

THE ECONOMIC FEASIBILITY OF PLANTING TIP GRAFTED AVOCADO TREES

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THE PROBLEM

The setting of the problem. For a number of years, avocado growers in Southern California have been trying to find a quicker and cheaper method of bringing an avocado tree into bearing than the five years usually required. Because the initial cost of the nursery tree is one of the largest single costs, nurserymen have been experimenting with different methods of propagation to find a method that will raise the tree faster and cheaper so the initial cost to the grower of nursery stock can be reduced.

The question then arises as to whether the trees developed by a new method make as good a showing after three years in the grove as those produced by the conventional method. If this can be demonstrated, then a return on investment in land, trees, irrigation system, taxes, and cultural costs such as planting, fertilizing, irrigating, and mulching can be realized sooner.

The conventional method of propagation consists of sprouting the seeds in the seed bed and leaving them there until the top of the seedling has three or four mature leaves on it. They are then lined out in the nursery row, and when they are large enough, they are budded. By the time they are ready to ball out a period of eighteen to twenty-four months has elapsed.

In 1946 Walter R. Beck, La Habra Heights nurseryman, experimented with a method known as the forced heat or tip graft method. This method consists of planting seeds in September in tar paper containers twelve inches high and six inches in diameter, and growing them in an enclosed plastic screen house heated to the optimum growth temperatures for seedlings. The temperature is held within a range of fifty to ninety-five degrees and the humidity is maintained at approximately eighty percent. The seedlings will be up to pencil size by December, when they are grafted, using a splice cut on a forty-five degree angle. About the first of February they are removed from the forcing house, and put in the lath house to harden off. The grafted trees are ready to plant in the orchard by the first of March, just six months from the time the seed was planted. Nurserymen can raise a tip grafted tree for approximately thirty percent of the cost of raising a conventional tree, and save twelve to eighteen months time.

Avocado nursery trees were in such demand at the time that the forced heat method was started that growers began using the tip grafted trees in large quantities before they were fully proved. As a result, experimenting was extensive; the results were very poor in some areas, but very favorable in others. This experimenting on a large scale has also been costly to the growers. They have lost much time and money trying to find the

best way to care for this younger and more tender type of tree.

Statement of the problem. The problem of this paper was to analyze the differences in tree growth and performance, amount of care required, and the cultural costs of the tip grafted trees compared with the standard avocado nursery trees after they have left the nursery. This problem involved investigations of the care given by the grower to each type of tree, and cost of this care and the resulting tree growth and performance. From these data, conclusions were drawn to determine which would be the better type for the orchardist to plant.

Scope of the investigation. In 1948 DeWitt V. Smith investigated the cultural practices used in growing trees by the conventional method and the forced heat method, making comparisons of advantages and disadvantages of each relative to the problems of growers and nurserymen respectively, and drawing conclusions as to the most practical method for each with particular emphasis on the period before the trees leave the nursery. Because of the recent development of the forced heat method at that time, the number of tip grafted trees that were planted was too limited, and the trees were too young to draw any definite conclusions as to the results after leaving the nursery.

The study was to extend the investigations that were made by DeWitt V. Smith. It was limited to the orchard comparisons of tip grafted and standard avocado nursery trees on Mexican rootstock in San Diego, Orange, Riverside, Los Angeles, Ventura, and Santa Barbara Counties on the points mentioned in the statement on the problem. The trees involved in this study have all been planted since March of 1947, the earliest planting date of the tip grafted type of tree. The study does not cover the nursery operations that were involved before planting the trees in the field.

DIFFERENCES IN THE AMOUNT OF CARE REQUIRED AND COSTS BETWEEN TIP GRAFTED AND STANDARD AVOCADO NURSERY TREES

Most of the variation in the cost of establishing avocado groves is a direct result of the amount of care necessary to keep the trees in good growing condition. This is true for both the tip grafted and the standard avocado trees. The amount of care necessary varies with the location of the grove. Because of the warmer temperatures in interior areas more sun protection and more frequent irrigation are necessary to prevent damage to the trees. Since many factors including the ones just mentioned affect the cost of establishing an avocado orchard, no exact costs can be given. The figures given in this chapter are not to be considered as the average for Southern California, but only as an average of the figures obtained from available cost studies and growers that were interviewed.

As a means of comparing tip grafted groves with budded groves, cultural costs for each type will be taken up under the headings mentioning various cultural practices. These costs are summarized in Table I.

Planting. The initial price paid to the nurseryman by the grower varies from \$2.75 to \$3.50 for balled trees, and from \$1.75 to \$2.50 for tip grafted trees. These cost variations depend on quantity bought, source, and the variety.

If the distance from the nursery to the orchard is not too far some nurserymen will

deliver the trees to the grove free of charge. If the grower hauls his own trees, there is some saving in cost if tip grafted trees are used instead of balled trees since twice as many trees can be hauled in the same amount of space because of their smaller size. It is very important that the trees be enclosed to prevent wind damage while transporting since avocado trees are very sensitive to wind damage.

Generally, tree holes are ready or in the process of being dug when the trees are brought to the field. A tree may be severely desiccated and sunburned between the time of delivery and planting if allowed to stand out for a few hours on a hot day. Tree holes for the balled trees are about eighteen inches in diameter and deep enough to permit throwing in a couple of shovelfulls of top soil for the ball to rest on.

The standard nursery avocado tree is handled by the ball, and the bud scar is faced to the north when placing the tree in the hole. After the hole is filled, the burlap is cut off at the top and laid back on the soil. This way the sack acts as a wick and lets the water run into the ball and wet it more thoroughly. Only well pulverized top soil is used for filling the hole, and the hole is tamped as it is being filled. This is the common practice for planting standard avocado nursery trees in Southern California.

In field planting a tip grafted tree, the tar paper container is slit on one side and the tree is placed in the prepared hole. It need not be much larger than the container. The paper is then loosened and removed. There is no special way of facing the tip grafted tree because of the indistinguishableness of the actual union. The hole is filled and tamped in the same way as the balled tree is.

Neither type of tree needs to be planted high, since trees that are planted one or two inches lower than they were in the nursery are easier to irrigate. During cold winters the bud unions of low planted trees are easier to protect by mounding up with soil.

Cone-shaped basins built on top of the general ground level with the bottom of the basin only slightly larger than the trunk of the tree are usually most satisfactory. Making too large a basin around young trees is a common fault of many growers. This results in wetting the soil around the ball without getting ample moisture into the ball. About a ten gallon basin is used for standard trees but a smaller basin, approximately seven gallons, is used for tip grafts.

The cost of digging tree holes for balled trees, planting them, and forming basins around them is approximately fifty cents. It takes only about half the time to perform these operations with tip grafted trees. This is because the tree hole for the tip grafts need not be as large, the tree is lighter and therefore may be handled faster and with less difficulty, and a smaller basin is used. The approximate cost of digging the tree holes, planting the trees, and forming basins around them is twenty-five cents for the tip grafts. These costs will vary with the type of soil. The heavier the soil the wider the margin between the two costs will be, because of the deeper hole necessary for the standard tree.



Fig. 1. Basin irrigation of tip-grafted tree. Note protection from sun, wind, and rodent damage.

Fig. 2. Furrow irrigation of newly-planted tip-grafted trees.

Fig. 3. Fifteen-months old Fuerte tip-graft with mulched basin.

Irrigation. The best method of irrigating the first year is basin irrigation. This can be done as shown in figure 1 by means of a tank truck or installation of a low head sprinkler system with hose attachment or sprinkler attachment. Furrow irrigation, however, is also used. An illustration is given in figure 2. Based on practical experience and observation, Colley Jeffers states that sprinkler irrigation is most suitable for avocados, particularly on hillside land. Moreover, sprinklers eliminate the need for planting on the contour. In addition, he likes the even distribution of water that results from sprinklers, as well as being able to regulate the depth of water penetration accurately over the entire orchard.

The first irrigation immediately follows the planting operation to help settle the dirt around the newly planted trees. Even with the best of tamping, it is necessary to settle the dirt with water so the soil will be tight against the ball, thereby disposing of all air pockets. It is important that the water surround the young tree entirely, filling the tree hole so all parts of the soil will be thoroughly settled. Where the soil is dry before the trees are planted it is a good practice to give the trees a second irrigation two or three days after the first. These primary irrigation practices are used for both tip grafted and balled trees.

The only water that a tree can obtain is from its small feeder roots. Newly planted trees have a very limited number of these small roots; therefore, their supply of water is very limited, even though the major portion of the soil around the young tree has plenty of water. This condition calls for frequent applications of small amounts of water. If possible, the soil should be wet at each irrigation to the depth in which most of the roots lie even though the lower layers still contain some readily available moisture. It is less expensive to wet to this depth at this time than later. The tip graft has twelve inches of original soil attached while the standard tree has about an eighteen inch ball. Therefore balled trees are irrigated to a greater depth than tip grafted avocado trees.

No definite time intervals can be set for the time to irrigate since it depends entirely on the type of soil, weather conditions, and the vigor of the tree. The failure of many young trees in the spring and early summer appears to be caused by overwatering. One common fault of some growers is that they do not take into consideration the cool, foggy weather that is sometimes present in these early months. Under these conditions, trees do not use nearly as much moisture as they do in warm weather. The cooler temperatures also result in poorer growth; therefore there is less leaf surface to transpire water. Field observation also indicates that damage is often done to trees that fail to start right off. These trees often receive the same irrigation that adjacent, vigorously growing trees get. The dormant trees do not need, can not use, and can have their roots damaged by, the extra moisture.

In the Rincon area, Richard Hibbard and other growers in this area irrigate the balled and the tip grafted trees at the same time. The average interval of irrigation for newly planted trees in this district is one week. Jewel Reed in the Irvine area irrigates the tip grafts every week and the standard nursery trees every ten days until they are well established. After a period of two months both are irrigated at the same time. In the Corona area Robert F. Feierabend irrigates newly planted tip grafted trees as often as every three days during extremely hot weather. Henry Hoeger whose orchard is in the same area obtains his water on specific calendar dates, and has had good results by irrigating both tip grafted and standard avocado nursery trees with a ten and fourteen day watering schedule.

Because of the smaller root system of the tip graft, water is applied more frequently, but not as much water is required at each irrigation since the tree can use only the water that is absorbed by the small feeder roots.

Newly planted trees usually receive between five to ten gallons of water at each irrigation, depending on the soil conditions and the size of the root system. Application of too much water will result in leaching essential nutrients below the root system where

they will be unavailable to the tree. As the root system spreads out, more water will have to be applied. Seven gallons is the average amount of water applied to newly planted tip grafted trees until they are well established and ten gallons is the average amount applied to the balled trees per irrigation. After the first season in the field, both the tip grafted and the standard avocado nursery tree are irrigated at the same time and with the same amount of water.

The frequency of irrigation may be reduced by mulching the basins as illustrated in Figure 3. Mulching keeps the topsoil open and prevents formation of a crust on the surface. This favors penetration of moisture and air, and thus maintains favorable conditions for both microbiological activities and plant growth. Also, a heavy mulch layer has a stabilizing effect on soil temperature by leveling off the extremes, and thus favoring bacterial activity. In cold spring weather, however, the mulch causes the ground to stay too cold and this results in retarding the spring growth. There does not seem to be any difference between mulching around tip grafted and standard avocado nursery trees.

The cost of installing a permanent low head sprinkler system is approximately \$600 per acre. By investing in a permanent irrigation system from the beginning, the labor costs that would ordinarily be necessary with tank irrigation will be saved. Because of the more frequent applications necessary with the tip graft the first year, the labor costs will be about twenty-five percent greater than for the balled tree, but the tip graft will use about ten percent less water because of its smaller root system the first year. Therefore, the average irrigation costs for tip grafts will be about \$27.50 per acre, and \$23.75 per acre for the standard nursery trees. Irrigation costs the second and third year will be the same for tip grafted and standard trees. The cost for a good mulch will be \$22.00 per acre, it being the same for the tip graft as the standard nursery tree.

Fertilization. The amount of fertilization necessary on young trees varies with the type of soil. Growers are more inclined to do more harm by over-fertilizing than not fertilizing at all.

The soils in Ventura County are rich enough so that no fertilization is necessary until trees are six to twelve years old. In the Rincon area of San Diego County, trees have shown excellent response to application of one to one and one-half pounds of ammonium sulfate the first year, and five pounds of material the second year. The third year eight pounds, which is approximately one and one-half actual pounds of nitrogen, is applied. This concentration is applied both to the tip grafted and the budded tree with equal response from each.

Marvin Rounds states that a little concentrated nitrogenous fertilizer, about the equivalent of a heaping teaspoonful every six weeks, will usually show results in increased growth the first year.

There does not seem to be any difference in results between the tip graft and the standard avocado tree although the tip graft is a more tender tree and too heavy an application will be more harmful to it than to the standard tree. The cost of fertilization for the tip grafted tree is the same as for the standard tree. The first year it costs \$1.50 per acre for material and \$1.00 per acre for application, or \$2.50. The second year the cost is \$7.00, and the third year it is \$14.00.

Rodent protection. In most sectors of Southern California the jack rabbit is the worst rodent. It uses the bark and the tender shoots of small orchard trees for food. The tip graft, being a younger and more succulent tree, is attacked much more readily than the standard tree. The standard tree is quite a bit larger, and the main branches are well above the level that the rabbits can reach.

The most widely used means of protection from rabbits consists of placing a cage of half-inch or inch mesh wire screen eighteen inches high and twelve inches in diameter around the young tree. In Ventura County cardboard cylinders twelve inches in diameter and eighteen inches high are used quite extensively with excellent results. The cardboard cylinders have two horizontal rows of one inch holes spaced ten inches apart to admit sunlight as illustrated in Figure 1. These cylinders serve as rodent, sun, and wind protection. Rabbit protection is a necessity in all avocado-growing districts of Southern California except in the Rincon area.

Gophers and squirrels are very serious pests to young avocado trees in San Diego County. Squirrels break trees off above the ground level or seriously damage the foliage. Poisoned barley has been very effective for controlling squirrels. Gophers will completely girdle and cut off the roots of young, tender avocado trees. They don't seem to bother the standard nursery trees as readily as the tip graft because of the hardier bark of the standard nursery tree. Poison and traps are the two main methods used for the control of gophers. Poison is more popular with growers in areas where gophers are numerous. Poison can be carried easier than traps and poison can be applied more rapidly than traps. However, when there are just a few gophers in an orchard, many growers prefer traps since by checking the traps a grower has proof that a gopher has been caught.

Two natural enemies of the gopher are the gopher snake and the monkey-faced owl. If the farmer understood the good the gopher snake and the monkey-faced owl did in helping to control the gopher increase, he would do everything in his power to encourage and help these two natural enemies to prosper and carry on their work of destroying gophers.

In areas close to uncultivated hills, deer are very often a problem. They seem to attack mainly the tip grafted tree because of its more succulent growth, although they are sometimes a problem with standard avocado trees. They will completely nip off the terminal shoots of some trees, thereby severely damaging them.

An increasing amount of deer and rabbit damage in orchards in past years has led to the development of a number of new methods of control. The most effective and least expensive of these methods is by repellents which have been tested in various sections of the state and which have been found to give excellent control.

Good-Rite Z. I. P. is a paste that is easily mixed with water and applied with any hand or power sprayer. Only those outside branches within reach of deer need to be treated, so low spray pressures should be used.

Another effective means of control of deer is by the installation of a fence. A seven and one-half foot fence with steel posts and other necessities can be obtained for twenty-six cents a foot. This serves as a three-fold purpose. It protects from deer, rabbits, and it

will prevent thieves from stealing the fruit when the trees start to produce.

Adverse climate protection. Since the standard nursery tree usually has one half of its foliage trimmed off when balled, the standard nursery tree's trunk is exposed to the sun. Therefore it is susceptible to sunburn. Tip grafts have all their original foliage intact when they are planted, thus furnishing their own shade.

When tip grafted trees are in the forcing house, the forced heat results in very succulent growth, but the plastic screen that encloses the house protects the tree from the direct rays of the sun. If planted in the orchard in this condition, they would be severely sunburned because of the extreme change in weather conditions. A good nurseryman puts the trees in a lath house for at least three weeks to condition the trees for the sun. Where there is no danger of cold weather, both tip grafted and budded trees may be successfully planted in February. If this is possible, they will normally have enough leaves by the time hot weather sets in to furnish their own protection, but the bud union of the standard nursery tree should be protected. If trees are planted after March fifteenth, it is good insurance to furnish them with protection, whether they be tip grafted or budded trees.

Mats, tree protectors, newspapers, or whitewash are used to protect the bud union of the standard nursery tree from the sun. About six inches above the union is the most susceptible part of the tree, so this should definitely be protected, whether it be by mats, tree protectors, newspapers, or whitewash. A good means of accomplishing this protection is by wrapping newspaper mats around the lower portion, and in addition applying a thick coating of white water paint above the mat. A tip graft doesn't need so much sun protection.

In areas subject to wind damage the trees are staked and protected from the wind by placing burlap or palm limbs on the windward side as shown in Figure 4. If the prevailing winds are from the south, this protection will also serve as complete sun protection; therefore other means of sun protection are not necessary.



Fig. 4. (left). *Six-months old tip-grafted tree. Note burlap sun-shade.*

Fig. 5. (right). *Six-months old standard-budded tree.*

The tip graft seems to require more staking than the budded tree. This is because of the tip graft being a more limber tree. There is some controversy as to the size of stake to use. Robert F. Feierabend and four other growers that were interviewed prefer to use a flexible redwood lath $\frac{1}{4}$ " x 2" x 4'. This type of stake is pliable and will bend with the tree in strong winds, thereby limiting the amount of injury incurred by rubbing against the stake. This type of stake is also cheaper. Richard Hibbard and seven other growers that were interviewed desire a two by two which is eight feet long. This type of stake has a longer life, is sturdier, and its height will make it available in later years for training the tree.

In the case of frost protection the caliber of the stock determines the resistance of the tree. Because of the smaller size of the tip graft the first winter, it will usually freeze a trifle easier than the standard nursery tree. If either type of tree is planted as soon as possible after the danger of frost is past in the early spring, it will be able to get established before the hot weather starts, and it will usually have one more growth cycle because of the earlier planting date. Consequently it will be larger by the following winter, and therefore be more frost resistant.

The areas investigated were relatively frost-free, so in most cases orchard heaters were not used. Because avocado trees are more susceptible to frost the first year, some frost protective measures are usually given. The most popular method used is that of mounding dirt four to six inches above the bud union. This practice has resulted in numerous savings to the grower in the number of trees completely killed by frost each year. Since the bud union of the tip grafted tree is usually closer to the ground than the standard avocado nursery tree, it is therefore easier to protect the tip graft. Another good frost protective measure is to tightly wrap the trunk with two or three layers of corn stalks or other good material. The wrapping is placed only around the trunk, the green leaves being left exposed. On frost protection F. Arnold White states:

The most efficient and economical means we have found of protecting our young trees from sunburning and frost is by placing a cylinder around them made from used newspaper mats. The mats are put on loose and last without adjustment for about two years. The mats gave us good protection from cold last year, where temperatures as low as twenty-three degrees were recorded. The unprotected trees in the same plots froze to the ground.

Insect protection. Fuller's rose weevil, grasshopper, leafhopper, cutworm, June beetle, katydid, mealy bug, and omnivorous looper are the major insects attacking young avocado trees in Southern California. Snails and slugs are also important pests in some areas. In some areas control is needed when one or more insects do too much damage. There isn't any difference between the amount of damage done to tip grafted and to standard avocado nursery trees.

Protection costs. The most satisfactory and economical protection for tip grafted trees is the cardboard cylinder since it serves the three-fold purpose of rodent, sun, and wind protection. Stakes should also be used in areas with moderate to strong winds. The cardboard cylinders can be obtained and installed for \$27.00 per acre. Stakes cost \$21.50 per acre, so the total protection cost per acre for tip grafted avocado trees is

\$48.50. Protection for balled trees costs approximately \$8.00 for sun protection and \$21.50 for stakes for wind protection per acre. As pointed out previously, rodent damage is of minor importance to standard trees. The total protection costs for balled trees is \$29.50. Therefore it costs \$19.00 per acre more for protection for tip grafted trees than it does for balled trees. Even though tip grafted avocado trees are more susceptible to frost, the same precautionary measures are given to them as are given to standard avocado trees. The cost of frost protection is very slight since most of the protection is a result of the grower's own labor, so it is considered under miscellaneous costs.

Weed control. Weeds are the major pest of young avocado trees. They rob what little moisture there is in the soil for the trees and limit root growth into new soil when not controlled. Mulching will help keep the weeds down in the basin but those outside the basin must be controlled either by cultivation or spraying. All too little importance is given to weed competition with young trees.

More and more growers are controlling weeds around the young trees by means of an oil spray. Hoeing is also practiced, but in hoeing such deep-rooted weeds as Bermuda grass and others of like nature, the avocado roots may be damaged. From the standpoint of time, an oil spray is more efficient than other methods especially when used on perennials such as Bermuda and ragweed. These weeds compete quite seriously with the young avocado tree since they spread by means of underground stems, and therefore take moisture and certain plant food elements needed by the young tree from the soil. Care should be exercised to keep the oil from getting on the trunk or leaves. It is best to pull the weeds that are directly under newly planted trees out by hand to prevent oil damage. In some areas morning glory is a pest and will grow under dry soil conditions. This weed can very easily be controlled by means of careful applications of 2, 4-D, but one or two follow-up applications may be necessary.

The same method of control is used for the tip grafted avocado tree as is used for the standard nursery tree. Since the tip graft is closer to the ground, more care is used to make sure no oil gets on the leaves, especially on windy days when the oil has a tendency to drift. The cost of weed control for both types of trees the first year is twelve dollars an acre, and for the second and third year, ten dollars an acre.

Pruning. Many growers, in setting out young trees, cut them back very little. In most instances the standard avocado nursery trees as purchased from the nursery are five to six feet in height. When they are balled, the nurseryman cuts the lateral roots as well as the tap root, the latter being cut about eighteen inches from the surface. Since most of the root system has been removed, he cuts the top back sufficiently to restore the balance; otherwise a weak-growing tree would result. Sometimes such trees remain inactive after planting for a season or two before starting to grow; in many cases they never grow. In regard to pruning in the field, Marvin Rounds states:

As little pruning as necessary to accomplish results is the practice which should be followed. It is better to prune lightly and often than to prune severely and less frequently. Pinching out the buds is a better practice than to permit branches to grow which later must be removed.

When balled avocado trees are obtained from the nursery, sometimes they are not

pruned back enough to compensate for the severe cutting that is done to the roots at the time of balling. This results in a tree that looks appealing to the buyer but is actually unbalanced. A good grower will properly trim this type of tree before planting it.

To give the tree the greatest possible structural strength and prevent limb splitting when heavy crops must be carried, George Goodall believes in establishing main branches at intervals approximately six inches apart, making sure two limbs are never directly opposite. Laterals should start at four feet and extend up to six feet. Just the lateral buds should be pinched out; never the terminal bud.

Tip grafted trees do not need to be trimmed back when planted since the root system isn't disturbed. Because the tree is smaller when planted than the standard nursery tree, a little more training is necessary with the tip graft than with the standard tree. This training is done as soon as the tree is well established in the orchard. It consists mostly of pinching out buds that would grow into undesirable positions. This method of training does not retard the growth of the tree, but instead, it sends additional sap into other parts of the tree.

The amount of pruning done by growers varies considerably the first three years. The chief objective of pruning is to develop a tree into a shape and size and also a strength of limb that will permit the bearing of optimum crops. Each grower has his individual theory how a young tree should be trained. Since the cost varies with the amount of training done to the tree for both the tip grafted avocado tree and the standard nursery tree, no definite cost figures can be set. However, in the study Joe Coony made in San Diego County, it was found that the first year the average cost was three dollars, six dollars the second, and ten dollars the third year. The figures were made on standard nursery trees, but tip grafted trees will have approximately the same training costs.

Disease. The three main diseases attacking avocado trees in Southern California are *phytophthora cinnamomi*, or root rot, sun blotch, and verticillium wilt. The spread of avocado root rot by nursery stock has been substantiated. Root rot is usually found on poor looking nursery trees. These of course should be avoided. Replanting in groves already infested with avocado decline is not successful. They invariably fail to grow, or grow poorly.

Sun blotch is a virus disease that is spread by budding and grafting. If nurserymen are reliable, they will obtain the budwood from trees known to be free of the disease, thus preventing the spread.

Verticillium wilt is a disease attacking trees from two to twenty years old. The disease usually occurs on only one or two isolated trees in a grove; thus it is not at present of economic importance. The best preventive measure is not planting on land previously cropped to tomatoes or other plants highly susceptible to verticillium wilt.

There is no difference in disease resistance between the tip graft and the budded tree. They both are readily susceptible if exposed to the disease.

Replanting. Inherently weak trees seem to be the main reason for replanting. Since the tip grafted tree is raised under conditions where anything will grow, the nurseryman does not have the chance to cull it as he does with the balled tree. Kenneth Smoyer states:

The tip graft is one year younger from seed than the standard tree; therefore the trees that would have been culled out in the nursery are in the field as weak trees, and must be replaced.

The main reason some orchards are not uniform and require quite a bit of replanting actually is the fault of the nurseryman from whom the grower obtained the trees. Cullage should be a continual process for the nurseryman, especially with the tip graft. If nurserymen will cull at least twenty-five per cent, a uniform growth will usually result.

There are many reasons for replanting. In some areas frost will either stunt the trees severely or kill them. This is particularly true of tip grafts because of their higher susceptibility to frost. Trees suffering from lack of water during the summer will frequently be stunted or completely killed. Where adequate adverse climate or rodent protection is not given trees, especially tip grafts, damage will be done, resulting in the necessity of replanting.

Bill Montgomery states, "In almost all cases the balled tree should have the same care the tip grafted tree should get, but the standard nursery tree will stand more abuse than the tip graft." Therefore the tip graft will consequently show more injury, and more replanting will be done with tip grafted trees than with budded ones.

Robert F. Feierabend, by building his own forcing house, was able to raise his own tip grafted trees and give them the necessary amount of cullage. Thirty-six hundred trees were started and approximately seven hundred were discarded, which was about twenty percent cullage. He reports that only one percent of the trees that were in the orchard for one year had to be replanted because of inherent weaknesses. Richard Hibbard, who obtained his trees from an outside source, reports that five replants per acre were necessary with balled trees and twenty trees replanted per acre with tip grafts. Fifty percent was because of rodent injury, mostly gophers; thirty-five percent was because of weak trees, and fifteen percent from miscellaneous causes.

TABLE I
Estimated Costs of Establishing an Avocado Orchard
Costs Per Acre—First Three Years

	First Year		Second Year		Third Year	
	graft	budded	graft	budded	graft	budded
Cost of tree	\$189.00	\$297.00	\$ 26.25	\$13.75		
Digging and planting	14.40	28.80	2.00	1.30		
Irrigation	27.50	23.75	23.75	23.75	\$ 30.85	\$ 30.85
Mulching-straw	22.00	22.00	22.00	22.00	22.00	22.00
Fertilizer	2.50	2.50	7.00	7.00	14.00	14.00
Protection	48.50	29.50	5.00	5.00	5.00	5.00
Weed control	12.00	12.00	10.00	10.00	10.00	10.00
Tree pruning	3.00	3.00	6.00	6.00	10.00	10.00
Miscellaneous	15.00	10.00	10.00	10.00	10.00	10.00
	\$333.90	\$428.55	\$112.00	\$98.80	\$101.85	\$101.85

Three year total cost per acre for the standard budded tree.....\$629.20
 Three year total cost per acre for the tip grafted avocado tree.....\$547.75
 Saving in cost by using the tip graft.....\$ 81.45

Summary. In Table I the cost of tip grafted avocado trees was figured at \$1.75 per tree and the cost of standard avocado nursery trees was figured at \$2.75. The average number of replants necessary for tip grafted trees in this study was three times as many as the standard nursery trees. Fifteen replants per acre were necessary for tip grafts and five replants per acre were necessary with standard nursery trees. These costs were entered under the second year cost of tree in Table I. The labor costs of replacing weak or dead trees were entered under the second year cost of digging and planting. The owner's own labor was not included in this table. This table only included cultural and tree costs. Other expenses such as cash overhead, depreciation, and interest on investment are the same for both the tip graft and the standard nursery tree and therefore were not included.

DIFFERENCES IN TREE GROWTH AND PERFORMANCE BETWEEN TIP GRAFTED AND STANDARD AVOCADO NURSERY TREES

Root system. The avocado is naturally a surface rooting tree. The fine fibrous rootlets, which absorb water, food, and air, develop in greatest abundance at or near the surface of the soil. Seventy-five to eighty percent of the feeder roots of the standard avocado nursery trees are cut by the balling operation. To compensate for this setback, fifty percent of the top is cut back.

Walter R. Beck states:

Trees grown in tar paper containers twelve inches high and six inches in diameter should be removed within ten months. If this will be done, the root system developed in these cartons does not become pot-bound. The central taproot goes straight through the ball and partially into the ground below. The side roots reach the side of the carton and then turn down. In no case do they have a tendency to curl around and become bound.

Since very little if any damage is done to the root system when planting, the tree is planted with all its foliage intact.

Growth cycles. Since tip grafted avocado trees are disturbed very little by the planting operation, they usually start growing as soon as they are planted, and they continue to grow. The setback the budded tree received by the balling operation will, in quite a few cases, result in the tree staying dormant for a period of a month or longer while the tree has time to compensate and heal up enough to start growing again. There are usually three growth cycles with the balled tree and four growth cycles with the tip grafted avocado tree during the growing season. All the growers interviewed indicated that this was true. Richard Hibbard, after watching growth on his twenty acre ranch of tip grafted and balled trees for two years, states:

The tip graft produced one more growth cycle than the standard "nursery tree for the first year. The growth is of the same type, and the amount of growth produced by one cycle is the same for the tip graft in most cases as it is for the standard tree. After the first year there is no difference in amount of growth produced.

Type of tree produced. Since growth habits and characteristics are inherited, the method of propagation will not make any difference in the type of tree produced. Trees

will have the same shape, provided the same method of pruning is used. The grower can develop a tree into numerous shapes by pinching out buds which would grow into undesirable positions. Domingo Hardison prefers the upright type of tree with less work than the spreading type of tree.



Fig. 6. (left). *One-year old tip-grafted Fuertes.*
Fig. 7. (right). *One-year old standard-budded Fuertes.*



Fig. 8 (left). *Three-year old tip-grafted avocado.*
Fig. 9. (right). *Three-year old standard-budded avocado.*

The tip graft has more foliage when planted than the balled tree since approximately fifty percent of the foliage is cut off the budded avocado nursery tree to compensate for the balling operation. At the end of the first season in the field, the standard avocado tree has the same type and amount of foliage, but the tip graft is usually smaller in size because it is a year younger from seed and is smaller when planted out, as it is shown by comparing Figures 4 and 5. One year old groves are compared in Figures 6 and 7. Figures 8 and 9 compare a three year old tip grafted avocado tree with a three year old standard avocado tree. The standard avocado tree has grown into a slender, more upright tree because it is interseted in a mature lemon grove, but the amount of growth on each of the two trees is approximately the same. Figure 10 shows the uniformity of the tip grafted grove of Walter R. Beck resulting from heavy callage in the nursery and

proper care while in the field.

At the Hardison Ranch Company and Santa Paula Lemon Company orchards, near Santa Paula, a comparison was made between tip grafted trees and those budded in the conventional manner. In virtually every case, the tip grafts have made excellent growth, equally as good if not better than the regular nursery trees.

The union between the stock and the scion is just as strong on the tip grafted avocado tree as it is on the budded avocado tree, contrary to some beliefs.

Interset planting. The practice of interplanting young avocado trees in mature citrus or avocado orchards has become fairly extensive in the last couple of years. Most of the available virgin ground that is in a frost-free area with an adequate water supply has been utilized, and growers have looked for other locations to plant. Growers have been planting young avocados in mature citrus orchards which have major diseases such as scaly bark, quick decline, or brown rot gummosis, thereby obtaining some income from the citrus trees that are still producing to help pay for the cost of bringing an avocado grove into production. Since the avocado is more susceptible to frost than the citrus tree, this practice is used only in areas relatively frost-free.

There are several methods of placing interplanted trees. Trees may be placed in the original tree row in hedgerow fashion when the already established trees have not crowded too closely together. They may be offset from the hedgerow pattern and placed in the tree row furrow, thus not competing with the original trees as quickly as trees planted directly in the tree row. The third method is the system of placing a young tree equidistant from each mature tree and leaving every fourth middle unplanted so it can be used as a drive row. When the original trees are pulled out, the fourth middle will then be planted.

Young avocado trees interplanted in a mature citrus or avocado orchard receive considerable wind protection from older trees. Citrus groves in areas subject to wind damage usually have a windbreak already established, thus adding to the protection of young avocado trees interset in citrus orchards.

Because of the additional irrigations given to young avocado trees interset in a mature citrus or avocado orchard the first year, there will be more moisture in the immediate vicinity of the newly planted trees. The roots of the mature trees are constantly seeking moisture and will therefore move into the root zones of the young trees, thereby robbing them of moisture.



Fig. 10. *Uniformity of tip-grafted trees in well-managed avocado grove*



Fig. 11. (left). *Two-year old tip-graft intersets in lemon grove.*

Fig. 12. (right). *Two-year old standard-budded intersets in lemon grove.*

Because of the smaller root system of the tip grafted avocado tree in comparison with the standard avocado nursery tree, the tip graft has a more limited area from which to obtain the necessary moisture and nutrients. It will therefore be more severely set back and stunted by competition with the roots of the mature trees. The roots of the standard avocado tree are larger and more developed, thereby making that type of tree more tolerant to competition.

Young trees planted in hedgerow form are closer to mature trees and therefore will not only be set back by root competition, but also by the lack of sunlight because of the shade given by the mature trees. This lack of sunlight causes the tree to develop into a more upright tree with very few main laterals forming close to the ground. The balled tree is more tolerant to abuse than the tip grafted tree and consequently will not be as seriously affected. Figure 11 illustrates the degree of stunting of a two year old tip graft as compared with a two year old standard avocado tree, Figure 12.

Fruit. The oldest avocado trees propagated by the tip graft method are only three years of age at this time. Although some fruit has been produced on the oldest tip grafted trees, it is too early to make any definite conclusions of the age when commercial production starts and of the amount of fruit produced commercially by this method of propagation.

Orchards containing inherently weak trees resulting from improper cullage by the nurseryman or poor cultural practices in the field will have a considerably lower production than uniform groves in healthy condition. The size of the tree has a direct effect on the amount of fruit produced. In cases of improper cullage and cultural practices, tip grafted trees have not been as uniform as the standard avocado trees. This has resulted in smaller trees and less fruit. However, tip grafted avocado trees that have received the proper cullage in the nursery and the proper care in the field at three years of age have just as much fruit as standard budded trees.

CONCLUSION

Amount of care and costs. By investigating the amount of care given to both the tip grafted and the standard avocado nursery tree by growers throughout Southern California and comparing the resulting costs, conclusions have been drawn as to which type of tree would have more capital invested at the end of a three year period.

From the figures given in Table I it can be seen that growers will save \$108.00 per acre the first year in the initial cost of the trees by using tip grafted trees instead of balled trees. However, the cost of replants the second year will be \$12.50 more for the tip grafted trees than for the balled trees because of the necessity of replacing weak trees. Therefore there will be a net saving of \$95.50 per acre in the cost of nursery stock if tip grafts are used.

The cost of digging the holes, planting the trees, and forming basins around them is \$11.10 greater per acre for the standard avocado nursery trees than it is for the tip grafted avocado nursery trees since it takes longer to perform these operations with balled trees.

Although tip grafts require approximately ten percent less water than budded trees, labor costs are about twenty-five percent greater as a result of the more frequent irrigations necessary with tip grafted trees the first year. Therefore the cost of irrigation for tip grafted trees is \$3.75 per acre greater than for budded trees.

As shown in Table I, protection costs are \$19.00 greater for the tip grafts than for standard avocado trees. This is because of the added amount of rodent protection necessary with tip grafts.

The cost of basin mulching, fertilization, weed control, and tree pruning are approximately the same for both types of trees. Miscellaneous costs are approximately \$5.00 higher per acre for tip grafts. This is because of the need for more frequent observation of that type of tree for damage caused by rodents, and for minor costs such as frost protective measures and pest control.

The total cost for the items just summarized during a three year period for standard avocado nursery trees is \$629.20, while the cost during the same period for tip grafted avocado trees is \$547.75. This represents a saving of \$81.45 per acre for the tip grafts in the three year period.

Tree growth and performance. When first class tip grafted and budded trees were used, in most cases there was very little difference in the growth of the two types of trees at the end of three years in the field. In many cases, however, tip grafted trees that should have been culled out in the nursery have been planted. This has resulted in some very unsuccessful tip grafted groves in Southern California.

Tip grafted avocado trees do not grow as well when they are interplanted in a mature citrus or avocado grove as standard avocado nursery trees do. The mature trees are too much competition for the smaller type of tree.

The standard tree is easier to raise successfully than the tip grafted tree. Less effort is needed to produce a healthy, vigorous budded tree. Cultural operations may vary more from normal without seriously affecting a standard avocado tree, since it will stand more abuse than the tip graft.

When the right type and amount of care is given to the tip graft, a tree that is just as good as a standard budded tree can be produced, and at a considerable saving to the grower.

More desirable type of tree. An experienced avocado grower intending to do his own work in establishing an avocado grove on cleared land, preferably virgin soil, and do it as cheaply as possible will be better off by using tip grafted avocado trees. The area should be relatively frost-free because tip grafted trees are slightly more susceptible to frost than standard avocado trees the first year. In some cases growers have also done the nursery work successfully, thereby further reducing the cost. A grower who does his own nursery work also has the advantages of knowing the source of seed and budwood, and he is able to give the trees the proper amount of cullage in the nursery.

Any newcomer who has never raised avocado trees before and the majority of average avocado growers who wish to establish a uniform orchard with a minimum amount of work are far better off using standard avocado trees. This type of tree is more resistant to frost in most cases, and it will take more abuse than the tip graft. This type of tree may also be successfully interset in a mature citrus or avocado orchard whereas this practice has a tendency to stunt tip grafted avocado trees.

Although Table I showed that tip grafts could be raised cheaper over a three year period, the situation may be entirely reversed when the trees come into commercial bearing. It takes very little increased production from a vigorous orchard to offset any initial or cultural costs that were necessary to produce a uniform, vigorous grove. Another study should be made after tip grafted trees have been in production long

enough so any differences in the amount of fruit produced can be given. At that time income obtained from the fruit can be figured in the comparison of costs. Definite conclusions can then be given as to which type of tree is the better type to plant taking production as well as cultural costs into account.

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