PRUNING MATURE BEARING TREES

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Three characteristics of pistachios must be considered when developing a pruning program for mature trees. First, pistachios alternate bear (see chapter 3), and the degree of alternate bearing is largely determined by the previous year's crop load. A large crop, borne on one year-old wood, reduces the fruiting potential for the following year by triggering the abscission of flower buds produced at the base of current season's growth. Pruning has been shown to mitigate this phenomenon by regulating crop load.

Second, pistachios express strong apical dominance in their growth habit. Explained in detail within this chapter, this characteristic becomes more pronounced with tree age, thus exacerbating the problem of bearing its crop largely on the canopy periphery. This results in structural branches becoming flat, shaded, and less fruitful.

Third, current orchard design of 17 feet (5.2m) within the row and 17-19 feet (5.2-5.8m) between rows strives to achieve early bearing without excessive crowding at orchard maturity. Failure to limit trees to their allotted space reduces crop capture by existing harvest equipment and further reduces orchard fruitfulness from shading.

Proper mature tree pruning seeks to minimize the effects of these factors and maintain the canopy at its highest possible yield potential. The productivity benefits from proper annual pruning are optimized only when complemented by other sound cultural practices such as irrigation, fertilization, and pest control. This chapter discusses principals and specific considerations for pruning pistachios as they relate its growth and fruiting habits. It also discusses how best to implement mechanical pruning. To assist the reader, a glossary of terms is provided at the end of the chapter.

The Growth Habit of Pistachio

Pistachios express strong apical dominance in their vegetative growth habit, meaning that vigorous current season shoots develop only from buds closest to the terminal of one year-old branches. Vegetative buds further down the branch are capable of producing long, vigorous shoots, but develop only short spur growth because of hormonal control exhibited by the terminal bud. This characteristic becomes more pronounced with tree age. Thus, branches may elongate for years without lateral branching, causing the tree to bear fruit further from its central axis. Early pruning studies indicated apical dominance could be overcome in older trees by cutting the entire canopy back into three and four year old wood (Crane and Iwakiri, 1980) This treatment produced new shoots on 14-17 year-old wood. Another study utilized light and severe pruning cuts to overcome apical dominance, but rejuvenation of older wood was not observed (Wolpert, 1986).

Pistachios also develop branch girth slowly. This increases the tendency for main fruiting limbs to become less upright with each successive crop. In almond, a nut crop without apical dominance, vigorous upright lateral shoots (water sprouts) develop where the main limb bends and light is favorable, providing natural replacement of main bearing limbs. However, apical dominance in pistachio promotes tree crowding, loss of tree shape, and limits flower bud formation on lower fruit wood due to lack of light. The eventual reduction in growth on the sides of the canopy promotes added growth in the top of the tree, where light is not limiting. Although high in fruitfulness, the upper canopy eventually grows beyond the height manageable by hand pruning crews. Therefore, a major objective of pruning bearing pistachios is to confine the trees to

their allotted space and promote light penetration for viable fruit wood and nut production throughout the tree.

Pistachios, like other deciduous trees, also have latent vegetative buds. Latent buds are sub-terminal buds that remain undeveloped for a season or longer. However, they remain viable in the older wood and are capable of producing a new shoot in response to limb breakage or severe pruning.

Recent studies of pistachio growth and development have provided greater understanding about the biology of short spurs versus long, whip-like shoots. Both originate from vegetative meristems that have differentiated a given number of node positions during winter dormancy. The number of nodes range between 7 and 9. Vegetative shoots produced from lateral buds distant from the branch terminal usually grow only until their predetermined nodes have developed. Their terminal meristem then "hardens off" rather than differentiating new shoot tissue for extended current season growth. The resulting short growth is a *preformed* shoot. Preformed shoots usually become highly fruitful spurs the following season.

The long, whip-like growth produced close to the terminal of one year-old wood also originates as preformed shoots. However, due to their position, apical dominance enhances their growth rate. Consequently, they experience two and sometimes three flushes of growth in one season. The first flush occurring in early spring represents preformed growth. The subsequent flushes originate from tissue developed by their terminal meristem and the final shoot length depends upon tree vigor and growing conditions. Shoots with this growth characteristic are called *neoformed*. Dormant heading cuts of vigorous one year-old shoots increases the likelihood of more neoformed growth since pruning reduces the number of vegetative buds and provides more growth substances for those retained.

The Fruiting Habit of Pistachio

Pistachios bear their crop on laterally on one year-old wood. An individual flower bud (inflorescence) botanically is a panicle consisting of an elongated central axis with lateral branches that produce as many as 200 individual flowers. Growers refer to the structure supporting the flowers as the "rachis", and the term "cluster" applies to the rachis and the nuts it eventually supports.

Dormant, one-year-old fruit wood is represented by both preformed (spur) and neoformed (whip) growth. Spurs can grow from large diameter, one year-old structural branches in young trees where apical dominance is not as great. Spurs often develop in the first flush (preformed growth) of whips, if those buds did not differentiate into flower buds the previous season. Long, whip-like growth usually develops flower buds in the preformed growth (first flush). If a one year-old whip is left untipped, the lateral buds are all capable or producing spur growth, which could then develop fruit buds for the following year.

Pruning Effects on Growth and Yield

Pruning of mature deciduous trees has several objectives. One is to confine the tree to its allotted space. This, for reasons already described, is of major importance in pistachio. Secondly, pruning is performed to renew fruitwood and distribute light throughout the canopy. The invigoration effect from pruning also helps maintain tree health and longevity. Pruning can improve nut removal at harvest and equipment damage from low branches. Finally, pruning can also be used to mitigate strong alternate bearing. A seven-year trial involving severe mechanical hedging and topping combined with normal pruning showed that cumulative split nut yield for the severely pruned trees was not different from the hand-pruned control. Further, severe hedging and topping, followed by normal hand-pruning in subsequent years strongly and persistently mitigated alternate bearing (Ferguson et al., 1991).

As with all deciduous fruit tree species, pruning has a dwarfing effect on total tree growth. Unpruned trees grow larger in total leaf area than pruned trees. Pruned trees appear more vigorous, as relatively more nitrogen is available to fewer growing points, but the length of the rapidly growing shoots will still equal less total growth than an unpruned tree.

Dormant pruning removes stored carbohydrates in the branches while simultaneously removing leaves capable of carbohydrate production. Reduction in leaf number also results in less root growth. Summer pruning is especially dwarfing. It removes shoots the tree has already expended energy to produce, in addition to removing leaves capable of carbohydrate production.

Heading and Thinning Cuts

Deciduous fruit and nut trees are pruned using heading and thinning cuts. The different response received from each can be used effectively to manipulate pistachio tree growth.

Heading cuts remove the terminal ends of shoots and branches. They are extensively used in tree training to position lateral branching and maintain high vigor for canopy development. Heading cuts are more invigorating than thinning cuts because they remove more buds per unit length (internodal distance is less near the branch terminal). Less stored carbohydrates are also removed due to the taper of the branch. Heading cuts are performed on mature trees to force lateral branching in three to five year-old wood and reduce the length of long one year-old shoots in the top of the canopy (tipping). Heading cuts need to be distributed over the canopy for uniform invigoration. The resulting neoformed growth (whips) will require tipping the following winter for the purposes of shortening and inducing lateral branching in the desired location. It is important to leave at least one vegetative bud above the flower buds produced near the base of the shoot. Failure to do so will result in the branch dying back to the next growing lateral after it fruits. Heading cuts can also be used to control neoformed growth and increase fruiting by tipping whips immediately above a growth flush. This causes the numerous vegetative buds, which typically differentiate at these points to produce preformed shoots (spurs) that assume the appearance of wagon wheel spokes. This becomes a highly fruitful unit the following season and prevents further terminal growth unless it is re-headed below the spur whorl.

Thinning cuts remove entire branches where they originate. They are less invigorating because they remove fewer buds than heading cuts but more carbohydrates. Thinning cuts are used to reduce the density of branches within the canopy and thus, improve light and potential fruitfulness for the remaining branches. Thinning cuts are also used to manage the outside of the canopy by removing branches which have become flat or are extending beyond the size of the harvest catch frame.

Hand versus Machine Pruning

Pistachio growers have the option of using hand crews, or mechanical hedging and topping equipment to accomplish the pruning task. Each method has advantages and disadvantages.

Hand Pruning

Hand pruning allows each tree canopy to be modified individually. Heading and thinning cuts can be applied as needed to optimize light interception, stimulate new growth in weak areas, and control tree size

Yield data collected in one pruning trial in western Kings County showed that properly hand-pruned pistachio trees produced more pounds of split nuts over six years than tress single or double side hedged by machine. The difference between hand-pruned and single-side hedged annually was 1,348 split nut pounds over six years; double sided hedging every other year differed significantly from hand pruning by 1,923 pounds of split nuts (Beede et al., 2002). However, considering that hand pruning large, mature trees can easily cost $200 per acre compared to $50 for mechanical pruning, the complications associated with hand pruning large acreage may not be justifiable.

Hand pruning crews vary in skill from expert to novice. Therefore, it is essential that the grower have a clear understanding of what type of pruning is desired and then is capable of communicating the objectives clearly and simply. One method of accomplishing this goal is to divide the instructions into four steps. The first is to remove branches that are broken, too low, crossing over the center, or overlapping one another. These are the relatively obvious cuts that can be performed by less skilled crew members. Second, thinning cuts must be made

to the outside of the canopy with the objective of "pushing" the bearing branches upright. This is accomplished by thinning off branches that are at less than 45 degrees. Branches must be cut back sufficiently to have those remaining be pointing upward and not out. Few thinning cuts are needed in the center of pistachios, since apical dominance causes most of the new growth to occur on the canopy periphery. The third step is to perform selected heading cuts in areas closer to the tree axis that are weak. These will hopefully stimulate latent buds to develop into new shoots that can be used to renew fruitwood. The final step is to use pole pruners to tip the one year-old whips produced primarily in the top of the canopy. Shorter growth can also be tipped elsewhere with the goal of creating as much new spur growth as possible. It is essential that the tipping crew know the difference between flower and vegetative buds so that at least one of the latter is retained on the tipped one year-old wood. Periodic review of the crew's work with the foreman avoids disappointment and arguments later.

Machine Pruning

Machine pruning is fast, inexpensive, and a large amount of acreage can be pruned with a single machine. Machine pruning utilizes equipment with a gang of rotating circular saws set at pre-determined heights or widths. All wood in the machine's path is removed by indiscriminant heading cuts. Depending upon the severity of the cuts and orchard vigor, the shoot growth produced requires supplemental hand pruning the following season.

Like hand-pruning, the objectives for machine pruning must be clearly understood so that the result is not surprising. Research conducted over four years in two locations prior to both "on" and "off " years showed no difference in yield between single and double-sided moderate side hedging (cuts made into one and two year-old wood) and hand-pruned controls (Ferguson et al., 1991). Unlike the earlier trial employing severe machine pruning (Ferguson et al., 1991), moderate side hedging had no effect on mitigating alternate bearing. The absence of yield differences between hand and machine side hedging was supported by additional research that showed pistachio compensates for the flower buds removed during pruning by increasing the number of nuts set per cluster (Beede et al., 1991). Pruned trees also had greater nut size than unpruned trees.

A six-year mechanical pruning trial conducted in a dense and vigorous 15 year-old 'Kerman' pistachio orchard on *P. integerrima* rootstock suggests there is less yield fluctuation by hedging one side every year compared to hedging both sides every other year. Cumulative yield data also suggests that the fluctuation may lessen with repeated side hedging. This observation may be associated with the larger amount of growth removed when hedging was first initiated before the 1997 growing season. Due to the density of the test orchard, the large amount of growth removed may have been more than the tree could compensate for (Beede et al., 2002).

The yield differences between moderate single and double-sided hedging in any given year is also affected by the potential crop. This experiment suggests double-sided hedging should not be performed prior to a low production year. Evidence for this recommendation is found in four of the six seasons studied. In 1999, when split nut production was only 1,900 pounds per acre in the hand pruned trees, double-sided hedging significantly reduced split nut yield by 316 pounds (19%) per acre compared to single-side hedging. In 2000, split nut production was above 4,000 pounds and no significant yield difference was recorded between single and double-sided hedging. In fact, the double-sided hedge treatment (pruned the previous year) produced significantly more split nuts (363 pounds) in 2000 than the trees hedged annually on one side. In 2001, the second "off" year, double-sided hedging reduced split nut yield by only 227 pounds relative to one-side hedging. Finally, in 2002, when split nut yield was 5,308 pounds, no statistical differences were recorded between trees hedged on one or two sides (Beede et al., 2002).

It is still unclear whether pistachio canopy height can be managed by mechanical topping without suffering significant yield loss (Beede et al., 2002). Topping levels designed to replace

manual tipping has not significantly reduced yield. This appears to be an acceptable, cost saving substitute that has already been implemented by growers. However, repeated mechanical tipping of one-year-old growth by 50% will allow additional gains in tree height and cause shading in the lower canopy. Correction will most likely require a remedial topping to remove up to five feet of growth. Data collected suggests that the yield loss from topping is correlated to the potential crop rather than physiological conditions associated with "on" and "off" year bearing cycles. Results also suggest that topping for tree size control prior to an "off" year will aggravate low yield in the current season and accentuate alternate bearing.

Experimentation with in-season re-topping to control vigorous growth appears promising (Beede et al., 2002). Trees re-topped in early August grew very little and nut quality was not adversely affected that year.

The mechanical pruning experiments presently conducted strongly suggest that this practice should be implemented before crowding occurs in order to minimize yield loss the first year. Growers also must ensure that the orchard floor is smooth and free from depressions. Small holes within the orchard floor caused the saw blades to dip deeply into the canopy. Growers wishing to perform tipping of one year-old wood can easily do so with the three-bladed, rotating "star" machine that can be mounted on a large tractor. The five bladed rotating star machine makes cleaner cuts than the three-bladed machine when performing moderate side hedging and topping. Travel speed must be monitored to avoid the rotating head from breaking large structural branches before they are cut. Dull saw blades aggravate this problem. When performing orchard rejuvenation, where cuts are often two inches or greater in diameter, breakage would appear to be much less with a hedger employing a stationary boom with five or six saws mounted on it. This provides a cutting plane that is much less likely to cause unwanted branch breakage.

Glossary of Terms

Apical Dominance: The effect that the primary bud, located at the terminal of a shoot or one year-old branch, has on suppressing growth of lower buds.

Biennial (alternate) bearing: Heavy crops alternating annually with light crops.

Branch: Growth older than one season which does not possess flower buds.

Fruitwood: One year-old growth with flower buds differentiated at the nodes along its length.

Heading cut: Pruning cut that removes a terminal portion of a branch or shoot.

Meristem: Undifferentiated tissue, the cells of which are capable of active cell division and differentiation into specialized tissue, such as shoots, leaves, and flower buds.

***Lateral bud*:** Bud at a non-terminal location on a shoot in the leaf axil.

Neoformed growth: The second or third "flush" of current season growth from the terminal meristem of shoots possessing 7 to 9 nodes in the first flush. Distinguished from preformed growth by the fact that its node number is not pre-determined during winter dormancy but dependent upon in-season growing conditions.

Node: Slightly enlarged portion along a shoot at which leaves and/or buds are located at regular intervals.

Preformed growth: The first "flush" of current season growth consisting of 7 to 9 nodes differentiated during winter dormancy. Buds at these nodes are usually floral.

***Reproductive bud*:** Bud whose vegetative meristem has differentiated into an inflorescence capable of producing fruit.

Shoot: Current season's growth.

Spur: One year-old wood consisting of 7-9 nodes, most of which possess flower buds. Derived entirely from preformed growth the previous season.

***Terminal bud*:** Bud at the apex of a shoot.

***Thinning cut*:** Pruning cut that removes an entire branch or shoot.

***Tipping*:** Heading cuts performed on dormant one year-old wood

***Vegetative bud*:** Bud containing leaf primordia and a meristem which has not differentiated into a flower bud. It therefore produces vegetative growth.

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