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Stump and Topwork - a Technique for Rejuvenating Mature Avocado Trees

The California avocado industry is searching for ways to increase industry-wide orchard productivity. The lack of consistent production is the most recognized impediment to a viable industry. The authors have been investigating various methods and techniques to achieve sustainable mid to high production that growers can adopt. In the authors' opinion, what is discussed below is a step in the right direction and it is hoped growers will investigate similar practices in their groves. Some words of caution: any change from the traditional way of doing things requires close observation, record keeping and an open mind as one learns through experience how to make the proposed system work under their situation. We can relate our experience and must say that nothing is perfect and expectations and results are likely to differ from one grove to another.

The avocado tree, when provided ample water, nutrients, and adequate growing conditions can grow to be a very large tree. Many orchards in California, the majority on seedling rootstocks, date back to the 1970's and 1980's. The bulk of the remaining trees from that era are tall, shaded, and very difficult to harvest, especially in groves planted on moderate to steep hillsides. The canopies have joined across their tops allowing little or no light penetration to the ground below. It is a common sight to walk into orchards in the 20+ year age bracket and

observe no lower branches and a park-like setting. Many orchards in this condition also experience a reduction in average fruit size, a decline in harvestable fruit and therefore a reduced commercial yield per acre. The California avocado industry has averaged about 5,700 lbs. per year for the last 20 years. Successful growers have been averaging 10,000 lbs. per year and some even more. It is estimated that to remain viable as a California avocado grower a sustained annual production of 10,000 to 15,000 lbs. per acre is needed to cover costs plus make a fair profit.

Throughout the years different methods to control overcrowding and tall canopies have been tried. Removal of every other tree buys growers a few good years until the grove becomes crowded again. After multiple tree thinnings, trees become further and further apart and remain extremely tall. Removing one or more branches each year has mixed results. Reducing tree height and letting the tree regrow is another option. Often in this situation trees can be cut back to different heights, normally from 3 to 15 feet. At best, it takes trees 2 to 3 years to come back into full production again. Often within this time frame the trees, especially those that were stumped high, become crowded again.

The common response after stumping is rapid regrowth. Trees are "rejuvenated", they look healthy and lush with great vigor and are expected to produce a good crop with large fruit. One of the reasons for the tree response to stumping is the large root to canopy ratio. Tipburn, which is characteristic in older trees, is usually not evident in the initial 2 years. Management of the regrowth is expensive and requires experience and understanding of which branches to leave, which ones to remove, and what to do once they reach the intended height. The trees tend to lose their "juvenile" look once the root to canopy ratio is more in balance and the trees bear fruit.

Some growers cut the scaffold branches at 12 to 15 ft. with the expectation that the tree will produce on the remaining lower branches, if there are any, and on the regrowth that occurs following pruning. It is a well-known fact that the closer to the ground one stumps, the longer it will take the trees to come back into production. The trees that are high-pruned begin to produce sooner than the low stumped trees, however they are quick to become tall and crowded again usually within 3 to 5 years depending on the orchard's tree density and the cultural care afforded the trees. In large poorly maintained trees stumping is often the only viable option. If canopy management is started earlier when trees are smaller, then cutting back does not result in severe loss of leaf canopy and trees maintain productivity, reducing substantial swings in yield. The success of this approach is determined by the tree size when first cut back.

The timing of stumping during the year is very important. Experienced and knowledgeable growers know to harvest early and stump the trees in the spring. Other growers elect to stump the trees when all the fruit have sized and

harvested. This may delay the stumping operation to late spring or summer. After stumping, some growers leave all regrowth on the stump while others select 3 to 4 vigorous branches and remove the rest.

It is common for growers to irrigate and even fertilize during summer following stumping. Again those who are experienced and are familiar with the literature of previous field research are careful with the early introduction of irrigation and apply water sparingly. The water requirements of stumped trees are significantly less than unpruned trees due to the drastic reduction in leaf area and water loss due to transpiration. Too much water with stumped trees will result in wet soils, root death and increased root rot. Vigorous regrowth from stumped trees is unavoidable and this will generally lead to little or no bloom the following spring. The trees are unlikely to flower and set fruit. Subsequent flowering depends on when the stumping was done and the quantity and vigor of the new growth. In essence, the grower is managing vegetative trees for at least 2 years and must bear the cost of applying water, fertilizer and controlling pests. Since the goal is to reduce crowding, tree height and to return to production soon, this rapid regrowth can negatively affect the intended future of the grove by allowing the trees to grow vigorously. The results of this practice are visible everywhere; stump in the spring to summer, begin to irrigate when significant growth appears and the weather warms up, and trees experience rapid regrowth requiring increasing volumes of water, fertilizer and some pruning. The trees are likely to grow even more vigorously in the following spring and summer in the absence of fruit set.

We would like to present and explain the strategy we have been developing for tree rejuvenation (Table 1). We have successfully deployed this strategy for several years with good results and have been able to bring the trees back to bloom, set fruit and enter a productive cycle in the year following stumping. These trees have a fair amount of harvestable fruit within 18 to 20 months. This method requires topworking the stumps with the same variety, Hass, with graftwood selected from known heavy producing trees. The stumps are either seedling rootstocks or even clonal rootstocks that were originally grafted to Hass and now reworked to Hass again.

The comparative cost of the two methods, stumping and managing the regrowth versus topworking the stumps and managing the grafts and growth, are comparable. One significant difference with the topworking approach is the greatly reduced or nonexistent need for irrigation that could amount to one to four acre-feet and likely more before any fruitset appears in the third year.

We discuss below the sequence of events involved in this alternative strategy. If this planting is intended to last several years both the graftwood and the stumps should be indexed for the presence of the sunblotch viroid.

Table 1. Timetable for the Stump-Topwork Rejuvenation method

Year	Approximate timing	Step
	Fall prior to rejuvenation	Prepare trees, fertilize properly
0	Winter	Collect graftwood from superior trees
	Spring (no later than early May)	Harvest trees Stump Whitewash stumps Add a line with drippers at the desired distance and interplant with clonal trees to increase tree density. Turn off irrigation to stumped trees but make sure it is in good working order Topwork trees
	Summer/Fall	Lightly irrigate stumped trees during prolonged hot and dry period Remove all regrowth on stump
1	Spring	Most topworked trees will flower and set fruit
	Throughout growing season	Remove unwanted growth including rootstock suckers and regrowth on main trunk
2	Winter – Summer	Harvest first crop of fruit
	Throughout growing season	Light pruning of poorly growing shoots
	October	Girdle or cincture one of the leaders leaving a lateral branch below the girdle. This could be done a year later depending on tree vigor and fruiting.
3	Spring	Girdled branch will flower heavily, bloom may be earlier than the remainder of the tree Other leader is likely to have little or no fruit and will produce healthy flush and flowering wood
4	Spring	Harvest fruit to allow a water shoot or a bud to develop into a replacement leader. If the renewed leader does not have sufficient growth to produce a good crop then the grower should wait a year before girdling the other leader. This leader is likely to produce heavily and should be girdled in the autumn even with fruit on it if the replacement leader is vigorous.

Prepare the orchard for rejuvenation

In order to have maximum time for the grafted shoots to grow and reach floral induction, and flower and set fruit the following spring, the trees must be stumped and grafted in the spring. Well fertilized trees in the year prior to stumping will ensure good fruit size, and will facilitate an early harvest. The trees should be strip harvested early in the season preferably by March and no later than mid-April.

Collect graftwood for topworking (Year 0)

When selecting graftwood it is important to know the productivity history of the source trees. Trees have inherent production characteristics that need to be observed over time and recorded. Individual trees can range from heavy producers with minimal alternate bearing characteristic, producing trees which are more prone to alternate bearing and trees that seldom produce fruit. Although rootstocks influence tree performance, selecting graftwood from known exceptional trees is advisable.

Graftwood should be selected from known, sunblotch-free exceptional producing trees. The graftwood can be kept in cold storage until the danger of freezes subsides. Select graftwood that is "mature", which means it is cut from trees that are not actively growing and the axillary buds are induced and differentiated. This stage is usually found in December, January, and possibly in early February.

Stump the trees (Year 0)

Stump the trees to a height of 3 to 4 feet as soon as harvest is completed. Remove the scaffold branches to create a single stump. The stump should be whitewashed to prevent sunburn. It is important to remove vegetative regrowth and suckers emerging on the stump. If this is a problem, NAA (TRE-HOLD® Sprout Inhibitor, AMVAC Chemical Corporation) could be applied up to 2 feet from the ground; make sure to follow label recommendations.

Turn off the irrigation system (Year 0)

Water usage is a very important factor addressed by lowering the canopy of large trees. The irrigation system can be turned off for almost 12 months, depending on summer temperatures. It takes 2 to 3 months for the grafts to begin to grow and since there are no leaves there is no transpiration and no need for irrigation.

Make sure the irrigation system is functional and remains in good repair. A functioning system is necessary if hot and dry spells happen during the late summer and autumn and the new growth begins to wilt or shows symptoms

of water stress. During periods of prolonged high temperatures one can irrigate once or twice to avoid stressing the new growth and causing leaf burn. Only small amounts of water are applied given the small canopy (deeper irrigation will be required if the water is saline). The tree can apparently survive without water due to the large root system foraging for water. Stumping only without topworking and similarly withholding the irrigation gave inconsistent results compared to the topworked trees.

Topwork the stumps (Year 0)

Figures 1-13 illustrates the various steps from stumping a tall tree through the insertion of the graftwood and follow-up protection. Topwork each tree with 2 grafts no later than the end of April.

Figure 1. Trees with multiple trunks need to be stumped to a single upright trunk. The stump should be cut to 4-4.5 ft above ground level.

Figure 2. Before grafting the stump is cut to about 3 feet. The cut should be slightly sloped to allow drainage of sap and rainwater.

Figure 3. The pre-selected graftwood should be kept in a cooler with some humidity to avoid sunburn and dehydration.

Figure 4. The bark is cut to match the graftwood prior to preparing it for insertion.

Figure 5. Preparing the graftwood with a beveled cut is critical for a good take. The beveled cut maximizes the amount of cambium on the graftwood allowing for ample contact between the graftwood and the trunk.

Figure 6. The graftwood has been inserted into the trunk. Two grafts are made on opposite sides of the trunk. The discolored area on the stump is from previous trunk injection with phosphonates.

Figure 7. Once the graftwood is inserted, the trunk is wrapped with tape to insure good contact of the graftwood with the trunk.

Figure 8. The area surrounding the graft is sealed with dilute asphalt emulsion to protect it from dehydration and water seepage.

Figure 9. Two sticks of bamboo are used as a support to the paper wrap that will protect the grafts.

Figure 10. The grafted area is wrapped with white butcher paper. A vertical slit is cut in the paper to allow for air exchange.

Figure 11. The graft beginning to grow.

Figure 12. The graft has been successful. The protective paper cover has been cut away and a stake is placed to support the growing grafts. Note that there is no shoots on the trunk.

Figure 13. An ungrafted stump. Note the vigorous growth on the stump.

There are two issues to consider regarding the placement of the grafts. The first is the phosphonate injection history, and the second is the prevailing wind direction. The grafts must be placed in an area where the cut surface does not show discoloration due to previous injections and potential further contact with oozing sap with phosphonate residues that can reach the grafts. The stump is cut at a slight angle for rainwater drainage and no grafting should be attempted at the lower side of the cut. If the trees have not been previously injected, wind direction should dictate the placement of the grafts. A metal stake placed next to the stump or a wooden stake nailed onto the stump will be necessary to support the new growth and provide wind protection.

We must emphasize again that topworking should be completed by the end of April. This will allow the young shoots to grow during the season and mature in October-November. If the growth is very vigorous and still growing in October, as is often observed under conventional stumping management, the probability that the buds will be induced to become floral is very low. If vigorous growth occurs there will be little if any flowering and fruitset the following year. The vigor during the floral induction period in the late summer/early fall is what most significantly differentiates our topworking strategy vs. the industry norm of allowing the stump to regrow at will.

Manage the regrowth (Year 0)

Remove any growth that appears on the stump and all suckers coming off the rootstock. Cut the suckers on the stump with a pair of clippers and apply phosphonate or a fungicide to the cut surface. Do not just break the suckers off; you could infect the trees with *Phytophthora citricola* or with other pathogens. Our experience is that when the trees are topworked as described above, regrowth on the stump is minimal and delayed.

In stumped trees that are conventionally managed (especially those that were stumped and then irrigated and fertilized once new growth has developed) regrowth is more vigorous with many dormant buds on the stump producing competing shoots. These rapidly growing shoots are highly vegetative and it is a great challenge to obtain any fruit set the year following stumping. If the re-growth is excessively vigorous it may even affect the potential for flowering and fruit set in the second and third year following stumping.

Figure 14. A panoramic view of a section stumped and topworked.

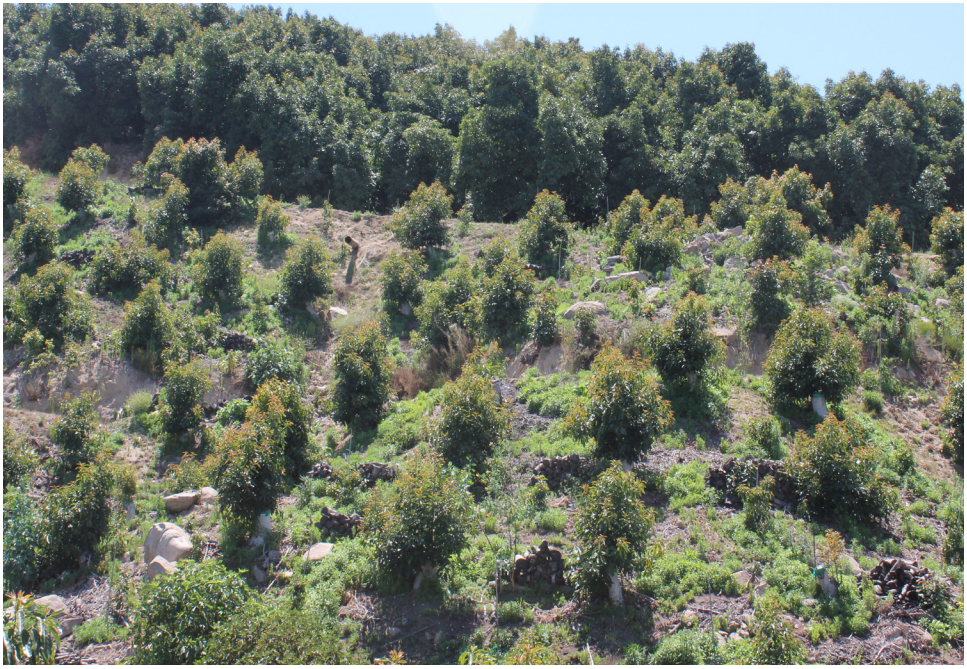

Figure 15. A panoramic view of trees topworked in May 2010. Picture taken in July 2011. Trees in the background are as tall as the topworked trees were before stumping.

Flowering and fruitset the following spring (Year 1)

By the following spring after topworking and properly managing the soil moisture, the growth on the graft is approximately 6 feet and it has been induced to flower (Figures 14-15). Production is almost guaranteed in Year 1 as long as the graftwood is mature and topworking is timely. It is not unusual to produce 6,000 lbs. of fruit per acre or even more on trees spaced at 15 x 15 or 15 x 20 feet. The tree growth is not excessively vigorous because of the requirement for assimilates by the flowers and the fruit (Figures 16-19). Not all the topworked trees behave the same and not all will produce well the first time around. We are studying the different inputs to find the reasons why we experience some variability. There are usually a very small percentage of grafts that fail; we re-graft these stumps but we are aware that these late grafted stumps are likely to behave like the ungrafted ones at least in Year 1.

Figure 16. This tree was stumped and grafted in March 2010. This picture was taken in June 2011 as an example of regrowth following topworking and fruit set.

Figure 17. The interior of a tree topworked in March 2010. Picture taken in June 2011.

Figure 18. The tree from Figure 17 showing that flowering and fruit set occurred.

Figure 19. This tree was topworked in May 2010. Picture taken in July 2011. The tree has remained vegetative without good flowering due to the lateness of the topworking. Note the increased vigor as compared to Figure 16.

Follow up in subsequent years

In Year 2 the growing tree will flower and set and produce 10,000 and even more lbs. per acre and by Year 3 we realize our goal of sustainable production of 10,000 to 15,000 lbs. per acre. Some pruning may be necessary to remove branches that are not growing as desired.

We have also developed strategies for sustaining high production per acre and controlling tree size and vigor. These strategies are outlined below.

Interplant trees to increase tree density

After stumping and topworking the trees as outlined above, we have also interplanted the orchard with trees on clonal rootstock. This can serve the grower in a positive way from several different perspectives. First, this will convert a conventional space orchard to a high density orchard. Under normal circumstances, it is very difficult to interplant young trees into an established orchard. The young trees normally do not perform well due to shading out from the larger trees and irrigation management can be challenging since young trees do not re-

quire as much water as mature trees. The second advantage to this approach is that the grower will have an opportunity to plant the orchard with clonal trees. Thus, in future years if there is a desire to remove trees the replacement trees are already planted and producing. Finally, the grower will see higher yields per acre from having the trees double planted.

If the grower desires to take this approach, a drip line should be introduced into the orchard to provide irrigation for the newly interplanted trees. The drip would then be later replaced by a sprinkler or spitter when the trees grow larger and require more water.

Develop a two-leader tree

This approach attempts to develop a management system to regrow a rejuvenated structure that is productive with good fruit size and consistent production for the long-term. Our goal is that by Year 3 we will try to have one leader producing heavily and keep the other leader rejuvenated to help mitigate severe to moderate alternate bearing.

In October of the 4th year from topworking (Year 3) one of the two original leaders is selected for eventual removal and to produce a replacement leader. The branch is girdled (circular or spiral cut with a girdling tool or cinctured with a thin saw blade around the branch). The girdle should be ⅛ to ¼ inch in width. If the girdling is done correctly the girdled branch tends to produce an abundance of flowers the following spring often with some determinant inflorescences that usually set copious amounts of rapidly growing fruit. Without adequate leaves to cover all the fruit before hot sunny days arrive it is advisable to remove some of these clusters of fruit. The girdling strategy results in a large quantity of fruit set on the girdled branch at the expense of the ungirdled leader that remains mainly vegetative. Note: make sure only strong trees are girdling candidates; as a weak tree can become debilitated and may not recuperate if it carries a heavy load.

There are two important outcomes from girdling (Figures 20-22). First a branch is loaded with fruit for the upcoming season most likely equivalent to what the entire tree would have produced if not girdled. This branch will be cut after harvest and a new shoot will develop that will become the replacement leader. The ungirdled branch is intended to be the producer of the following year's crop.

Figure 20. A tree which was topworked in 2008. The right leader was girdled in Fall 2010. Note the fruit set on the girdled branch. The left scaffold is more vigorous and has less fruit set for harvest in 2012.

Figure 21. This branch was girdled in Fall 2010. This is the healed girdle. Picture taken in June 2011.

Figure 22. Evidence of flowering and fruit set on the girdled scaffold in June 2011.

The sequence of events is as follows. Girdle one of the leaders not too close to the main trunk and above a lateral branch on the leader in the Fall (October - November). This girdled branch should flower heavily and have a good fruit set. The girdled branch should be harvested early (by Mid-April at the latest). The branch should be cut below the healed girdle wound to allow a new shoot to emerge above the original graft and below the girdle. There are two ways that you can renew this leader. First the lateral branch below the girdle is likely to have buds that will push one or more vigorous upright branches when exposed to light. Occasionally a dormant bud will begin to grow below the girdle on the main branch and should be encouraged to develop.

The replacement leader is allowed to grow straight up like a water shoot and may need to be lightly pruned to develop an upright structure and to manage any excessive vigor. The original second leader will be girdled the following fall as described above depending on the amount of growth of the replacement shoot. The goal is that you will end up with alternating rejuvenated leaders every 2 to 3 years.

In conclusion, we have presented a strategy we have been developing with trial and error over the last 7 years. We have seen sustained production of 10,000 to 15,000 lbs. per acre, in rejuvenated older groves, utilizing the combination of stumping, topworking, girdling, and interplanting. This approach is not excessively labor intensive but does require that the grower is attentive to the trees and stumps, and topworks and girdles at the proper time of year. This is one viable system that can contribute to the imperative of sustainable increased production of the California avocado industry while reducing costs and increasing profits.

Further Reading

(all references with the exception of Whitsell et al. are available on www.avocadosource.com searching by author. Search by subject when other material is sought.)

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