth. Bending always carries risk of breakage; very thick or thin leaders are more likely to snap when they are bent.

Notching and scoring

Notching (Figure 6) and scoring (Figure 7) can promote the growth of new shoots to fill-in trunk sections where few branches are present. Such sections frequently exist even on fully feathered trees which can have several long, lower limbs, followed by "blind" areas on one or both sides of the leader, and a cluster of small shoots near the top.

Notching with a hacksaw blade removes a strip of bark about an eighth of an inch wide immediately above a bud. The cut is made by drawing the blade across the stem, going only deep enough to remove the phloem (bark) tissue, but stopping once the xylem (structural wood) is reached. The cut should extend beyond each side of the bud, going about a third of the way around the leader.

Scoring requires a sharp knife to ring circumferentially around the entire stem, slicing thinly through the phloem, but not removing any of the exterior bark. For full effectiveness, the ends of the cut must meet evenly on each side of the leader without leaving a gap.

Notching and scoring interrupt the movement of hormones within the tree similar to heading, but without removing any potential bearing wood. However, the branching response is not as strong. Shoot formation is sometimes erratic, making it necessary to perform notching cuts above every 4 or 5th bud, or scoring roughly every 10 inches along the leader.

Selective cuts should extend in a section starting and ending approximately 10 to 12 inches above and below any existing branches. During early spring, notching is usually more successful in achieving



(Figure 6)



(Figure 7)

the desired amount of bud activation; the barrier does not heal as quickly and the period of response is longer. In contrast, if work is delayed, scoring is usually more successful in later spring.

Notching and scoring are most effective when performed between 2-4 weeks prior to full bloom, roughly from the green tip to ½-inch green stage for apple. A proactive approach to spreading the developing shoots is necessary; activated buds will grow rapidly and can create narrow crotch angles if left unchecked.



(Figure 8)

Bud removal

Bud removal (Figure 8) when done from the dormant to tight cluster stage on apples, pears, and cherries encourages growth of the remaining selected buds. Competition for the tree's limited stored resources during bud break is reduced and distributed more equally, especially if a majority of the larger buds towards the top of the tree are removed. Disbudding is accomplished by hand pinching, rubbing, or scraping off with a knife roughly every

3rd or 4th bud along a bare section of the stem. Retain selected buds so that they are evenly distributed in all directions around the center of the tree. Notching or scoring above some of the remaining buds can further increase the branching response. This technique works best when it is performed on last year's (1-yr. old) growth where the buds are raised and easily distinguished. Bud removal is rarely successful in activating latent buds ("eyes") on older wood.

Plant growth regulators

Growth regulators (also known as bioregulators) are products that mimic plant hormones and alter development. When used for branch promotion, growth regulators are commonly applied as foliar contact sprays during active growth in the spring or to the periderm (bark) during bud swell. Concentrations are very low, usually in the hundreds or thousands of parts per million (ppm). Growth regulators require adequate coverage, rapid tissue absorption, and translocation to active sites of development at concentrations sufficient to produce a response. When applying, growers should always read the label instructions carefully in order to get the desired results. Because the amount of active ingredient is very low, minor discrepancies in concentration can produce large disparities in effect on plants.

Weather conditions before, during and after application of a branch inducing growth regulator, along with tree health, vigor and age are important factors that will affect plant response. Moderate to cool temperatures, overcast and slow drying conditions can enhance absorption and increase the response. Temperature extremes (either very hot or cold), high light intensity, and fast drying conditions

can reduce the rate of absorption and decrease response. Morning applications are best when conditions are cool and humid, while evening or night applications are preferred when hot and dry. Heavy dew or rainfall within six hours before and after application will dilute the active ingredient and reduce activity. It is better to reschedule an application if conditions are not favorable. Older, slower growing trees are generally less sensitive and may require higher rates than younger ones. Trees that are weak or stressed due to drought, waterlogging, winter injury, low nitrogen, and pest damage are more sensitive than healthy ones in full leaf. Despite damaged foliage also limiting absorption it is safer to reduce the rate or forego application in such situations.

Branch inducing growth regulators will contain cytokinins, gibberellins, or both. Cytokinins stimulate cell division and differentiation and promote shoot initiation and the release of lateral buds from apical dominance; they also play an indirect role in overcoming dormancy. Gibberellins, like cytokinins promote cell division, while also stimulating elongation to increase shoot length. However, at higher than recommended label rates, gibberellins may cause blossom thinning and also increase the amount of fruit removed by chemical thinners. Higher rates may also cause pygmy fruits to develop on some cultivars and inhibit return bloom the following year. Lower rates intended to moderately thin fruit, reduce russeting, improve size or shape (typiness), or to increase fruit set after frost will not diminish return bloom.

The following are some chemical plant growth regulators labeled for lateral branch promotion on tree fruits. Be sure

to check the product registration as some are not available for distribution in all states.

Cytokinins

MaxCel® - Valent BioSciences, LLC.
(not registered in KS, NE, OK)

Exilis® 9.5 SC - Fine Americas, Inc. (not registered in IN, KY, KS, MO, NE, OK)

Exilis Plus® - Fine Americas, Inc. (not registered in AR, IA, IN, IL, KY, KS, MO, NE, OK)

Cytokin® - Miller Chemical & Fertilizer, LLC. (not registered in KY, IA, KS, NE)

Cytokinins and gibberellins

Promalin® - Valent BioSciences, LLC.

Typy® - Nufarm Americas, Inc.

Cytoplex® HMS® - Miller Chemical & Fertilizer, LLC. (not registered in IA, KY, KS, NE, OK, WV)

Perlan® - Fine Americas, Inc. (not registered in AR, IA, IN, IL, KY, KS, MO, NE, OK)

Foliar sprays are effective starting when terminal growth is 1-3 inches long at the time of application. Rates for non-bearing trees are generally between 125 and 500 ppm for apples and 250 and 1,000 ppm for pears and sweet cherries. For first-leaf apple trees received from the nursery as whips, apply 500 to 1,000 ppm of MaxCel 20 days after bud break followed about a week or so later by removal of the 2nd through 4th apical buds on the leader. For second- and third-year apple trees, apply 200-300

ppm (non-bearing) or 200 ppm (bearing) of MaxCel. Spreading of some rapidly growing shoots is usually necessary, but for most, the developing crotch angles are wider compared to other branch promoting techniques and require less manual labor for correction.

Growers should determine the volume necessary for complete coverage of the target plant surface and know the application rate before making a spray. It is essential to thoroughly wet any bark and foliage in the area where branching is desired. Applications over the entire tree will require calculating the tree row volume per acre. Directed applications using an air-blast sprayer or high-volume hand-gun require knowing the nozzle flow rates. Calibration is the only way to ensure the accuracy of a sprayer, i.e. that it is applying the intended amount of water and specific amount of chemical per unit of area. For more information reference the Midwest Fruit Pest Management Guide.

Some additional considerations are necessary before making a spray application to ensure effectiveness and avoid potential crop injury. The addition of an adjuvant (surfactant) to the solution may improve coverage but is not always necessary. For example, MaxCel already has a surfactant included in the product and should not have any further added. A pH near neutral (usually between 5-7) is best; pH's above 8-8.5 will require the addition of a buffering agent (acidifier) to avoid potential deactivation. Always check the label's application instructions before adding any extra chemicals and perform a compatibility test if necessary. Air temperatures above freezing (32°F) or 40°F (for Typy) and below 90°F are recommend at the time of application.

Effectiveness is increased when the maximum temperature is above 65°F for MaxCel and 70-75°F for Exilis 9.5 SC and Exilis Plus before, on the day of, and 2-3 days after application.

Applications mixed with interior white latex paint and spread by brushing, sponging, or with a hand-held spray bottle to the bark surface above selected buds have much higher concentrations (5,000 to 7,500 ppm) than foliar sprays. In order to avoid injury to the tender growing tips of first-leaf trees, apply when the terminal buds begin to swell but before any shoots emerge, otherwise, stunting, abnormal growth or death of the growing point may occur. Thoroughly cover the surface with a uniform layer when applying. Adding a wetting agent during mixing (if directed) may improve dispersion into the latex and absorption through the outer waxy layer of bark. A one year pre-harvest interval exists for any type of application to non-bearing pears and sweet cherries.

Combining methods

Combining multiple bud activation methods can increase plant response, especially for second and third year trees or others that are harder to stimulate. A Washington State University experiment on sweet cherries reported that notching, scoring or applying white interior latex paint containing 5,000 ppm of Promalin® or Perlan® onto individual buds or to the bark in-between buds did not increase lateral shoot growth when used alone. Bud removal did increase branching in some trials but was ineffective in others. In contrast, scoring or notching above buds followed by applying a bioregulator-latex paint mixture over the cuts (Figure 9) increased lateral shoot development two to fourfold compared to other treatments.

Nicking or bark scraping prior to painting was also effective. The authors concluded that the outer layer of bark on older trees poses a significant physical barrier to the penetration of bioregulators into the active tissues. The mechanical removal of this physical barrier was a primary factor in improving the efficacy of applied plant growth regulators in order to induce lateral branching.

Filling-in bare areas ("blind wood") on the leaders of second-leaf apple trees is more difficult than on first-leaf trees. Based on a University of Massachusetts branching trial, the publication authors listed below in the references suggest notching directly above an existing bud scar ("eye"), then applying 1,500 ppm of Maxcel®. It is necessary to make several spot treatments at regular intervals in the area where branching is desired as the response is fairly localized.

References

Cowgill, W., J. Clements and W. Autio. 2017. Branching Young Apple Trees with Plant Growth Regulators (F-140—2017) UMass Extension Fruit Publication. <http://umassfruitnotes.com/v82n3/a2.pdf>



(Figure 9)

Table 1. Advantages and disadvantages of branch promotion methods.

	Advantages	Disadvantages
Heading	Simple, fast, and effective. Easy to understand and implement. Useful on “whip” nursery trees.	Delays fruit production. Regrowth underneath cut is vigorous, requiring disbudding or remedial pruning, and spreading of new shoots.
Weak leader renewal	Simple, easy to understand, quick to implement. Devigorates the leader.	Some reduction of early yields. Requires extra labor to tie up new leader during dormant pruning.
Bagging	Effective on leaders up to 32 inches in length. Heading, bending or tying down is not required.	Requires extra labor to place and remove bags. Time-sensitivity is necessary to achieve desired results. Difficult to locate materials.
Snaking	Useful in devigorating the leader without heading or renewal. Does not reduce early yields.	Extra labor is required throughout the growing season for bending and tying. Leader may break if brittle, weak or bent too far.
Bending	Devigorates the leader without removal. Option of leaving in place as scaffold or tying back upright.	Extra labor is required to bend and tie in place. Leader may break if brittle, weak or bent too far.
Notching and scoring	Fills bare sections of leader without removing fruit-bearing wood. Can be successful on older wood.	Requires extra manual labor and is seasonally time-sensitive. Branching is often erratic, requiring more cuts to fill bare sections
Bud removal	Proactive approach to bud activation on one-year-old wood only. Done by hand.	Extra early-season hand-labor required; is time sensitive. Does not work well on older wood.
Plant growth regulators	Least labor-intensive approach to branch promotion. Good results are possible if the label is read and followed. Combining multiple methods can increase the branching response.	Requires a detail-oriented approach and focus on tree health and growth stage, weather conditions, chemical formulation, spray solution pH, dilute concentration rate, and coverage during application for successful results. Erratic branching, growth distortion, and crop loss is possible if label is not followed.