FIRST EDITION March 1983

LIBRARY OF CONGRESS CATALOG CARD NUMBER 83-70334

ISBN 0-9675198-0-2

Bonsall Publications
4339 Holly Lane Bonsall, California 92003

Printed in the United States of America

PREFACE

My interest in preparing a study of avocado and complementary crops in northern San Diego County goes back more than 20 years when I became a grower almost by accident. A neighboring friend and fellow grower, Reinhold Gerber, in what was then called North Carlsbad, exposed me to our fine farm advisor, Don Gustafson. In my first meeting with Don he supplied me with many university pamphlets, and I recall thinking that the material should be organized under one cover that would also include the experiences of growers in the field.

Several years later I found myself living on our ranch in the Lilac area and, being employed by what later became the Johnson Agricultural Corp., I held a number of different billets for Wilbur L. (Bill) Johnson at different times. Near the midpoint in my "Johnson career" I operated a tool crib and supply activity, which brought me into direct contact with our grower customers. One of those customers was Mrs. Helen Knox, who found that I was able to provide satisfactory answers to her many questions about the industry and grove management. She also noted that I was in attendance at most grower and industry meetings. Our friendship became strong even though she chided me that I had not prepared in pamphlet form the information that might be useful to neophyte growers who were our customers.

I presented her suggested publication ideas to the Johnson Agricultural Corporation's General Manager, Cmdr. Harold S. (Hal) Keith, U.S.N. (Ret.), who urged me to proceed forthwith under the aegis of Johnson. Having only the most modest experience at writing, leftover from the late '30s when I had an article published, I didn't know that I could not do it. When the manuscript was roughed in, though I had not reread the second half once, Cmdr. Keith called for it because of a printing commitment and I was assured that all the grammatical corrections would be made. This three-page tract was well received and has been revised twice since the original printing; I feel very comfortable with it. Growers tell me that they have found it helpful to them, which is gratifying to me.

In the spring of 1977, Mr. Richard J. (Dick) Burchall came to the Johnson offices to make inquiries about our company's newsletter, to which I had made minor contributions. Dick had a publishing background and was new to avocados and to Fallbrook. In the course of our first conversation he recognized a need for an industry magazine that you now know as the "avocado Grower" and that in little over five years has become a new and very important voice in the world of the avocado fraternity. While the magazine was to provide a forum for the industry, Dick wanted me to put under one cover a "how to" book that growers could use in understanding the avocado business as well as one that could furnish an historical background. It is my hope that as a grower you will benefit.

It was not long after that spring meeting that Dick met Alan L. Myers, who was fresh out of journalism school, at a church -- of all places -- and set him to work putting the magazine into shape. It was not enough that Alan became our fine and accomplished editor, but he has also provided suitable editorial corrections, suggestions and photography for my fumbling efforts as the contributor of "Midshipman's Butter For All Hands." In a short time, additional talented help was required and Ann Fagin signed on in advertising. Of course, any organization worth its salt,

such as the "Avocado Grower", had to have a very fine secretary in the person of Charlotte Weise.

In the second year of publication Alan moved up to the new Avocado Commission as a vice president and, happily for the magazine, another talented young man, Mark E. Affleck, was recruited to the editor's billet, an office that he fills with distinction.

When it was determined that it would be inappropriate for the magazine to act as publisher for an avocado "how to" handbook, I approached my long time friend, Paul H. Thomson, to inquire if his Bonsall Publications would have an interest in publishing such a book. Paul, as a horticulturalist and a co-founder of the California Rare Fruit Growers, recognized a need for such a work, especially by new growers entering the industry, and agreed to give it the light of day.

As originally envisaged, Paul was merely to edit the manuscript and then publish it, an undertaking that would involve little work on his part. As work progressed, it soon became apparent that he would be not only a collaborator but also a coauthor. For his efforts in reviewing the original work published by the Avocado Grower magazine under the title of "Midshipman's Butter For All Hands" and in re-organizing the material and suggesting changes and additions, I am very grateful. Readers will recognize his contributions for their clarity and lucidity. It has required the combined efforts of both of us over a period of almost two and a half years to prepare the manuscript for publication. It is sincerely hoped that the reader will benefit from this collection of useful material.

Much credit must be acknowledged to my good, cherished, and esteemed friends Jane B. Lorenz, C.P.A., and James K. Lorenz for their encouragement and specific aid and suggestions.

There are two others who in their separate ways have made unique contributions to this effort. First, the distaff side of my household, Joyce, has aided me by reviewing the work, giving spelling corrections on demand, and supplying great moral support and encouragement for this effort to help growers. Second, and only because fate put him last in chronological order, the holder of my real estate license, my broker and good friend, Joe Mecaro, who through his forbearance has permitted his offices to be used for many magazine and book related activities.

The purpose of this effort is to help orient the newcomer to the avocado industry and to remind and refresh the experienced grower's memory of a little of our industry's flavor and excitement.

Over the years the avocado industry has attracted those special and unique individuals who can see the beauty and charm of developing harsh lands into fine and productive groves of that wonderful "love fruit," the avocado. This writer believes that it is quite possible for a man to have a love affair with a woman, but equally possible to have a love affair with an avocado tree. For me the charge may be bigamy, but I am wedded to the 'Reed' and 'Zutano' varieties for practical as well as aesthetic reasons.

So, gentle readers, go forth and prosper knowing that the book is the distillation of the knowledge of our farm advisors, old time growers, packinghouse field men, grove managers, and C.A.A.B. and C.A.C. members' long experiences.

"THINK AVOCADOS"
Frank D. Koch
145 Cerco Rosado
San Marcos, California 92069
31 March 1983

"Midshipman's Butter For All Hands" by Frank D. Koch appeared in the Avocado Grower magazine as a series of articles copyrighted by Rancher Publications. The series started in the first issue of October 1977 and ran for a total of 19 issues through April 1979.

In a letter dated 9 February 1983, Rancher Publications released to Frank D. Koch the copyright on the series.

Chapter I
HISTORY

Historical records do not indicate the exact date the avocado was introduced into California, but it is thought the introduction may have occurred around 1850. There was a tree planted near a building of the Mission Santa Cruz that was probably the oldest known avocado tree in the state. (Substituted "was" because it doesn't exist anymore, right? Sm)The California State Agricultural Society Report for 1856 stated that Thomas J. White grew the avocado in Los Angeles. The oldest living tree is found on the University of California, Berkeley campus and was planted in 1879. In other southern California locations, avocados were planted by various people who introduced and planted seed from Mexico and Guatemala. (1)

For purposes of this endeavor, the avocado industry began in California in 1911, when Frederick O. Popenoe sent Carl Schmidt into Mexico to seek better varieties for his nursery, "The West India Gardens" of Altadena, California.

Mr. Schmidt was compelled to tell and retell the story of his fortuitous discovery of the Fuerte avocado. "Popenoe was a nut -- an imaginative, idealistic nut without which our nation would suffer and certainly make little progress. In 1911, his current nutty idea was that California would be a good place to grow avocados -- and that people would like them." (2)

At that time, Mexico had no commercial avocado production, so the hunter of avocado budwood first searched the marketplaces for fruit that showed promise and then sought out the tree. This was the case for Schmidt, who located what turned out to be the Fuerte as a dooryard tree in Atlixco, Mexico. Budwood from this parent tree became the backbone of the California industry.

He told the story like this:

Two years later came the big freeze. (1913-14 Ed.) In the spring when we began to take stock of damage, it was the Fuerte that came through and it was the only avocado that survived. It thus proved itself adaptable to our temperatures.

In 1911, when Carl Schmidt found the seedling tree growing in the back yard of Señor Le Blanc in Atlixco, Mexico, the tree was so sturdy and produced abundant fruit of such superior quality that Le Blanc had given it the favored designation of "avocado De Chino," after the excellent silk imported from China.

The following year, J.T. 'Grandpa' Whedon, a resident of Yorba Linda in Orange County, decided to sell the pigs he had been raising to supplement his pension as a retired superintendent of the Ohio Street Railway Company and become an avocado grower -- even before he ever tasted one. He purchased five acres of land, which so upset his wife that she refused to move to the ranch with him and continued to maintain a separate residence.

Wife or no wife, Grandpa Whedon ordered forty avocado trees from the West India Gardens. All were types that were local favorites but none were from the buds of Señor LeBlanc's dooryard tree. The trees were to be picked up the following spring.

As fate would have it, that January was extremely cold and the damage was extensive, especially in the Southern California area, with temperatures as low as 12 degrees Fahrenheit. All the young trees in the nursery were frozen except for the trees that had been budded to Carl Schmidt's find from Atlixco. Mr. Popenoe, noting their hardiness, named them 'Fuerte' after the Spanish word for strong.

The following March, Grandpa Whedon hitched his old white horse to the buckboard and drove to the nursery to bring his trees home with him. When he arrived, he was told that all of the trees that he had ordered, and paid for, had been killed in the freeze.

"When he demanded his money back, Popenoe was forced to tell him that his money was only part of the over $100,000 that the nursery had lost during the freeze, and that there was no money to return. Finally, Grandpa Whedon agreed to accept the un-tried scrawny little trees and took them back home to begin the world's first Fuerte avocado grove.

When his orchard came into production he had standing orders from hotels in Los Angeles and San Francisco who were willing to take all he could ship, paying as much as $12.00 per dozen. Because of the Fuerte's cold resistance and high quality fruit, the buds from his trees were in great demand, and in some years, he realized as much as $6,000 from buds alone (3).

From such fluky experiences like Grandpa Whedon's have come many of the varieties we use today to build our exciting avocado industry.

Demand for seed was also high in those days. Gil Henry of the Henry Avocado Co. in Escondido, California, spins an avocado yarn that his father told him during this same time frame. According to Henry you had to turn in a seed from one avocado before you could buy another one. That's because in those days old seed was the principle source for nursery stock.

The California Avocado Association was organized in 1915 and the name changed to California Avocado Society in 1940. One of the chief founders was J. Eliot Coit, Ph.D., who was one of the guiding lights of the industry until the early 1970s.

The California Avocado Society -- old, prestigious and professional, with no interest other than the betterment of our industry -- has membership that spans the globe, wherever people care about avocados. The Society has been the building vehicle and the principal forum, through its annual yearbook, in the quest for newer and better varieties as well as better orchard management and cultural practices. It has also had a keen interest in solving the root rot and sun blotch problems and has been the common meeting ground for all segments of the industry. The Society's yearbook has long been the only Bible our industry has had, and growers anxiously await each new issue.

From these beginnings in the San Gabriel Valley, we can follow the avocado trail to the coastal strip between Encinitas and Oceanside and back inland to the Escondido and Fallbrook areas. After the end of World War II, there was a renewed interest in avocados. Much new acreage was brought into production until the industry had a record large crop in 1959-1960, resulting in very

low returns to the growers. It was in that period that this writer became smitten with avocados, becoming a true aficionado, and can recall that California average returns per acre were $365.00 for that crop year. For the crop year '78-'79, returns were up to $2,136.00, an increase of over four and one-half times the value of the crop 10 years previously (4).

Many growers attribute the turn around in returns of the early 60s to two important factors:

A. A. The grower's "bootstrap" efforts to help themselves using the "marketing order" mechanism, which permits growers to band together under state law to tax themselves to promote their product. That order became effective in 1961 under the name of the California Avocado Advisory Board (CAAB), comprised today as follows: 2 handler co-op members, 2 independent handler members, 5 grower co-op members and 5 independent grower members. In the last six years there has also been a fifteenth member added to the Board who is appointed by the Governor to represent the public interest. It is the function of this seat holder to act as a liaison between the Board and the public for the exchange of information. The first public member appointed by Governor Edmund G. Brown, Jr., was Mrs. Mary Means, a home economist and consumer counselor for the San Diego Gas and Electric Company, now retired. Gwen Romig has been appointed by the Governor to succeed Mary Means as the second public member and is active under the new California Avocado Commission (CAC).

Growers felt stifled under the marketing order and formed the California Avocado Commission (CAC) to perform the promotional functions of the Advisory Board, which operates essentially as a private corporation funded by industry growers, but retains the police powers of the state to enforce the collection of assessments from growers to operate the commission. The 1978-79 crop year was the first year that the CAC was used to advertise and promote the crop rather than the old marketing order.

In support of this move, the Calavo newsletter "Together" of June 7, 1977, made the following observation:

. . . Inflexibility of the marketing order system . . . a system attempting to blanket thirty-four diverse commodities . . . has made it increasingly difficult to formulate the type of specialized advertising and promotion program necessary to meet the needs peculiar to our expanding avocado industry.

Growers have added to the marketing order's mission. CAAB has been asked to seek solutions for the vexing problems of Phytophthora cinnamomi (root rot) as well as other diseases. This is being accomplished under its subunit, the Production Research Advisory Committee (PRAC). Currently, growers are taxing themselves at the rate of 4.7% of the price received for fruit. Of that, 4.5% goes to CAAB/CAC for marketing; the other .2% goes toward production research.

B. The second factor helping to turn the industry around was the emergence of the Hass variety to prominence. With Hass as the summer fruit and Fuerte for the winter, the industry had year-round quality fruit that would help fill gaps in the production marketing calendar.

The Fuerte variety of avocado had long been the standard of the industry and was promoted in all of the advertising as a green-skinned fruit by those who sold the fruit to the public. It would take a formidable advertising campaign to acquaint the public with the merits of a dark-skinned fruit. The Hass variety was discovered in 1926 and patented in 1935 and began to attract the attention of several growers with an experimental turn of mind. Among these, Harlan B. Griswold planted a large acreage of Hass in the San Luis Rey Heights area of Fallbrook and found that it produced consistent crops of fine quality fruit. During the 1950s, he recommended Hass to any and all growers who were considering an avocado planting.

With the advent of the California Avocado Advisory Board and its campaign to re-educate the public to accept dark-skinned avocados in the summer and green-skinned avocados in the fall and winter, the marketplace resistance to dark-skinned avocados was largely overcome by the late 1960s. Advertising was supported by the fact that Hass is an avocado that the growers can be proud of. It ships well, has a good shelf life, and is of fine eating quality. It has now replaced the Fuerte as the standard of the industry by virtue of an increased supply around the calendar, with harvesting during ten months of the year.

In any discussion of avocados, it should be noted that while the lion's share of production is in San Diego County, there are significant volumes of fruit produced in Ventura, Santa Barbara, and Riverside counties, with lesser amounts produced in Orange, Los Angeles, San Bernardino, San Luis Obispo, and Santa Clara Counties and in the San Joaquin Valley.

Florida's avocado industry, an important factor in avocados that are marketed east of the Mississippi, must be reckoned with. In recent years, Florida avocados, which are still known as "alligator pears," have come into the California market because of their successful lawsuit against the law requiring California avocados to contain 8% oil at maturity, which had formerly excluded Florida fruit. The Florida growers, who use dates and fruit sizes rather than oil testing to determine maturity, are particularly pleased to bring their fruit into California in the late summer and fall period when returns are historically higher. Florida operates under a federal marketing order. Californians traditionally have had little fruit during that time slot. At the present time, that picture has changed because of the increased plantings of Hass in the Santa Barbara and Ventura regions.

California growers are interested in avocado production elsewhere in the world where avocados can be grown, but there seems to be a large domestic demand for resources in those countries.

The largest packer and shipper "Calavo," a cooperative, was created by the California Avocado Association about 45 years ago to tackle the job of marketing their members' fruit and has been a leader in the industry ever since. In most recent years, Calavo has controlled about 50% of the California avocado production.

For those readers who may be historical buffs, the William T. Horne Memorial Library in the Agriculture Library on the campus of the University of California at Riverside, has enough avocado reports and articles to keep the fan amused for many a long winter's afternoon. The library was named for an early avocado researcher.

The San Diego County segment of the industry has been blessed in many ways -- good soil and climate conditions and imported Colorado River water - but also in a personal way, by the outstanding contribution of our Co-operative Extension Farm Advisor, Don Gustafson. This writer has the good fortune to have had a most cordial relationship with him in excess of twenty years. He has diligently monitored the ebb and flow of the industry in his more than 30 years of service to growers.

I recall a remark Don made at the 1962 Avocado Institute meeting in Fallbrook after some low return years for growers. He felt that "ours was not a dying industry," and offered strong words of encouragement when they were most needed by the industry. He has always provided the kind of support appreciated by growers. For the proof of his statement, we have only to reflect on the vast acreages of newly developed lands in the Lilac, Valley Center, Pauma Valley, Rainbow, and Fallbrook areas. If this proof is not enough, it is a simple matter to gaze over the county line into Rancho California in Riverside County for even more potential production of avocado. Don knows the growers are grateful for his efforts by the kudos that have come his way. It might not be unreasonable to suggest that he is at least the midwife, if not the father, of drip irrigation for avocados in California -- to the benefit of all.

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CHAPTER II
GROVE DEVELOPMENT

As we view new plantings of avocado, we find at least two types of grove ownership: (a) investment for speculation, often under limited partnerships, where some partners may never see the land or the grove and, (b) small ownership, where the owner plans to retire a few years down the road. The owner sees the raising of avocados as a way of life and may dream of going out into his grove at night just to listen to the trees grow. It is to the latter owner that the following is addressed.

Before entering the avocado industry, one should examine the economic trends of the industry -- especially before land acquisition takes place. Pamphlet material is readily available on this subject and on many other facets of the avocado industry through the Farm Advisor's office in the various counties or through the Cooperative Extension, University of California, Berkeley, California 94720.

Also, there are many fine orchard development companies that would be happy to review the industry for the prospective grower. In San Diego County, the farm advisor has made himself available through office days, ranch calls, newsletters, and avocado schools for the dissemination of useful information to the neophyte as well as the seasoned grower.

CLIMATE

Climate is probably the most important factor involved in growing avocados. There may be ample water and the best soil, but without suitable weather conditions the avocado will not grow. It is rather demanding in its requirements of heat and cold and does not tolerate extremes of either. Coastal areas, with their relatively small diurnal temperature range, provide the tree with just what it wants. As we move progressively further inland, conditions become less inviting for tree growth. Temperature fluctuations are greater, winds may be damaging, and water losses greater due to these factors. In short, avocados will not grow and produce successfully in desert areas where it is too hot or in low-lying areas that get too cold.

Cold air drains down slopes the same as water does and comes to rest in the lowest point, after which time it accumulates, and as the cold layer gets deeper, it slowly progresses up the slope. The point where equilibrium is reached between the dense, cold air at the bottom and the warmer air from above is usually the frost line. Avocados will grow above this frost line, but below this line they will be subject to occasional freezes and will not produce crops on a regular basis, though the tree may survive. When choosing a site, it is necessary to have a slope long enough that the air will continue to drain away below the trees and thus pull warmer air from above to offer frost protection. The further inland one goes, the higher the altitude must be to provide adequate air drainage. The ideal grove site in northern San Diego County would be situated at about 750 to 1500 feet in elevation with good air drainage on all sides. The most favorable exposure would be to the south or the west to avoid the damaging Santa Ana winds that can literally blow the fruit off the trees and sometimes blow the trees over as well.

No matter how carefully we may select a piece of land by looking at its physical features, there is no substitute for placing thermometers on the piece in question to give an accurate indication of its frost, or lack of frost, potential. To do this one should have several minimum registering thermometers placed in areas where the cold is most apt to settle, part way up the slope and at or near the top. The thermometer must be protected from the direct rays of the sun by a box-like cover, usually made of wood. It is mounted on this frame with a screw through the hole on the left and a small screw or nail on the right. This screw is placed where the right end of the thermometer will rest on it at an angle slightly higher than horizontal. To reset the thermometer, the right end is removed from the nail and lowered until the black marker falls to the ambient temperature at the time of the reading. Thermometers should be read and reset no less than once a week and a record made of the low point reached during the week by each thermometer at its location. These records may later be compared with a known area where records are kept to determine how much warmer or colder your spot is. To get an even more accurate picture, a thermograph can be used to register the duration of the cold. Thermographs are quite expensive, whereas the low cost minimum thermometers would provide accurate enough information for grove selection.

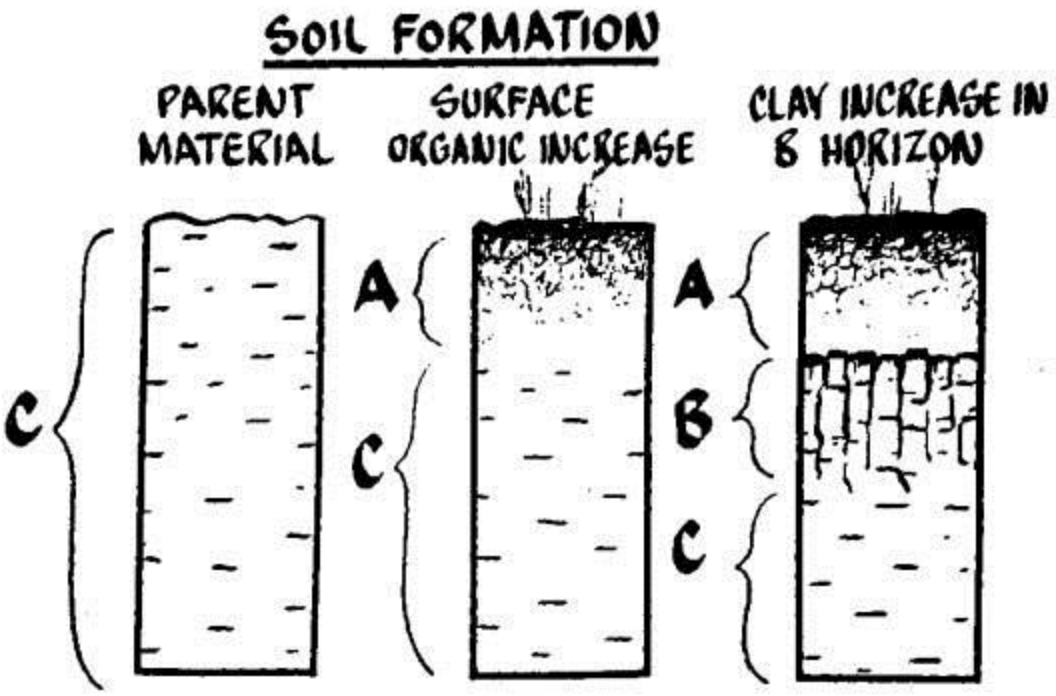
It is important to remember that the avocado is native to tropical regions and that it is being grown in southern California under conditions that are marginal at best. In our arid to semiarid climate we must, as nearly as possible, try to provide the missing elements found in the tropics. By doing so, we can make the tree feel more at home and coerce it into producing crops for us.

WATER

An adequate water source must be provided for the avocado, which will not produce in our arid to semi-arid climate without it. The source can be a well or wells located on the property and developed by the owner at his or her own expense. If the property is located within a water district, the district line should (although it may not always) run to the edge of the property with a water meter owned by the district. It is up to the property owner to run distribution lines from the meter to water his trees. The water should be delivered to the meter in adequate amounts and pressures and be of suitable quality. There should be no more than 700 parts per million (ppm) of total dissolved solids in the water.

SOIL

Soil is formed from the underlying rock by weathering, which may include wind, rain, heating and cooling of the rock, stream abrasion, and in northern areas, freezing, thawing, and glacier action. As the roots of plants decay, chemical action takes place to dissolve the mineral particles and the roots themselves break apart rocks and hard soils into ever-smaller pieces. Soils may occur in a wide variety of colors from black to white and everything in between. They may form in place (residual soils) or may be transported from their place of origin by wind or water (depositional soils) (Fig. 1).



The earliest distinct layer to show up in a recently formed soil is a dark-colored zone that extends downward for several inches from the surface. The dark color is due to the accumulation of well-decomposed organic matter, or humus. A few percent of humus can turn a light-gray or brown soil almost black. More humus is found in soils: 1) in cool climates than in hot climates; 2) in wet climates than in dry climates; and 3) under grassland than under forest. The humus-containing layer forms part of the "A" horizon of soils. It may develop in a few decades.

Young soils usually have "A" horizons and "C" horizons, which consist of loose or weathered rock material, but no "B" horizon. If they are residual soils, they will also have an "R" horizon of unweathered rock. If the soils are depositional, the "C" horizon will extend indefinitely into the loose material. "B" horizons form very slowly in soils that are on stable land positions -- i.e., they are neither being lowered by erosion nor raised by deposition. A "B" horizon is an accumulation of clay in a layer beneath the soil surface. It builds up as the result of: 1) the downward movement of fine particles by percolating water; and 2) the formation of new clay particles due to chemical reactions in the soil. Such an accumulation of clay takes thousands of years. Often the clay layer forms a barrier to water penetration and root growth so that these old soils are less well adapted to plant growth than young, deep soils.

Figure 1.

As soils break down and plants grow in them, changes take place in the appearance of the soil. The upper layer is composed of soil particles made up of not only the minerals, but also of all kinds of living and dead soil organisms such as bacteria, fungi, and plant matter in all stages of decay. This humus content seldom exceeds 5% and in most western soils is nearer 1% to 2%. As soils develop, they are classified by layers called “horizons.” Several of these horizons make up the soil “profile.” These horizons are further designated as A,B, C, and R; A has the most humus at the top and R is the underlying rock (Fig. 2).

SOIL PROFILES

Soils are the product of partial weathering of rocks, but weathering continues in the accumulated soil. A number of changes slowly occur, giving *rise* to more or less distinctly visible layers below and parallel to the soil surface. These layers are called horizons and the sum of all horizons for a soil is called its profile. Soil horizons are designated by the letters "A," "B," "C," and "R," going downward from the soil surface. Each lettered horizon may be subdivided, if necessary, by numbers and subscript letters. Not all soils have all the lettered horizons.

Figure 2.

Soil is composed of three sizes of particles: sand (the largest), intermediate silt, and clay (the finest). The capacity of the soil to hold water and air is dependent on the particle size. Sandy soils have a low water holding capacity but good aeration, and clay soils hold water well but are poorly aerated. Soils with a high humus content have a more nearly uniform water capacity and aeration, regardless of the particle size (Fig. 3).

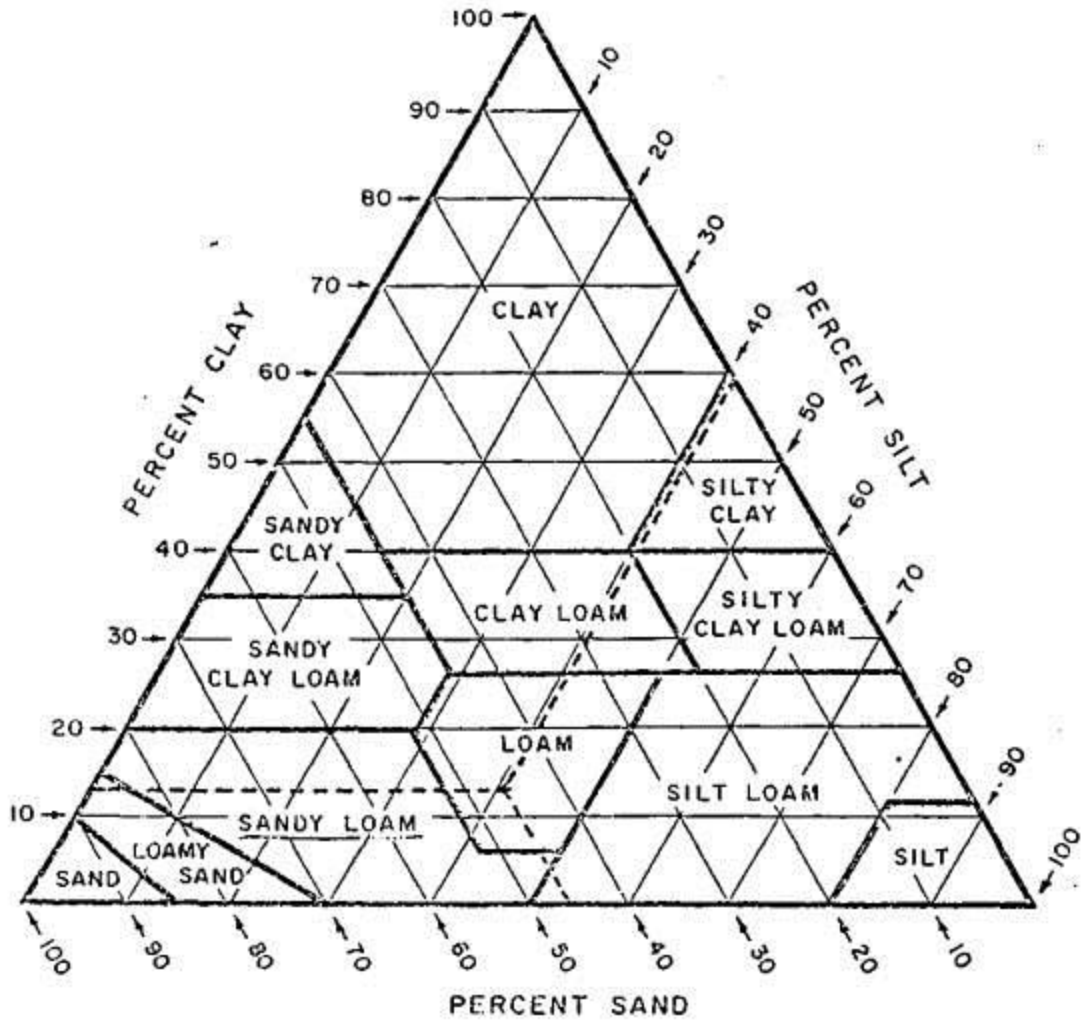


Figure 3. Soil textural triangle. The percentages of sand, silt, and clay in any soil may be plotted on this diagram to determine the textural class of that soil.

It should be noted that the accumulation of well-decomposed organic matter typically found in the upper horizons of soil (humus) contains many nutrients known to satisfy the needs of plants. Avocados enjoy an environment high in decaying matter in the root zone; for adult trees, mulch from fallen leaves is often sufficient, but for younger trees, growers may need to add mulch.

The percolation of water through a humus soil permits plant roots to extract moisture and nutrients more efficiently, and humus tends to act as a reservoir of soil moisture for the benefit of the plant. The percolation affect is usually referred to as water infiltration. A well-drained soil would have a high rate of infiltration.

TABLE 1

SOILS AND AVOCADO ROOT ROT DAMAGE

ROOT ROT HAZARD RELATED TO SOIL SERIES

SEVERE HAZARD		
Aliso	Huerhuero	Rocklin
Altamont	Madera	San Joaquin*
Bonsall	Merriam	Santa Lucia
Cibo	Milpitas	Sespe
Clear Lake	Montezuma	Sweeney
Cometa	Olivenhain	Tierra
Diablo	Placentia	Twin Oaks
Dublin	Porterville	Watsonville
Escondido	Rincon	Zaca

MODERATE HAZARD		
Ballard	Las Posas	San Andreas-Tierra
Botella	Naciamento	San Benito
Carpenteria	Ojai	Sobrante
Chino	Pleasanton	Soper
Conejo	Ramona	Zamora
Fallbrook	Salinas	

SLIGHT HAZARD		
Baywood	Marina	Vina
Elder	Metz	Visalia
Greenfield	Mocho	Vista
Hanford	Sorrento	Yolo
Honcut	Tujunga	

* If hardpan is properly ripped this soil has only moderate hazard.

Avocados will grow in many soil types, but for best growth and production the soil should be medium textured to provide good aeration. Avocados have a shallow root system, but there should be at least 3 to 4 feet of soil over a preferred granite base. In San Diego County, such suitable soils are classified as Cieneba, Fallbrook sandy loam, Vista sandy loam, and Escondido fine sandy loam with preference given to Vista sandy loam (see Table 1). Growers can easily observe the profile and depth of the soil where there are road cuts, because roads will most often bisect the areas to be planted.

The previously mentioned soil types will generally have a near neutral pH between 6.5 and 7.5, which is optimum for best avocado growth and production. pH is a chemist's symbol that expresses the degree of acidity or alkalinity of a substance on a scale of 1 to 14, with 1 being most acid and 14 most alkaline. Neutral is 7. Each number is 10 times more alkaline than the one below it or 10 times more acidic than the number above it.

In summary, the three essential growing conditions for avocados are:

1. Relatively frost-free land;

2. A well-drained soil with a near neutral pH; and

3. Adequate water of suitable quality.

Land Selection

When the economic questions have been resolved, the location of suitable lands is the next order of business. This is probably best accomplished through the employment of a real estate broker and consultation with specialists from the Soil Conservation Service, U.S.D.A., who can offer expert knowledge on the suitability of lands (Fig. 4).

Since the advent of drip irrigation and the higher cost of land, growers have been planting on steeper slopes than they formerly had. Regardless of the slope, provision must be made for working the ranch and for the removal of fruit. There are some clear advantages to a higher elevation and steeper slopes because they are apt to be warmer and have soils that drain well. Therefore, steep slopes should not be viewed with dismay, though without careful planning of roads and access, maintenance and harvesting could present major problems. It should be kept in mind that many ranches are successfully managed on less than perfect lands, but may require more of everything in the grove manager's bag of tricks.

Poor quality
Figure 4. Soil Conservationist Sam Aslan holding his soil-coring tool "John Paul".

LAND PREPARATION

Land Clearing By Machine

Brush removal by machine is usually performed on gentle slopes by using a bulldozer blade, discing, or mowing with a heavy-duty mower. Many growers want the land ripped 18" to 36" deep to break up the old gopher runs, allow better water penetration, and bring to the surface any rocks or roots that should be removed. Ripping also permits growers to see what is underneath the surface, such as clay pockets that need to be identified.

Avocados do not like "wet feet" and clay, with its slow drainage, would surely create an unsatisfactory condition for tree growth. After ripping, the land should be floated (smoothed). This produces a polished land preparation job that will permit easier future maintenance of the grove.

Land Clearing By Hand

If the slope is too steep or too rocky for clearing with mechanized equipment, native brush can be cut to ground level with hand tools such as machetes, axes, saws, and brush hooks. Hand clearing tends to be more costly than machine brushing and has the inherent difficulty that the brush may regrow and have to be removed again later, increasing future grove care costs. On the

other hand, the remaining roots will stabilize the soil for erosion control. In the past, brush that was removed was placed in windrows and burned, but because fire burns very rapidly in the windrow, it may burn out of control and damage adjacent property. Burning is much easier to control and less likely to cause damage if the brush is placed in a series of separate piles that can be burned one at a time. Sometimes brush is piled in ravines and permitted to decompose. This practice invites an infestation of rats, squirrels, and poisonous snakes by providing protected home sites for them.

Runoff occurs when storm or irrigation water exceed the soil's capacity to absorb them. This can be responsible for severe erosion and grove damage (Fig. 5).

Erosion control on newly opened land should be carefully considered because winter rains can be very destructive. Common practice and prudence dictate that all buried main lines and submain lines be carefully covered with straw to reduce erosion damage. Likewise, swales, barrancas, and other potential trouble areas should have a similar straw treatment for the same reason.

Poor quality
Figure 5: This newly planted grove has been ravaged by a deep ravine from an unexpected summer rainstorm. Erosion control must be considered even during the dry months. However, all is not lost since the ravine may now be used as a bed for drainage pipe to carry away future floodwaters and irrigation runoff.

Some steep hillsides may require straw for the entire cleared area at the rate of 2 tons per acre. Straw is suggested because it is apt to be relatively inexpensive and is an easier material to use (Fig. 6).

This writer remembers vividly the damage done on his neighbor's land on two successive wet winters in spite of the good preventive measures taken to reduce the problem. The key word in the use of erosion control materials is "liberal," because our crystal balls for determining weather do not usually work well. If the erosion control measures are taken late in the year, it may be desirable to sow barley before strawing, as well as in unstrawed hazard areas. This work should be done by hand. If the acreage is large enough, it may be more economical to sow the seed by aircraft. Ideally, the winter rains will germinate the seed, providing the desired growth for protection.

Poor quality
Figure 6: This young grove is well mulched with plenty of straw to prevent erosion. Despite a 2½" rain storm in August 1977, the ground remains unscarred by erosion. This grove is off to a good start. As the straw decomposes around the young trees, it should be replaced to maintain mulch.

PLANNING CONSIDERATIONS

It is in this stage of development that the long range detail planning takes place. Decisions made now will affect the ranch for years to come; therefore, it is important to anticipate future needs. Some of these considerations are noted as follows.

Flood Waters

There may be problem areas necessitating the drainage of floodwaters from rain and sprinkler tail waters. There are contractors who specialize in this work, and planning for it in the early stages of development is often beneficial to growers. Most growers prefer the type of control that has an underground drain line, usually of concrete tile placed in a barranca, with control dams and drop inlets spaced strategically the length of the drain line.

A swale, or marshy low-lying area rank with vegetation, is occasionally found in avocado growing areas. A swale is gentle in slope, contrasted to steeper canyons, and is likely to be filled in during the land preparation phase. These areas should not be planted with avocado unless suitable drain lines are installed to make the land usable. A marshy area, also called a loblolly, is often an indication of a nearby spring and the soil may remain waterlogged year-round without sufficient root aeration. In wet years, flood waters may remain in the area and kill the trees when their roots do not get the oxygen they need and simply rot away.

Bee Locations

Bees are important in the pollination of the avocado and ideally should be located in the interior of the grove. Like humans, bees are lazy. Avocado blossoms are the last choice for a bee because it would rather be out in the citrus or native brush seeking a lighter kind of nectar. If bees have to go through the avocados to reach the flowers they do like, they do a better job of pollinating the avocado trees.

Beekeepers like to have an all-weather road to the hives' location to accommodate their large trucks (Fig. 7). These locations should have sufficient space for the bee boxes to be worked on both sides of the truck. For your future crop, you will need the apiarist more than he will need you, so it would be wise to provide a situation to his liking. Beehive locations should be at least 700 feet away from a dwelling to satisfy the members of the household as well as the bee inspector.

Poor quality
Figure 7. Beehives should be located on an all-weather road to provide access for the beekeeper to manage the hives.

Leach Fields

If you plan to build a home on the property, provisions will have to be made for the home site and its associated septic leach field. A consultation with an architect or builder would be in order at this point.

Fruit Removal Systems

If land is steep, give some thought to the picking and removal of fruit from the grove. Regrettably, at this writing, solutions to this problem have not crystallized in the industry. There have been tests utilizing helicopters, mules, and burros, and all leave something to be desired. However, an avocado harvesting committee has been active in seeking an answer to this vexing question and we await further reports from them.

The following suggestions are mentioned for possible consideration and incorporation into the ranch plan.

B. W. "Bud" Lee, Ventura county farm advisor, has introduced to us an interesting idea practiced in the Japanese citrus industry that may have merit. The Japanese have been using a permanently installed monorail system with a gear rack on the under-side of the rail to which the pinion gear of the motor unit is engaged. The rails are of galvanized steel measuring about 2" square, upon which the power units are mounted in such a way that the car can be detached and moved to another rail elsewhere in the orchard for further movement of fruit.

The engine itself is a 3 to 4 hp., air-cooled, two cycle type common in the U.S. The rails are tailored to fit the terrain by bending the rails to fit at the site and can match very steep lands. On 55% slopes, the monorail can carry 330 to 440 lbs. moving at 55 feet per minute. Trailers, usually measuring 2'x 6', are added to carry the fruit.

Kicker-arms are mounted on the rail supports so that that the motor unit can be stopped at any predetermined point by striking the clutch handle on the unit, thus disengaging the power. The systems are reported to be remarkably stable and operate without swaying, wobbling, or falling off the rail. Costs for these systems in the U.S. are still being studied.

On steeper slopes, footpaths running horizontally between the tree rows have been useful for fruit removal and other cultural care activities. Such paths can be hand dug or formed by a special Japanese machine designed for that purpose.

Some growers have found it advantageous to terrace their steep slopes by machine and plant on the outside edge of the terrace. This method permits grove work to be performed more easily than on footpaths.

Two young engineers in the Escondido Area, Chuck Cawley and Vic Roberts, recognized the fruit removal problem of steep slopes and have advanced a canvas chute system. Picked fruit is funneled into a chute that moves the fruit down the slope and into the waiting bins without bruising the fruit. The chute provides a direct route for fruit from the picker's bag to a fruit bin or field box at the bottom of the slope. This system permits the relocation of the chute and its supporting frames from one point to another within the grove. Anchors on the high and low ends of the setup are the only permanent part of the installation. It is the belief of the writer that this system will offer the most efficient service at the most economical price of any of the arrangements now on the horizon, but the future may bring us better systems.

In the mid 1970s Dick Markano of Fallbrook began developing and marketing the "Agri-Tube" as a modern method of hillside harvesting. It is said to be a cost effective way to remove picked fruit from slopes above 20° (36%) by increased worker productivity.

The Agri-Tube operates as an inflated zigzag tube that guides picked fruit, by gravity, from the picker's bag to the bin in an undamaged condition.

The Agri-Tube is stored on a reel, mounted on a small trailer that can be towed to an uphill location. Because of its lightweight and lack of frame or anchors, it can easily be rolled down the slope to a ranch road and bin. A small gas-powered compressor fills and maintains air pressure in the tube until it is ready to be rolled up on the reel and moved to another location.

A word of caution when picking thin-skinned varieties such as Fuerte, Bacon, Zutano, and Covocado: the fruit should be dry -- no fog or light mist. When these classes of fruit are damp, they pick up a burned or "toasted" appearance from handling and motion in the picking bag that may tend to downgrade them.

Work Areas

All orchard operations require practical and usable work areas. Growers will need underground fuel storage, fertilizer storage, bins and field boxes, and parking areas for vehicles along with covered areas for mechanical repairs and servicing. Buildings used for storage should have locks, as theft can be a problem in unsupervised areas. The use of helicopters for orchard spraying is becoming more common and a helicopter landing pad big enough for the helicopter and its attendant servicing equipment may be necessary.

Ranch Roads

When land has been cleared so that it is possible to see what the terrain is like, an experienced tractor operator will be able to cut in the ranch roads to fit the terrain. Aside from roads to a home site and to bee spaces, ranch roads will take on more importance to the working ranch as the years roll on. Three tree rows between ranch roads should be a minimum. The actual number of rows between roads will depend on the steepness of the terrain, with more roads on the steeper slopes. Growers generally feel that there should be no more than six tree rows between ranch roads, and that a perimeter road is necessary as well (it can act as a fire break). Fire is always a threat to an avocado orchard. Because there is apt to be much fuel in an orchard, it would be prudent to clear barrancas of brush for additional fire protection. Perhaps negotiations with neighbors for a firebreak on their undeveloped lands would be advantageous.

Ranch roads can become washed out where they cross drainage channels. Runoff from natural rainfall and from irrigation water should be channeled through culverts under the road and into catchment basins to prevent erosion. If possible, the culvert should extend well past the edge of the road before the water begins its fall to a lower elevation.

Steve White, a grove manager in (city), has been doing something interesting in his own grove by planting what he calls a citrus barrier along the outside edges of his ranch roads. The theory

behind this practice is that citrus roots seem to repel the avocado root rot fungus and thus bring a measure of control should infection ever get started in the grove. Bearss lime on macrophylla rootstock seems to perform well as a barrier and also provides a good crop of limes.

Other Amenities

Other amenities include access roads or a public or private roadto the property, because fruit will have to be hauled out someday. While electrical service may not be essential to the performance of the grove, it is certainly useful for wind machines, pumps, irrigation timing devices and housing for the owner and workers.

If the owner intends to live on his or her ranch, some consideration may also be given to the proximity of schools, churches, recreational areas and shopping centers. Telephone service, good radio and television reception, and fire and police protection are important to the city dweller, but are also important to the farmerin an ever-greater degree. Strictly speaking, these aspects have nothing to do with whether you have a successful avocado grove, but they will certainly make living in the country more pleasurable and add to the quality of life.

LAYOUT

Like the blueprint for a building, the layout plan shows the location of ranch roads, soil types, home site, bee spaces, work areas, irrigation system, possible water, electric, gas, septic tank, or sewer lines, wind machines in cold spots, and the placement of specific tree varieties best suited to the soil type and microclimate. It may also show plans for a future fruit removal system. It is here that the rough farm plan and costs start to take shape.

Orchard Layout

Groves are commonly laid out in irrigation blocks, and within the blocks trees and irrigation lines are set out as nearly horizontal as possible to reduce water pressure problems. Tree rows are established along these horizontal (lateral) lines with the distance between rows varying according to the tree variety. Where there is a choice on northern or eastern slopes, the 20' dimension (the distance between roes) should run north and south to permit maximum sunlight in the aisle and to let the cold air escape more easily.

Parts of the land may be cold enough to warrant the use of the Bacon variety, one of the most cold resistant varieties. Other parts of the land may be warm enough for Hass or Reed varieties.

The choice of variety will determine the number of trees needed per acre and will have an effect on the ultimate costs.

You should discuss with your nurseryman the relative merits of tube-grown trees versus field-grown burlap-balled trees, keeping in mind that from seed to 30" nursery trees, it is a 14- to 24-month process. To insure a supply of trees at the proper time, arrangement should be made early with your nurseryman. Nurserymen usually ask for a deposit to grow and hold your trees for you.

Tree Shape

In avocados, tree shape must be considered when planning for spacing in a grove layout. For example: Fuertes tend to be spreading while Hass are less spreading, and Bacon, Zutano, Covacado, and Reed are upright in their natural growth (Figures 8, 9, 10).
After the variety has been selected and tree spacing has been determined, the tree locations can be marked with a short wooden stake to develop the grove layout plan. The top portion of the stake can be dipped in a can of brightly colored paint to improve visibility.

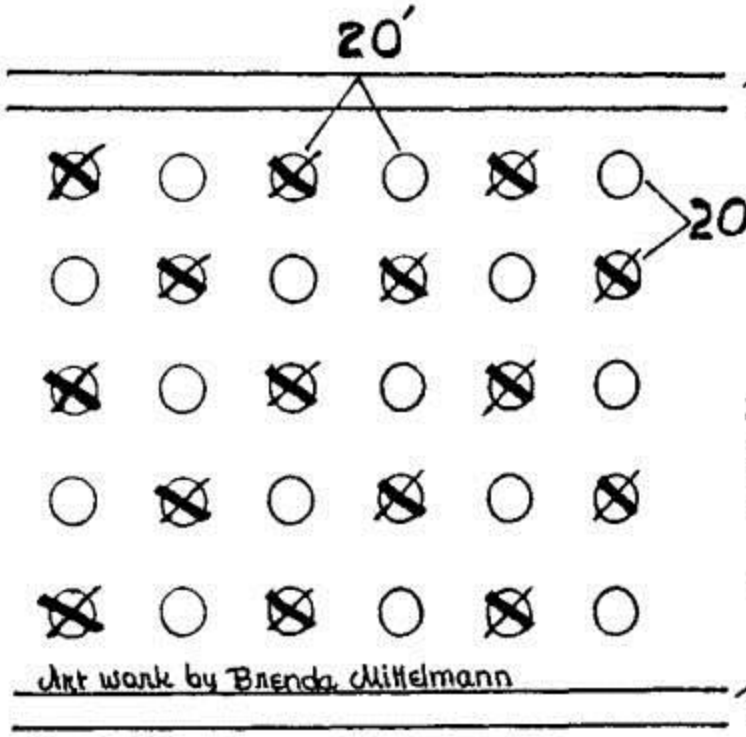


Figure 8

○ Fuertes

⊠ Zutanos

20' x 20' for Fuertes with Zutanos on alternate rows diagonally. 100± trees per acre.

Art work by Brenda Mittelmann

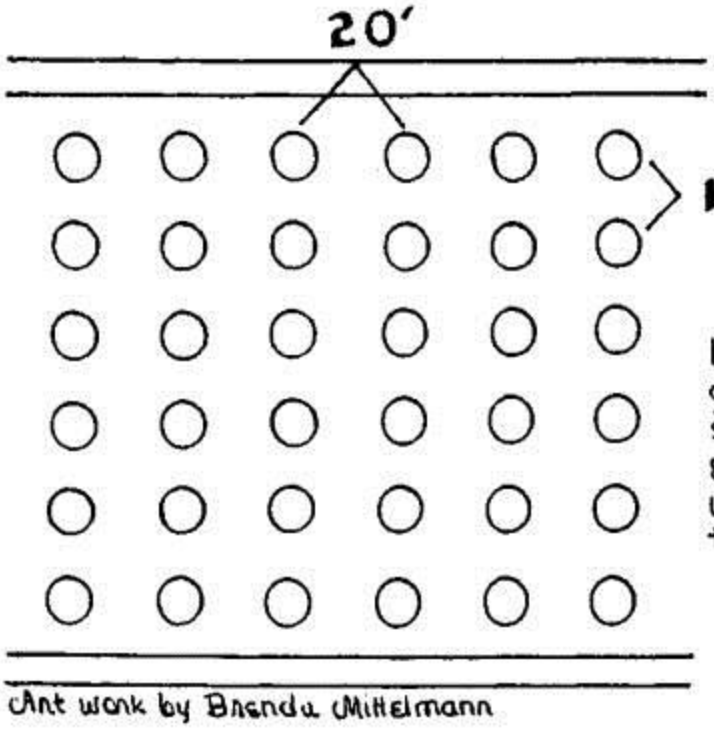
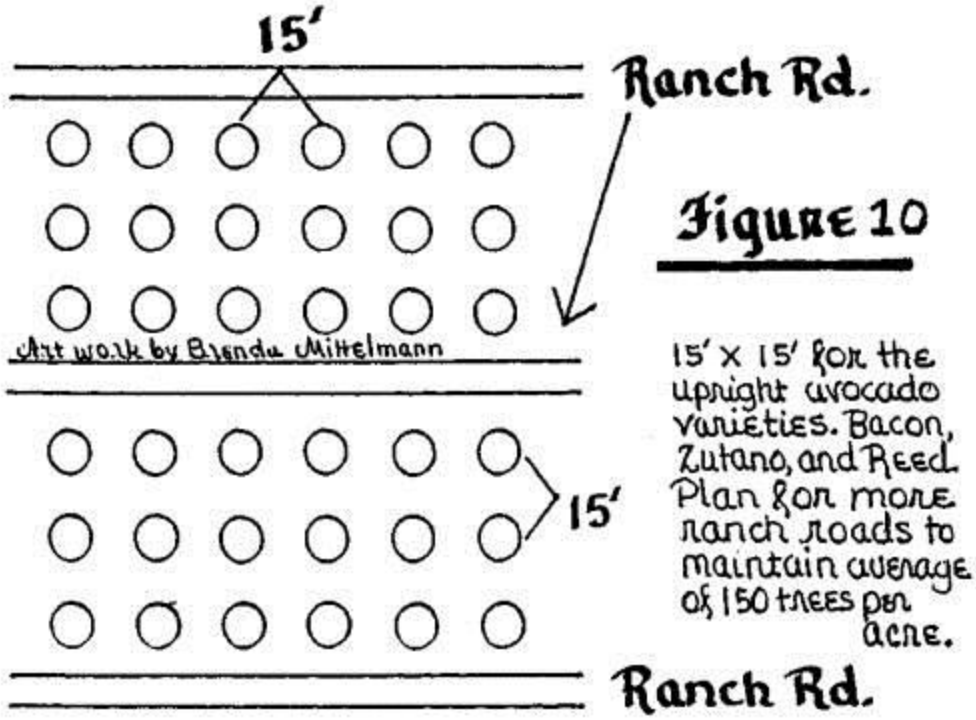


Figure 9

15' x 20' for Hass groves. 20' dimensi should run north-south to permit winter sun to warm the land. 135± trees per acre.

Art work by Brenda Mittelmann



IRRIGATION SYSTEMS

Irrigation systems are usually laid out in blocks, a block being the amount of land that can be irrigated at one time. This is known as a "set" and is the largest area that can be irrigated using the available water pressure and volume. Using a sprinkler system in a mature grove, with trees irrigated by Star or impact type sprinklers, a set is approximately one acre. Under drip irrigation, with 8 emitters per mature tree and with a 2" meter, a set may be as much as ten acres due to the slower rate of water application.

Choosing an irrigation system in the development of new land should pose no major problem for owners who are new to avocados. The choice of either a drip or sprinkler system can be defended. The accompanying comparison chart reveals some of the advantages and disadvantages of the two most widely used systems (Table 2). There are many component items on the market today and your development designer will be able to recommend the combination best suited to your land.

Sprinkler

The sprinkler or standard type irrigation system is an arrangement of main lines, sub-main lines and lateral lines with their associated valving. Each tree has its own riser to which the sprinkler is attached. The piping is made of polyvinyl chloride pipe and is cut, welded with solvent, and

buried in trenches at the grove site with usually only the risers showing above ground. For lateral lines, assembled ½" PVC is literally pulled into the soil by a device attached to a track laying tractor, leaving a riser in the proper location for every tree. This homemade implement opens the ground, inserts the pipe with attached fittings and backfills the trench in one pass. The equipment is capable of installing almost 5 miles of laterals per day.

Sprinklers come in three basic categories: spitters, revolving, and impact. These come in different orifice sizes to apply given amounts of water at a given pressure over a definite-sized water pattern. After long use, the sprinkler orifices may become enlarged by the wear of foreign material in the water and may require tip replacement.

Young trees are normally started using ¼ circle spitters. As the trees become larger these may be exchanged for ½ circle, and later full circle, spitters and end with revolving sprinklers that provide full coverage of land with a diameter of 25'. Thus, the gradual increase in the irrigated area keeps pace with the growth of the root system over the years.

Table 2.
COMPARISON OF DRIP AND SPRINKLER IRRIGATION SYSTEMS

Drip Irrigation System	Sprinkler Irrigation
Advantages:	Advantages:
1. Fertilizer injector required which saves labor and material because there is little waste and uses smaller amounts of both.	1. Usually irrigates once a week.
2. Replaces moisture and nutrients frequently (to the trees' satisfaction).	2. Gives a chance to fight fire..
3. Entire drip system is usually cheaper to install with saving in pipe size and wall thickness.	3. Gives half a chance to fight cold.
4. Emitter hose attached to a buried lateral or surface hose with less breakage problems.	4. Easy and fast to check for correct operation.
5. For those who use their filtration setup properly there are important labor saving opportunities.	5. Easy to balance the system by changing size of tips or spitters, and adjust lateral valves.
6. Use less water - young trees may see savings of 75% and older trees perhaps 25%.	6. Could be automated and have a fertilizer injector.
7. Dry barriers between trees slow root rot fungus movement, should infection come onto the scene.	Disadvantages:
8. Routine maintenance usually confined to flushing ends of hose twice or three times per year.	1. More sets of water (usually about an acre per set) with one water meter, using more meter hours.
9. It is possible to irrigate more acres per set of water.	2. Sprinkler tips or spitter orifices wear oversize and need to be renewed.
10. Less moisture for weed competition in areas surrounding the tree. Less weed control necessary.	3. More opportunities to waste water.
Disadvantages:	4. Uses more water, therefore, more costly to use because of a larger wetted area.
1. No chance to fight fire or cold.	5. Systems are not apt to have a fertilizer injector so more fertilizer and labor is used with higher costs.
2. On most Avocado soils it will be required to irrigate at least every other day during irrigation season.	6. Usually has a rigid riser to each tree which is subject to damage and repair.
3. Without good filtration it means high labor costs to check emitter operations.	7. Under sprinkler irrigation Avocado trees tend to retain their shallow rooted characteristics and may become more vulnerable to tipping over in a wind storm.
4. May require expensive filtration equipment and attendant back flushing water disposal problems.	
5. Animals chew on soft plastic parts and hose and cause leaks.	

It has long been thought that mature trees of the spreading types like Fuerte and Hass transpire 40-60 gallons of water per day during the warmer periods of the year, and that growers should budget for 3½ acre feet per acre per year when applied by sprinklers.

We used to think "slow delivery" sprinkler tips with a .4 gallon per minute rate of delivery on each sprinkler arm or a .5 tip on one arm and a blank on the other were slow. By contrast, a drip emitter may deliver as little as ½ gallon per hour. As you can see, the opportunities to waste water by run off on sprinkler systems are rather sizeable. This fact, coupled with known and anticipated increases in water costs, makes planning for the most efficient and beneficial use of water crucial.

Drip

If you choose the drip approach to irrigation, a typical installation might resemble the following sketch.

The first California drip irrigation systems in avocados were installed less than ten years ago. The industry began by laying a drip irrigation hose on the soil (Fig. 12) surface next to the trunk of the young trees, and installing an emitter at that point. When the tree was in the ground about two months, an additional emitter was added about 3 feet away from the first emitter, with the hose repositioned in such a way that the tree trunk equally divided the two emitters.

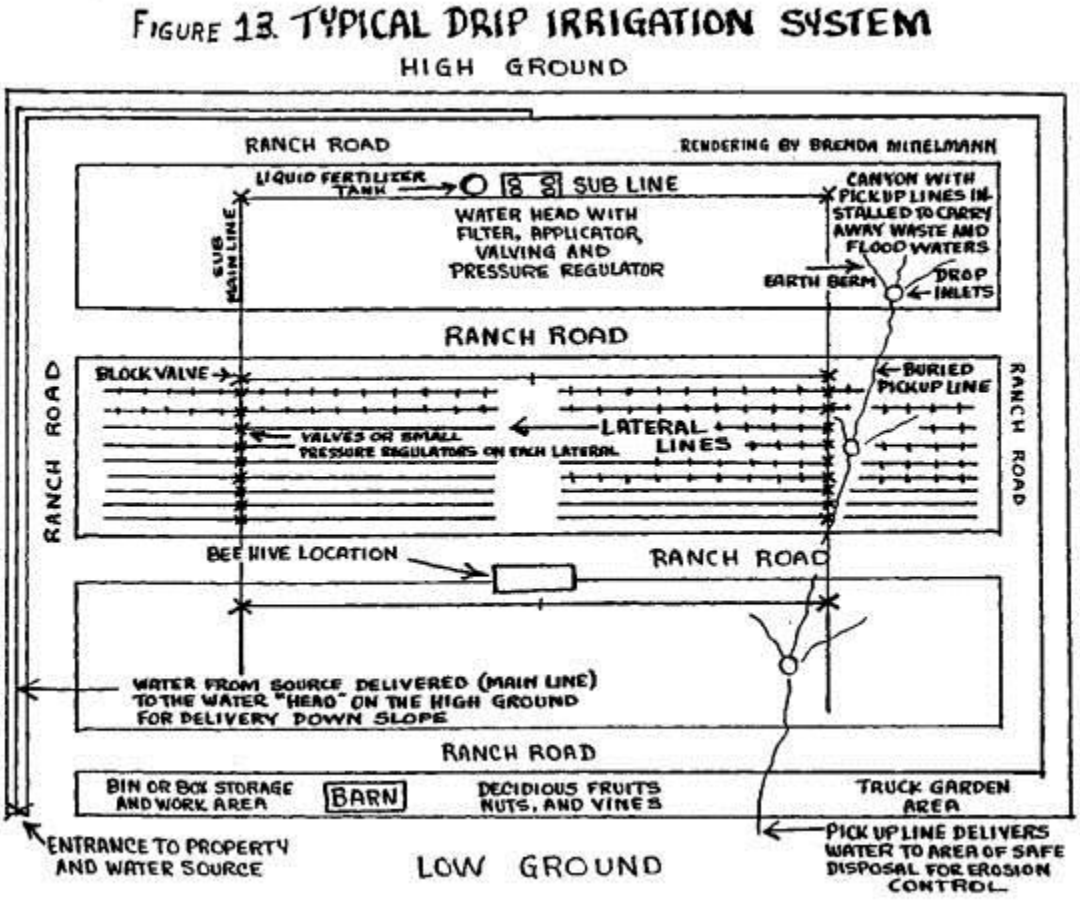
This plan envisioned that as the tree grew, additional emitters would be added to the surface hose and that perhaps there would be eight or more emitters by the time the trees reached adulthood. To accommodate larger trees, an additional surface hose line could be added on the other side of the tree with the necessary emitters, or a "pigtail" could be attached by a "T" to the original surface hose line. The pigtail would be placed near the tree drip line, which would be equipped with the additional emitters.

Poor quality
Figure 11. Young grove on spitters with no erosion control. Basins around trees will serve for the first few months but should be allowed to "melt" down before winter. Otherwise, basins may trap the cold around the bud union and damage or destroy the tree.

Poor quality
Figure 12. Close-up of a drip system. The hose coming off the riser is called a "pigtail." For newly planted trees, two emitters placed 3' apart on the pigtail are used. As the tree grows, the pigtail can be unwound with more emitters added at 3' intervals.

Later, buried PVC pipe laterals seemed a good idea, as in a sprinkler system. At each tree location, a riser came off the lateral to which an assembly of hose and emitters were attached. A drip hose assembly can be attached directly to the buried lateral. The reason for connecting to the buried pipe is that there could be less damage from future grove practices like picking or weed control.

Because of the nature of drip irrigation, use relatively low water pressures, typically 15 psi, on the tree rows. Correct pressure is sometimes achieved by installing a small pressure regulator on each lateral.



Poor quality
Figure 14. Obstacles are no obstacle when PVC hose is used for irrigation lines. The large, unmoved rock in the foreground is "overcome" by the flexible hose (right center of rock) allowing both the row of trees and spitters to continue in a straight line. This grower is using a spitter irrigation system.

Poor quality
Figure 15. Irrigation systems that are properly designed and maintained can offer a substantial cost savings in water and fertilizer. The system shown above is collectively known as a "water head" and consists of a water filter (the horizontal cylinder) with a removable screen for cleaning, an injector tank in which the fertilizing materials are placed and carefully monitored into the distribution line, and special valving to prevent back-feeding of the fertilizer in the water source line.

For the most uniform application of water it is desirable that differences in elevation along each lateral be less than 10'. However, in some circumstances, this problem can be relieved by the use

of pressure compensating emitters to equalize the water delivery between the high and low areas in a given line.

There are many variations of the drip system from which to choose (Fig. 15). Generally, the initial cost is apt to be cheaper than a sprinkler system, and it is expected that there would be important added savings in the water, irrigation labor, and fertilizing costs. With a drip system, there is less waste and more efficient use of moisture and nutrients by putting them just where the tree wants them. With a drip system it is mandatory to fertilize through the system.

Filters

Two sources of water are generally available for irrigation in most avocado growing areas -- water from wells or from the local irrigation district. Other sources might include spring or stream water, but these sources are rarely used. Regardless of the source of the water, it is usually necessary to filter it before it is introduced into the irrigation system. A filter is a device that separates foreign matter from the irrigation water before entering the system. In some situations where water may enter the system under fluctuating pressures, it is necessary to use a pressure regulator to equalize the pressure before the water enters the filter.

The most common type of filter is a screen of perforated metal varying from coarse to fine. Often two are used together, the coarse to remove the larger particles and the fine to remove the silt and algae. Filters must be removed from the filter tank and manually cleaned with a brush and a jet of water.

If water contains large amounts of trash and algae, it is often necessary to filter it using a sand filter first. The sand used in these filters is of uniform particle size. Sand filters are used in pairs but are connected so that either one or both may be used separately or together. These filters are back-flushed to remove the foreign particles by passing a stream of water through the filter in a reverse direction. The cleaned water from one filter is used to back flush the second filter and then the process is reversed to clean the first filter. A screen filter is often used in conjunction with the sand filters. This screen filter acts as a fuse does in an electrical circuit to assure that no trash enters the system in the case of failure of the sand filters. In newer filter systems, back flushing can be automated, but although this option is available to the grower, most systems are back-flushed manually. Some provision must be made to dispose of the water used in the back-flushing operation.

Where well water is used, it may be necessary to use a coarse screen filter as a sand trap to remove the larger sand particles from entering the system and clogging the sprinkler tips or causing excessive wear in the tips. The latter tends to enlarge the orifices, causing them to deliver too much water. The sand trap is installed at the well head as the primary filter. The accumulated sand must be periodically removed by hand from the trap.

With drip irrigation, it is mandatory to have a reliable filter system to clean the water so that it will not plug the small orifices in the dripper. When a sprinkler system is used, a filter system may or may not be essential depending on the cleanliness of the water source.

Fertilizer Application

When any type of liquid fertilizer is to be applied using the irrigation system, a holding tank must be provided either by the grower or the supplier of the fertilizer. When dry materials are used, a covered storage shed adjacent to the fertilizer injector is a necessary convenience. After the fertilizing materials are placed in the injector tank, a bypass system creates a pressure differential to actuate the injector with its associated valving, including a double check valve to prevent the fertilizer from flowing back into the potable water supply.

After the fertilizing cycle is completed, the irrigation lines should be thoroughly flushed with clean water to remove any trace of fertilizer. Nitrogen fertilizer residuals form nitric acid, which is extremely corrosive to the metal parts of the irrigation system.

Hot Line

Every ranch is likely to benefit from a hot line system in the grove. A hot line is a separate water line with risers and valves at strategic locations through the planted ownership and even into undeveloped areas. Such a line should be pressurized at all times so that water is available on demand. Usually these lines are part of the original irrigation system design and serve best when placed along internal ranch roads and in work or fruit storage areas.

Some beneficial uses of hot lines are:

1. Source of water for spray rigs.

2. Fire control.

3. Special application of irrigation water for problem areas.

4. Source of drinking water for field workers to avoid tampering with a functioning irrigation system by untrained persons.

5. Source of fogging water to precool harvested fruit awaiting delivery to the packer. In the summer and early fall, field heat that the fruit retain adversely affects its quality, but packers can ship precooled fruit much further away from the California market with confidence. The more fruit that can be moved away from local markets, the stronger grower returns are apt to be.

Tensiometers

If tensiometers are to be used in the grove, arrangements should be made at this time for their purchase. The locations where they are to be placed should be marked on the layout map. The use of tensiometers is discussed under the heading DETERMINING SOIL MOISTURE in Chapter III.

Soil Percolation Testing

Before actual tree planting begins, growers should check the new irrigation systems as well as the soil. With planting holes, testing water should be allowed to fill up the holes both to preirrigate and to determine if there are any clay pockets in the planting zone. If the water cannot percolate out of the hole in less than 24 hours under dry soil conditions, it had best be left empty or be used by some other plant such as citrus.

BOTANY

Botanically, the avocado belongs to the Lauraceae family, which is widely distributed and includes camphor, cinnamon, the California laurel or bay tree, and the eastern sassafras. It is in the genus Persea and the species americana, or Persea americana Miller. The species is divided into three distinct races; the Guatemalan, Mexican, and West Indian.

Brief description of the races of the avocado are as follows.

West Indian
Moderately thin, leathery skin, watery flesh with low oil content, fruits large to very large.

Guatemalan
Thick skin often with grit cells, medium to high oil content, fruits medium to large.

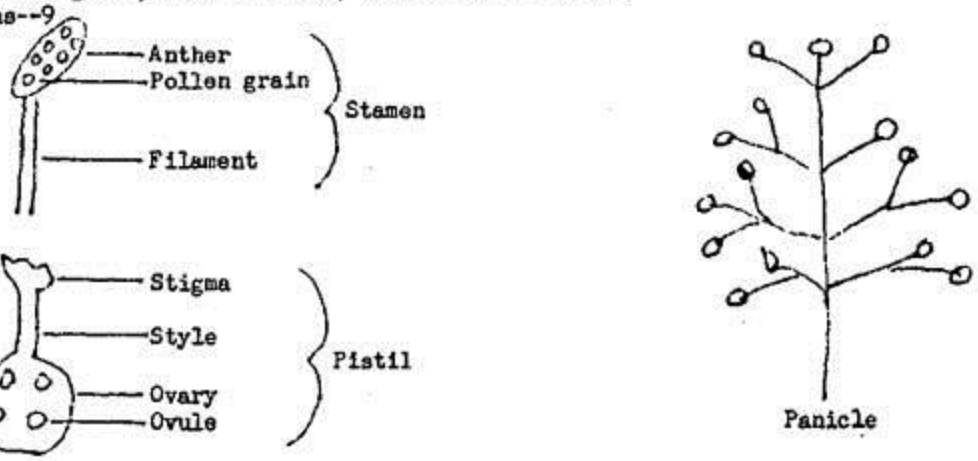
Mexican
Very thin skin, flesh buttery with high oil content, anise odor in leaves, fruits small to medium in size.

Flower

Perfect--has both male (stamens) and female (pistil) parts

Flowers pale yellow, borne in terminal and axillary panicles at end of branch. (Panicle has a single central stem with smaller stems branching off, each with one, two or three flowers)

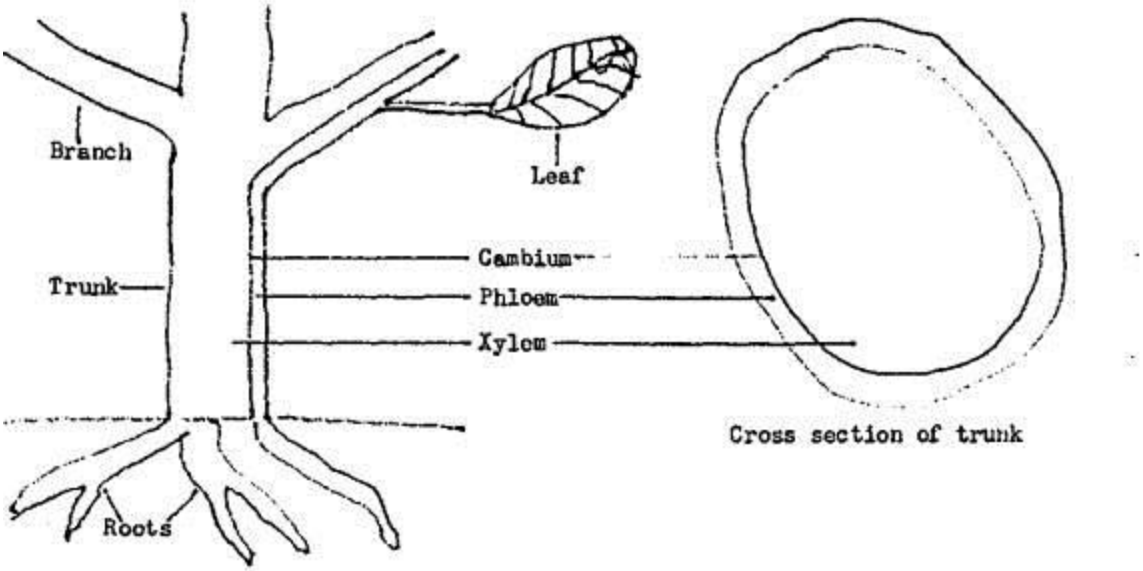
Stamens--9



Trunk, roots, branches and leaves

Phloem cells--inside edge of bark, distributes food manufactured by leaves

Xylem cells---woody portion of trunk, distributes water throughout the tree



The avocado tree is an evergreen subtropical with leaves that persist for several seasons. The new growth varies in color from wine to maroon on the different varieties and occurs in flushes. After a flush of new growth has terminated, there is a period of four to six weeks when the soft, new growth hardens off or matures and accumulates starches or food for the next flush. As the new growth hardens, the bark changes in color from green to gray. Seedling trees may grow to a height of 50 to 60 feet, but grafted trees seem to be somewhat dwarfed and may only attain a height of 20 to 40 feet. The rather inconspicuous, yellowish flowers are borne in panicles and contain both pistil and stamens (Fig. 16). The bearing surface of the tree is usually the outer

portion of the foliage that contains the stems or fruiting wood from which the flowers will emerge in the spring and, when pollinated, will become fruits.

The root system is composed of large, lateral roots that anchor the tree to a depth of 4' to 8'. From these emanate a profusion of feeder roots that extract nutrients from the soil and fill the soil to a depth of some two feet. They are most plentiful on the surface of the soil and here feed on decaying leaves. This feeder root zone can be clearly seen when leaves are raked aside, illustrating that the avocado is a relatively shallow-rooted tree.

RECOMMENDED VARIETIES

The West Indian is the most tropical and frost tender of the three races and is the variety grown in Florida. It has not been successful in California. The Guatemalan race is the ancestor of many of our early commercial varieties and of the Hass variety, which today dominates the market. It is tender to frost and must be planted in the warmest locations. The Mexican race is the hardiest of the three and has been used for many years as a rootstock for the more tender varieties since the air near the ground is the coldest and a hardy rootstock will not freeze as readily. It can be identified by an anise (licorice) odor in the leaves when they are crushed. Both Bacon and Zutano varieties are considered to be of Mexican origin. The Fuerte is considered to be of hybrid origin as a cross between the Guatemalan and Mexican races.

The ideal avocado varieties for commercial production in California have not yet been found. Growers have sought that elusive perfection since the turn of the century. Those ideal varieties would have the following qualifications: uniform size and appearance, fruit that ships well with a good shelf life, regular production of fruit that has consumer and trade acceptance, trees with fruit that can tolerate temperatures into the low twenties, and fruits that mature in quantity and are available for the market year around. While this ideal may not be attained in the immediate future, it can be used as a guide.

Fuerte

This variety, found by Carl Schmidt as a dooryard seedling tree in Atlixco, Mexico in 1911, has long been the standard of the California avocado industry and is referred to as a fall and winter variety. The tree is large and spreading and intermediate in its cold resistance to about 27°F. The fruit is green in color, pear-shaped, 8 to 14 ounces in size, and of very high quality. It performs best away from the coastal influence but not in the hot interior growing areas. Although good crops are produced regularly in a few areas, yield generally tends to be erratic in most of the areas where it is planted. Individual trees in a grove may produce good crops while many may produce little or nothing. The suggested tree spacing is 20' x 20' to be thinned as they crowd.

Fruit is said to be "set" when the flower has been pollinated, most frequently by bees. For pollination to be effective, nighttime temperatures need to be 50°F or above and daily average temperatures 70°F. In addition, conditions should be favorable for good bee activity to transfer the pollen from one flower to another. The Fuerte, our problem variety, is known to set better crops when interplanted with varieties such as Covocado, Jalna, Topa Topa, and Zutano, which have "A" type flowers that cross pollinate the "B" type Fuerte flowers. At present, the Zutano variety is the only one recommended for commercial use.

Because the Fuerte has a long period of bloom that may extend from Labor Day to the Fourth of July, there may be more than one set of fruit on the trees at the same time. If warm periods occur during this time, some fruits may set and produce "off bloom" fruit that matures in early fall and brings better prices. Off bloom fruits generally have a flattened bottom and are squatty in appearance. Differentiated from the off bloom fruits, the first fruits of the regular crop set are known as "early bloom." These mature earlier than the main portion of the crop, are of the normal Fuerte size and shape, and may be harvested at the same time or slightly later than the off bloom fruits.

Most noticeable on newly set match head and pea sized Fuerte fruits are the red stems, indicating they are likely to reach maturity. This is a sight that growers just love to see. When temperatures are borderline for good fruit set, "cukes" may be formed. These small, finger-sized, unpollinated, seedless fruits are marketed as "Cocktail avocados" and bring a good price.

Hass

The original tree, a chance seedling, was grown and selected by Rudolph G. Hass in the early 1920s at 426 West Street at La Habra Heights. It is thought that the old variety is probably the genetic source of the Hass. Mr. Hass and Mr. H.H. Brokaw, father of the present owner of Brokaw Nursery, saw great promise in this seedling and it was registered with the California Avocado Society in 1932. Later, Mr. Hass applied for a plant patent on his tree and was issued Plant Patent Number 139, on 27 August 1935. A commemorative plaque, supplied by the California Avocado Society, has been placed next to the mother tree.

This variety is a vigorous, moderately spreading tree that produces a high quality fruit, mostly dark-skinned at maturity, weighing 6 to 14 ounces. It is ovoid to pear-shaped with a tough, pebbly skin; ships well; has a good shelf life; and since the early 1970s has enjoyed wide

consumer acceptance. The commercial season is from May to October, although there is usually some fruit available year-round. Mature trees tend to have alternate bearing habits, are tender to frost below 30°F, and should be planted only in locations that are nearly frost-free. The Hass variety has replaced the Fuerte as the standard of the industry. As a spring and summer fruit, it complements the Fuerte, a fall and winter fruit. Suggested tree spacing is 15' x 20' to provide for early heavy crops and for later tree thinning to maintain production.

Growers in the Ventura-Santa Barbara area have noted that the set on Hass trees is improved by being in close proximity to Bacon variety trees. Hass has an "A"-type flower that is complemented by the "B" type of the Bacon. The percentage of improvement has not been determined by any serious investigation.

Zutano

This variety is believed to have originated in Fallbrook on the old Truitt Ranch on Alvarado Street. Zutano is a vigorous, upright, precocious and cold resistant variety (26°F). It is a regular and heavy producer of green, pear-shaped fruit of medium size (8-14 oz.), but of modest quality, because fruit tends to split on the bottom and neck when over mature. Because of its penchant to set heavily, the tree requires training and propping to support the crop. It bears well over a wide range of climatic conditions and complements the Fuerte variety as a cross-pollinator when used as an interplant in the Fuerte grove. Zutano has a "B" type flower.

The fruiting season is October to January. For marketing purposes Zutano fruit, along with several other green fruits, are referred to as "other greens." Trees planted at a spacing of 15' x 15' with no more than five tree rows between ranch roads work very well. Unlike the thinning problems of Hass and Fuerte varieties, tree topping will be beneficial to reduce picking costs and to enhance production.

Bacon

In his search for a cold resistant variety that could be grown on his ranch in Buena Park, California, James E. Bacon planted large numbers of seed and fruited the resulting seedlings. One of these showed exceptional hardiness, was named Bacon, and was introduced to the trade in the late 1920s. The tree is upright, hardy to 24°F, and used in the colder avocado producing areas. While the tree and the fruit tolerate cold remarkably well, the fruit stem is its "Achilles heel" and weakened fruit will require prompt harvesting after a cold snap. Because the variety is mostly grown where cold is a threat, the fruit should be marketed before cold becomes a problem. The fruit is dark green, oval in shape, of medium quality, and from 7 to 14 ounces in weight. In the interior growing areas it develops a serious end spot problem that requires prompt harvesting when mature. The season is November to January. When the fruit is marketed, it is classed as "other greens" along with other green-skinned fruit marketed during the fall and winter.

Growers in the Pauma Valley area feel that a planting combination of Bacon and Covocado varieties complement each other, resulting in improved fruit set. The Bacon has a "B" type flower. The two varieties may be set out on a 15' x 15' spacing. On steep slopes the ranch roads

should be close together, with perhaps only three rows between roads. On more nearly level land the distance between roads may be increased to as many as six rows. Closer roads provide easier access for grove operations and for fruit removal during harvesting.

Reed

The late James S. Reed found and observed a chance seedling in his 6-acre grove in Carlsbad, California in 1948. After several years of records, he became so impressed with its virtues that he applied for a patent. Patent number 1967 was granted to him on 16 August 1960 and expired in 1977. It can now be propagated without paying a patent fee. The Reed variety is thought to be a hybrid between the Nabal and Anaheim varieties. It seems to be the result of a "perfect marriage" because it has all of the positive attributes of the parent varieties with none of the negative attributes of either.

Mr. Joe L. (Roy) Shields, who married the widowed Mrs. Reed, has been active in the promotion of this variety that has won a place on the California Avocado Society's recommended list.

The Reed has an "A"-type flower and the trees may be planted at a spacing of 15' x 15'. The tree is upright and a heavy and regular producer of fruit. Reed fruit are large, green, nearly round, and weigh from 8 to 12 ounces near the coast and 12 to 18 ounces in the inland areas with a good seed to flesh ratio. This commercial variety is of very fine quality when harvested after Labor Day, though it is harvested July through September and selectively picked to the middle of November. The tree's frost tolerance is comparable to Hass (30°F), and the fruit has good shipping and shelf life qualities.

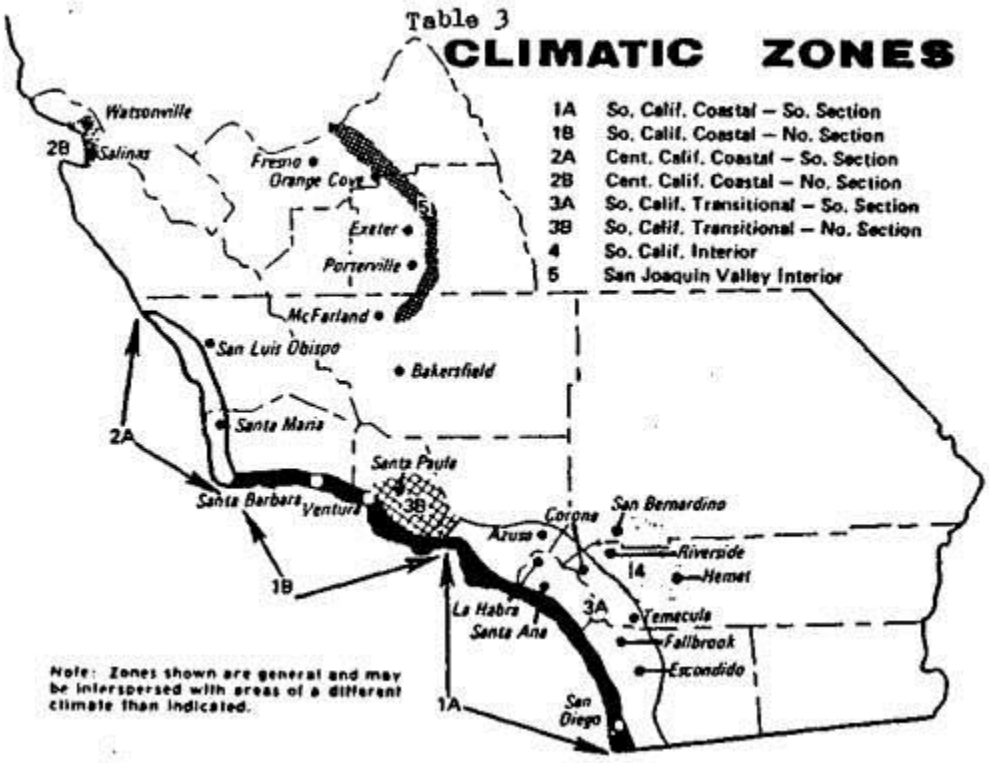
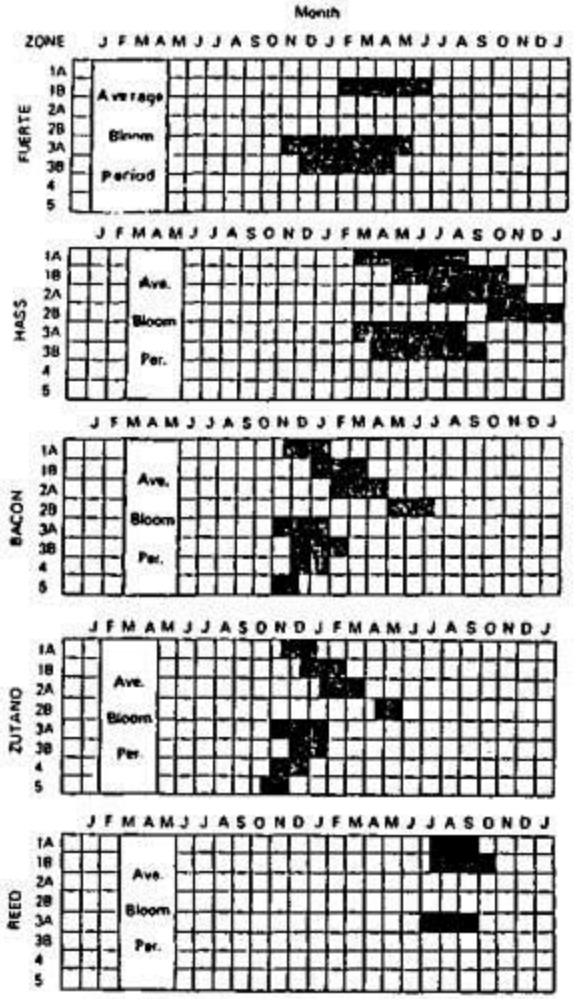


Table 4

VARIETY	PARENTAGE (Origin)	SEASON	AVERAGE SIZE (Ounces)	SHAPE	SKIN				RELATIVE SEED SIZE	FLAVOR	EATING QUALITY
					Color	Texture	Thickness	Peeling Ease			
HASS	Guat. Sdlg. (La Habra, Cal.)	SEE ATTACHED CHARTS	5-12	Ovate	Black	Pebbly	Medium Thick	Excellent	Small to Medium	Nutty Rich	Excellent
FUERTE	Guat. X Mex. (Atlixco, Mex.)		6-14	Pear	Green	Leathery	Medium	Good to Excellent	Medium	Mild Rich	Excellent
BACON	Mex. Hybrid (Buena Park, Cal.)		8-12	Ovate	Dark Green	Smooth	Thin	Fair to Good	Medium to Large	Mild	Good
ZUTANO	Mex. Sdlg. (Fallbrook, Cal.)		6-10	Pear	Yellow Green	Smooth	Thin	Fair to Good	Large	Mild	Fair to Good
REED	Guat. Sdlg. (Carlsbad, Cal.)		8-18	Round	Green	Slightly Rough	Medium Thick	Good	Medium	Nutty Rich	Good

VARIETY	SHIPPING QUALITY	TRADE ACCEPTANCE	TREE GROWTH	FLOWER TYPE	TIME OF BLOOM	LIMITATIONS	COMMENTS
HASS	Excellent	Excellent	Medium Spreading	A	Mid	Sensitive to frost, heat. More subject to mite, insect and drought damage.	Individual trees alternate but orchard production consistent. Long fruit life on tree.
FUERTE	Good	Excellent	Large Spreading	B	Early	Sensitive to microclimate conditions for good fruit set. Alternate and inconsistent producer.	Production usually increased by pollinator. Fruit holds well on tree.
BACON	Good	Good	Tall Upright	B	Early-Mid	Sets crop in top of tree. Moderate producer.	Tree very frost tolerant.
ZUTANO	Fair to Good	Fair	Tall Upright	B	Early	Susceptible to blossom-end breakdown, corkiness and rust in some zones. Short fruit life on tree.	Heavy consistent producer. Tree frost tolerant.
REED	Good	Fair to Good	Slender Upright	A	Late	Frost sensitive. Large size limits trade acceptance. Branch breakage in windy areas.	Fruit holds well on tree.

AVERAGE HARVEST SEASON



NOTE: Absence of a harvest season indication in chart denotes information not available or variety not suited for zone.

RECOMMENDED FOR COMMERCIAL PLANTING

VARIETY	ZONE							
	1A	1B	2A	2B	3A	3B	4	5
HASS	YES	YES	YES	YES	YES	YES	Warm Areas	NO
FUERTE	NO	NO	NO	NO	YES	NO	NO	NO
BACON	YES	YES	YES	YES	YES	YES	YES	YES
ZUTANO	NO	NO	NO	YES	YES	NO	YES	YES
REED	YES	YES	?	?	YES	?	?	NO

The production and quality of any variety depends upon many factors. Consult your University of California Farm Advisor for the variety or varieties best suited for your particular location.

FROST TOLERANCE LIMITS OF TREE:

Hass	30°F	Zutano	28°F
Fuerte	27°F	Reed	30°F
Bacon	24°F		

Cold damage varies and depends upon the duration of cold, season in which it occurs, stage of tree growth, tree health, etc. Fruit and stems may be damaged if temperatures remain below 28°F for significant periods of time.

Table 5

PREPARED BY:

THE VARIETY COMMITTEE, CALIFORNIA AVOCADO SOCIETY

in conjunction with the

COOPERATIVE EXTENSION SERVICE, UNIVERSITY OF CALIFORNIA

<![endif]>

OTHER VARIETIES

There are, and have been, other varieties of good to excellent quality that are suitable as dooryard trees for the home owner and for trial by the commercial grower for experimental purposes. Three of these new varieties have been named and introduced to the trade as potential commercial varieties and are now in the process of being evaluated.

Jim

Jim is anew variety developed by Jim Bacon in the Buena Park area from a Bacon parent. The tree is vigorous, semi-upright, and appears as hardy to frost as the Bacon which tolerates temperatures of 20°-24°F. It is a precocious bearer, produces good crops regularly, and propagates easily from either buds or grafts.

The fruit is green, pear-shaped to long-necked, has a medium-sized seed that is tight in the fruit and a medium thick skin, averages 8 to 10 ounces, and ships well. The fruit tests 14% oil content in early November. Jim has been planted on a limited scale but since the fruit has a long neck, it creates a problem for the packer at times, as long necks are less than compatible with the sizing and packing equipment. This good quality fall fruit is marketed as "other greens" and commands about the same price per pound as Bacon and Zutano. Its flower type is not yet determined.

Pinkerton

This new variety originated in the grove of John Pinkerton located in Saticoy, Ventura County. Mr. Pinkerton died in 1979. His son, Allan, has been quoted as saying that it appears that sloppy farm management produced the seedling. One might suspect that nearly all varieties have come to us by loose farm operations. It is believed that the tree is a cross between the Hass and Rincon varieties with cold tolerance about equal to the Hass.

The tree was patented by Mr. Pinkerton and assigned Patent Number 3712 on 29 April 1975. Exclusive propagating rights have been given to the Brokaw Nursery in Saticoy and trees are sold with a patent charge of $1.00 per tree.

The tree is of medium size, but more spreading than Hass. It is clearly from the Guatemalan race with an "A"-type flower. Typically it has two sets of fruit in Ventura County that mature in October and November with the bulk of the crop coming off in the winter and very early spring. Marketing season in general is November to March. The tree is a very heavy bearer.

Warren Currier III, a keen observer, has reported in his "The Agricado Market Weekly" newsletter the following interesting points:

a. The tree seems to have much greater limb strength and tolerates winds better than most other varieties;

b. It is much less alternate bearing in its production habits than Hass and is a precocious bearer;

c. It has a long shelf life and will hold in cold storage for two weeks, which may make it a superior export variety.

Some have referred to the fruit as the "Ventura Fuerte'' or the "Winter Hass." The fruit is green with a medium-thick leathery skin that is pebbled much the same as the parent Hass and weighs from 8 to 14 ounces. The high quality flesh has a high oil content and is smooth in texture. It ships well and has a good shelf life. It has at least one drawback, because some years the fruit has a "neckyness" (a long neck), which seems to be a peculiarity of juvenile trees, that does not mix well with the packer's equipment. The weather may also be a factor that is involved in the production of these long-necked fruits.

This would seem to be a variety tailor-made for San Diego County growers, who have land warm enough to grow Hass. Creating a mix of Hass, Reed, and Pinkerton would permit them to harvest fruit year-round from varieties with a similar frost tolerance. Due to its early season, precocity, heavy production, and high quality, the Pinkerton deserves serious consideration as a commercial variety in new avocado plantings.

TABLE 6

CALIFORNIA FRUIT AND NUT ACREAGE AS OF 1981

CROP & VARIETY	1969 and Earlier	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	Acreage Standing in 1981 Bearing	Non-bearing	Total
AVOCADOS																
Anaheim	104	---	---	---	---	---	---	---	---	1	---	---	---	104	1	105
Bacon	1,340	162	238	488	609	1,106	988	542	437	445	530	507	514	6,355	1,551	7,906
Covacado	71	4	20	7	21	26	43	27	10	21	10	10	10	219	61	280
Fuerte	8,350	434	425	320	564	884	715	394	49	84	76	70	20	12,084	299	12,383
Hass	6,664	940	1,555	2,083	3,740	5,052	5,155	4,001	3,775	3,924	4,117	3,485	3,158	36,889	10,760	47,649
Jalna	177	---	1	20	20	38	54	40	18	18	18	18	18	350	90	440
Jim	---	---	---	---	10	23	1	9	---	---	---	14	6	43	20	63
MacArthur	365	---	13	13	1	2	7	5	26	25	10	15	---	406	66	472
Pinkerton	---	---	---	2	---	---	9	1	---	48	2	10	---	12	60	72
Reed	193	13	48	49	65	84	149	75	34	41	103	45	33	676	256	932
Rincon	227	3	---	---	---	10	21	4	8	10	6	6	---	265	30	295
Susan	50	11	19	38	26	67	22	32	13	8	5	---	8	265	34	299
Wurtz	52	---	---	2	1	---	---	---	---	---	---	---	---	55	---	55
Zutano	859	124	237	246	506	865	608	618	484	420	365	305	460	4,967	1,130	6,097
Others	400	21	38	247	386	310	334	372	108	90	103	71	78	2,108	450	2,558
All Avocados	18,852	1,712	2,594	3,515	5,949	8,467	8,104	6,120	4,962	5,125	5,343	4,556	4,305	64,798	14,808	79,606

This chart, prepared by the California Crop and Livestock Reporting Service, shows the trends in commercial Avocado varieties over the past 22 years. In 1969 Hass acreage was only 3/4 that of Fuerte. In 1981 Hass is almost four times greater than Fuerte and has grown at the expense of other varieties. It is very difficult for a new variety to gain acceptance.
(Chart excerpted from The Agricado Market Weekly published by Warren Currier III)

Santana

Around 1960, Stephen R. Nemcik of Buena Park, California planted a Zutano seed in his backyard. Since it came into bearing it has carried a heavy crop of fruit every year. During the fall of 1971 this tree was brought to the attention of James E. (Jim) Bacon, a long-time avocado

grower and developer of the Bacon and more recently the Jim avocado varieties. He found the fruit to have early maturity and excellent size and appearance. After checking the fruit for quality and even ripening he reached the conclusion that here was "the most promising early fall variety yet." Because of this, Mr. Nemcik applied for and was awarded Plant Patent 3,703 on 15 April 1975 for this tree under the name Santana.

The tree is an upright grower, resembling its parent, the Zutano variety. It is precocious in bearing with first year grafts often setting fruit and setting heavy crops in the second year and thereafter. The tree appears to be about as hardy as the Zutano.

The fruit resembles Zutano in appearance but is somewhat larger and has no end spotting, while the seed is average in size and the skin thicker than most fall varieties. Maturity dates are earlier than both the Bacon and Zutano varieties in Buena Park, with fruit ready to pick by the end of September. Quality is good at earliest maturity and progresses to very good. It differs from other early varieties because it hangs well on the tree as late as March.

DOORYARD TREES

During the many years it took to bring the avocado to its present stage of commercial development, many varieties were named both from the United States and from foreign sources. A record of these may be found in the back issues of the California Avocado Society Yearbooks. Suffice to say, the great majority of these littleknown varieties have been systematically eliminated since the industry cannot afford to handle all of these "cats and dogs." The result has been the concentration of a few varieties as the backbone of the industry, and these have been described in more detail on previous pages.

Many trees of these old varieties are still in existence where old groves have been subdivided and some of the avocados left as ornamentals in yards. Some of the owners of the older, smaller groves have never top-worked these old varieties to commercially acceptable ones and these continue to produce small quantities of fruit that is eaten by the owners, sold locally, or given to friends. These old trees must have some redeeming features or their owners would not keep them merely for their historical value, though this may also be a factor in their survival. In the opinion of their owners, these old varieties produce fruit of much higher quality than the commercial varieties on the market today, which are often picked when the price is right but without regard for maturity and subsequent poor quality. The homeowner can give more individual attention to his trees and pick them when the fruit quality is highest and thus afford to keep a few trees that will give him satisfaction rather than remuneration. One long-time grower, now deceased, was once asked "Why do you grow that watery, poor-tasting Anaheim variety?" He answered, "Oh, I don't grow Anaheims to eat, I grow Anaheims to sell." For eating he grew Benik, Nabal, and Queen, three high-quality varieties that are of too large a size for commercial use.

Some folks will eat an avocado, stick three toothpicks in the seed and grow a tree in a glass of water. When it grows into a small tree, they wonder what to do with it. The answer is to plant it -- providing, of course, that they live in a climate where the avocado will grow. It will make a nice ornamental evergreen tree that in time will bear fruit. Half the fun of growing such a tree is the suspense of waiting to see just what kind of a fruit it will have. And, if anyone should attempt

to disparage the growing of a seedling tree for fruit, let it be said that as of this writing, every one of our accepted varieties originated as a chance seedling in someone's grove or back yard. Because most of the seeds that consumers plant come from very good fruit, chances are very good that the seedling will produce fruit of at least acceptable quality and perhaps even of exceptional quality, size, and quantity. Such a dooryard tree might even combine these characteristics to the extent of becoming a new and better variety for commercial use. The best avocado variety has yet to be developed and named.

The California Rare Fruit Growers is a dedicated group of enthusiasts and hobby growers that are always looking for just such an exceptional tree, be it an avocado or any other kind that produces a better fruit than what we now have. Toward this end, two avocado varieties have been named and registered with the California Rare Fruit Growers. The first of these was grown by Orton H. Englehart of Escondido, who introduced it under the name 'Creamhart' and registered it on 2 December 1974. It is a pear-shaped green fruit weighing from 10 to 16 ounces with a small seed and flesh of a very fine flavor. The tree is round-headed and produces a good crop every year, ripening from late January to early June. The tree is frost tolerant to 27° F.

The second was registered on 4 July 1977 under the name of 'Stearns' and was found in Baldwin Park in the early 1920s by Alex Stearns, who propagated and grew it for many years. The fruit very much resembles the 'Fuerte' variety in appearance and was marketed by Stearns as an "early Fuerte," the quality being as good or better than the Fuerte. Fruits weigh 8 to 14 ounces, have a medium-sized seed, and mature from October to February. Oil tests have shown the fruit to have 10% oil content on 1 September, 15% on 1 October, and 20 to 25% the remainder of the season. The tree is upright spreading -- somewhat similar in shape to the 'Hass' variety. Production is good and regular. Stearns is a fall fruit of high quality that could well produce commercial dividends for growers. The tree is frost tolerant to 26° F.

These two varieties, combined with a summer variety such as 'Reed,' could make a three-tree dooryard avocado orchard that would provide high-quality fruit year-round for a family, plus some for your friends and neighbors.

FRUIT DROP

In all varieties of avocados there are two periods during the year when a certain percentage of the fruit that has set will drop. This is particularly evident during years when there is a very heavy set of fruit. "June drop" has been identified in other fruiting trees as well as avocados. At this time, many pea-sized fruits will be found on the ground. Later, after the fruit has matured to walnut on up to lemon size, there is another period when a lesser amount of fruit will drop, usually during the month of August. Any estimates of the crop for the following harvest year should be made after the August drop, which is the last drop that can be expected before the fruit matures.

The reasons for these two drops are not well understood. The June drop may be due in some way to improper pollination when the nights were too cold for the pollen to be effective. The August drop is probably due to a self-thinning by the tree, which may have set more fruit than it can comfortably carry. When these dropped fruits are cut open, the seed is black and dead -- hence

the fruit will not mature further and is aborted. The Hass variety is particularly subject to fruit drop. In any event, fruit drop is no cause for concern because the tree will still carry a good crop to maturity in spite of the drop.

Poor quality
Figure 17. A ranch road in an avocado grove is littered with fruits from the August fruit drop. Trees will still mature a full crop.

NURSERY PRACTICES

Nursery trees are produced from selected Mexican type seeds such as Topa-Topa, Mexicola, and Ganter that have been heat-treated to kill any root rot fungus that may be present. Since the early 1970s, nurserymen have found that West Indian seeds produce good nursery trees that are much more resistant to salts in the soil than the Mexican rootstocks. Because the West Indian stocks are not cold tolerant, they are used as rootstock for the Guatemalan varieties such as Hass and Reed, which are planted on warmer land.

In the early years of the avocado industry all nursery stock was field grown. A 1/8" slice of the bottom of the seed and about ½"of the top were cut off to promote growth, the seed coat was removed, and the seed planted 18" apart in rows directly in the ground. A large Dixie cup was placed over the seed, and dirt was packed around it to hold it in place. When the seed started to grow, the top was removed from the cup or the entire cup was removed. After the stem of the tree reached 3/8" to ½" diameter, the tree was budded to the variety of choice. A "T" shaped cut was made in the trunk and a shield-shaped bud inserted under the bark and securely tied with rubber budding bands or plastic tape. The top few inches of the tree were removed at the time of budding. When the bud had grown to a length of about 3", it was tied to the upper portion of the tree to keep it growing upright. Later, the balance of the rootstock was removed immediately above the bud. This point is called the bud union.

Budding was done in the early summer and if sufficient growth was made by the bud, the trees were ready for digging in the spring. An 18" balling spade was used to dig around the tree and remove an 8" to 10" diameter tapered ball of dirt containing the roots. This was wrapped in burlap and securely tied with binder twine. At this time, half of each leaf and a few of the smaller limbs were removed to balance the top with the root system that was pruned when the tree was dug up. These trees were delivered to the grower "balled and burlapped" and ready to plant.

In planting these field grown trees, the ball was placed in the hole and the dirt backfilled to cover about 2/3 of the ball.

The twine at the top of the ball was cut and the burlap laid back on the ball and the remainder of the soil placed on top of the burlap. This prevents the soil in the ball from drying out because the burlap acts as a wick to evaporate the moisture from the ball if it is exposed to the atmosphere.

In the evolution of growing nursery stock in the field to the present day practice of growing stock in plastic bags and tubes, a transitional stage was used. In this stage, seed was planted at a depth of some two inches in seed beds about a foot deep, and when the young trees were some 6" to 8" tall they were transplanted to bottomless tar paper containers about 5" in diameter by 16" deep. They were then budded in the containers and sold to the grower when large enough to plant. With container-grown trees, growers have the advantage of not disturbing the root system as with those trees removed from a field. A disadvantage is that the tree may remain in the container too long, if not sold, and the root system becomes pot bound to the point that the tree will not grow well when planted. This may be partially remedied by moving the container to prevent the roots from growing into the ground. If the root ball becomes pot bound a knife may be used to cut through the roots from top to bottom after which lateral roots will be initiated. This is done immediately after the container is removed and just before placing the tree in the planting hole.

During the 1970s there was a tremendous expansion in the acreage planted with avocados, which in turn created an unprecedented demand for nursery-grown stock. Old nursery practices were much too slow, forcing nurserymen to delay filling their orders for as long as three years after they were placed. To accelerate production, they turned to greenhouses with controlled temperatures and humidity. Seeds were planted in small 2" by 8" plastic bags or tubes and when the young trees were about 3/16" in diameter the tops were cut off squarely and split for an l½". A small terminal scion some 3" long was trimmed to a wedge shape at the basal end and inserted into the split trunk. It was then tied with a rubber budding band and placed in a greenhouse with high temperatures and humidity, where the stock and scion quickly made a union, and within two weeks the graft commenced to grow. This rapid growth is achieved due to the large food reserves stored in the seed. After the young graft is well established, the tree is hardened off in a cool greenhouse and then transplanted to plastic sleeves 6" by 18" deep and grown outside of the greenhouse until sold to the grower for planting.

Due to the ravages of root rot, the latest development is the grafting of clonally propagated, root rot resistant rootstocks. This is an insurance policy against times when a grove becomes infected with root rot. The University of California Riverside's Dr. George Zentmyer has found several trees that are highly resistant to root rot, and these are propagated for rootstocks. Because it is almost impossible to root these in the conventional manner, a different method for rooting them has been developed by Mr. Edward F. (Ted) Frolich of UCLA.

This method is known as the etiolation technique. Only avocados with very large seeds are used as seedling rootstocks for etiolation rooting. Seeds are planted in gallon cans and grafted to the clonal scion. When the stem of the graft reaches about ¼" in diameter, the top is cut off just above a whorl of buds that is generally found within an inch of the graft union. A 4" wide band of black tar paper is formed into an extension of the can and filled with vermiculite. The plant is placed in a dark box with high temperature and humidity and the food reserves in the large seed quickly cause several of the buds to grow up through the four inches of vermiculite. When growth is some 3" or 4" above the vermiculite, the plant is removed into the light, where the upper portion will quickly assume a green color to provide food for the plant. The tarpaper collar is then removed, the branches severed from the plant, and the branches are then placed in flats where the cuttings are rooted in the conventional manner. Because the basal portion of the

cutting has no chlorophyll, it performs as an underground stem and soon sends out adventitious roots. The rooted cuttings are transferred to containers and grafted in the usual manner to provide nursery trees with a known degree of root rot resistance. Duke 7, Duke 6, Huntalas, G-6, and G-22 are recommended by UCR for propagation.

The avocado nursery industry operates under two concepts that have the intent of assuring the grower that he is buying quality trees. These are registration and certification of nursery stock, and these concepts are controlled by state regulations developed by the avocado industry itself.

Registered nursery trees are those produced from seeds and scions known to be free of the sun blotch viroid. Registration may become less important following the discovery that sun blotch can be transmitted on pruning tools and by insects pollinating the flowers.

Certified trees are those produced under sanitary growing conditions. Avocado seeds are immersed in a vat of hot water at a temperature of 120°F for a period of 30 minutes to kill the root rot fungus. If the seeds are not planted immediately after the heat treatment, a fungicide is applied to them and they are held in cold storage to prevent growth until they are ready to be planted. In order to insure that trees are free of root rot, procedures include the following: the potting soil is sterilized, the trees are grown on concrete to avoid contact with the ground, and personnel are required to step in a fumigant before entering the growing area. Trees that are certified as free of the root rot fungus sell for about twice as much as regular nursery stock.

PLANTING

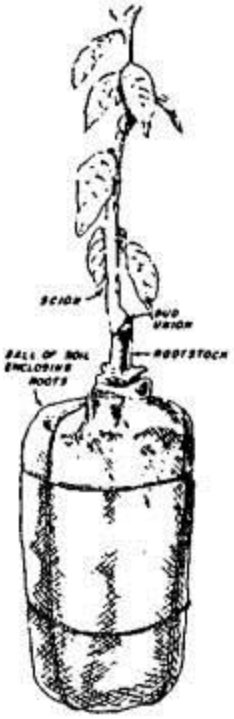
Prior to the planting operation and fall rains, it may be advisable to strip spray the area to be occupied by the young trees with a pre-emergent herbicide such as PrincepR. This chemical can lie on the surface of the ground for up to six weeks without degrading and will be washed into the surface when rains do come. A contact weed killer such as weed oil or ParaquatR can be used together with the PrincepR, as these are quite compatible in the same mix. This mix will kill the weeds currently growing in the strip and prevent weed growth during the fall, winter, and spring, thus giving the young tree a chance to become established without weed competition. Weed control progressively becomes less of a problem as the trees become larger and shade out the weed growth.

The preferred planting dates for avocados begin about 15 February with the last tree planted no later than 1 May to permit the maximum benefit of the growing season, yet allow the trees to harden off before the following winter. Although the cooler nights of the fall season will cause a cessation of growth, no fertilizer should be applied to trees after Labor Day in areas where there is a reasonable expectation of frost by mid-December. Though mature leaves may withstand the frost, the tender, succulent growth of new leaves can be severely damaged.

With trees grown in planting tubes or containers, ,which in all probability have been tip grafted, the tube is placed in the hole to a depth where the top of the soil in the container is level with, or slightly above, the ground surface. While the tube is in the hole, the plastic is removed by slitting the tube lengthwise with a linoleum or other sharp knife. Do not attempt to slit the tube, remove the plastic, and then lower the tube of dirt and roots into the hole. Too often the dirt crumbles, leaving a bare root tree in your hand. This tree will take a long time to grow if it does not die. After the plastic is removed the soil is backfilled around the mass of dirt containing the roots. The topsoil should be filled in first to provide good soil for the roots to establish themselves in, and the subsoil added last. Tamp the soil firmly around the mass of dirt as it is filled in and water the tree as soon as practicable to wet the soil and drive out any remaining air pockets.

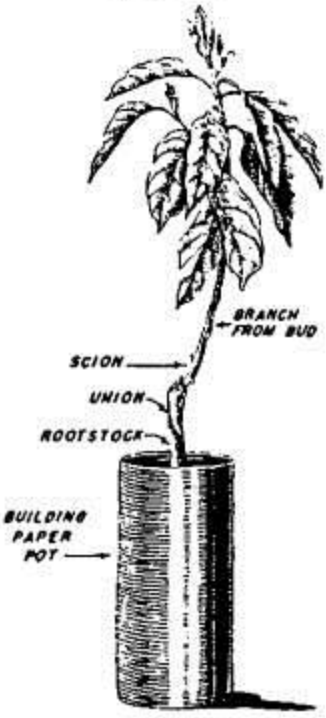
Field budded trees are very seldom offered for sale any more, but in the event one does purchase budded trees, it is best to plant the tree with the cut surface facing in a northerly direction. After the bud takes, the seedling rootstock is severed just above the bud union and the cut surface painted black with a nontoxic asphalt emulsion compound such as “Tree Heal” or “Tree Seal.” It is this black surface that should point north to avoid sun damage.

STANDARD BUDDED



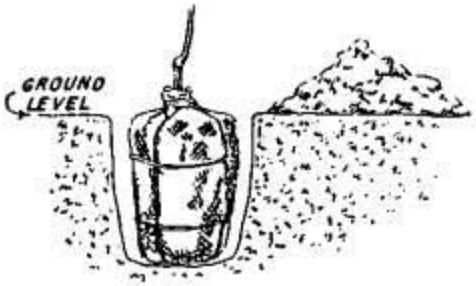
Field-grown tree

TIP GRAFT

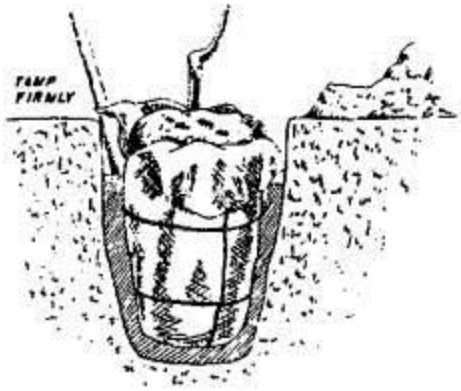


Container-grown tree

TWO TYPES of trees are used: the standard budded and the tip graft. Whichever you choose, be sure there is plenty of soil around the roots

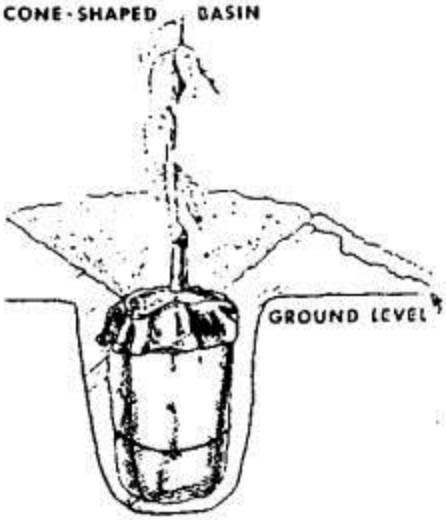


DIG HOLE deep enough so top of ball is level with the ground.



NOW TAMP the soil firmly around the ball, cut sack and fold edges outward.

CONE-SHAPED BASIN



BASIN FOR irrigating can be made by building up cone of soil around tree. During winter rains basins are opened.

Figure 18

Even though the soil is packed tightlyand the surface of the tree ball level with the surrounding soil, there may be some water runoff with sprinkler irrigation, which can be reduced by mulching.

This writer would prefer not to use basins around young trees because basins tend to collect cold air and rain water during the winter months even when "V" notches are cut in the basins in the fall of the year permitting the cold air and water to escape. However, with a sprinkler system, there can be water savings for the first few months of tree growth if you place an old can over the sprinkler and allowing a basin to be created by the blockage the can creates. With drip irrigation there is no need for basins because the water delivery is so slow that there is little or no runoff.

A tree wrap should be tied around the young tree trunk to protect it. Sun can damage the green wood, as can the cold. Modest protection from small rodents is also provided by the wrap.

Growers seem to prefer a wrap of corrugated cardboard, the exterior of which is coated with thin aluminum for maximum protection and to reflect heat. Old magazines or newspapers also work quite well, especially on a few back yard trees. Remove all plant growth below the top of the wrap and tie the top and bottom somewhere between loose and snug. The wrap should be positioned to cover the bud union. If cold is apt to be a problem, you may want to mound up some soil or straw mulch outside of the wrap but over the bud union for added cold protection.

With the young tree firmly set in the soil and wrapped, the next step is to loosely tie the tree to the 2"x2"x6' stake above the tree wrap using any one of the plastic materials that are available commercially. Tying and retying the tree to the stake should be a continuing process until the time the diameter of the area at the bud union exceeds the size of the stake. The stakes should be of good quality, because after two to four years they can be removed and made into l"x2"x6' stakes useful for supporting future scaffold branches. You can easily make the narrower stakes by passing them through a circular saw. Adjustable tree hooks, available commercially, are placed over the end of the stake with the branches in need of support placed on the hooks.

Sometimes it is necessary to replant trees among older trees in an orchard. Nurserymen usually supply larger size nursery trees for that purpose. These replant trees may receive less fertilizer than those planted earlier unless there is an injector in the irrigation system. If not, it might be advantageous to place a tablet or granular slow release fertilizer in the tree hole outside the ball of the tree about halfway down its length, thus insuring a constant source of nitrogen for the young tree.

In the permeable and thin soils often found in California's avocado growing areas, using mulching materials is a must to preserve surface moisture and to improve the tilth of the soil. Baled straw is apt to be the cheapest mulch when the cost of labor and material are significant. If the price is right, pine chips and shavings are good. Well-composted manures make a fine mulch and help to provide humus, but involve much labor. In addition, the source should be known to be free of root rot fungus. When estimating the mulching needs of new trees, counting seven young trees to the bale may be about right. However, it will be necessary to repeat the mulching after the previous mulch has decomposed, because mulches break down rapidly under a heavy

fertilization and irrigation regime. Mulching becomes unnecessary when trees are big enough to provide their own leaf mulch.

REFERENCE CITED

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CHAPTER III
T.L.C. GROVE CARE AND MAINTENANCE

As we have seen in the previous chapter, grove planning and development for even a small ownership requires much skill, thought, and attention to detail. Grove care is no different, and must be applied with Tender Loving Care (T.L.C.).

IRRIGATION

The preferred approach is to have the grove developer complete his work and the first irrigation of the planted trees by the first of May. While completions later in the year are successful, the young trees will stand a better chance of surviving the following winter if they are set out early in the spring. If they are in place with a long growing period, they are more apt to "harden off" before the first likely chance of cold damage, which is approximately December 5 in northern San Diego County.

After planting, the young orchard needs regular attention. The first order of business is irrigation. Unlike many other plants, even older avocado trees will not seek moisture. It is up to the grower to supply water when and where the tree wants it.

If your orchard is in a windy area, extra water is required, both in amount and frequency of application. This is especially true with orchards on hilltops and hillsides, where soil may be shallow and coarse with a low capacity to hold water. In San Diego County, trees exposed to strong, desiccating winds suffer damage from water stress. This is not uncommon during the fall and winter Santa Ana winds and with the strong westerly winds that occur regularly during spring and summer, and has a drastic effect on water use of plants. The effect is more than most growers realize. Tests with grass plants growing in areas where winds were dry (10-30% relative humidity) show water use was three times the normal use on clear, calm days.

Table 7
IRRIGATION APPLICATION GUIDE FOR AVOCADOS

Tree Spacing	Tree Age (yrs)	Average Irrigation Water Requirement-Gallons Per Tree Per Day											
20 x 20	1	1	1	2	3	4	5	6	5	4	2	1	1
	2	2	2	4	6	8	10	12	10	7	5	3	2
	3	3	3	6	9	12	14	17	15	11	7	4	3
	4	4	4	8	12	15	19	23	20	14	9	5	4
	5	5	5	10	15	19	24	29	25	18	11	6	5
	6	6	6	12	18	22	28	34	30	21	14	8	6
	7	7	7	14	21	26	33	40	35	24	16	9	7
	8	8	8	16	24	30	38	46	40	28	18	10	8
CONSUMPTIVE DAILY WATER USE AC IN/AC		.03	.03	.06	.09	.12	.15	.17	.15	.11	.07	.04	.03
Months		JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC

These values are net water needs. Add water for inefficiencies and for leaching. These values are based on long-term average water use. Actual use values may be higher or lower for early or late seasons or for unusually hot periods.

Net Gallons per Tree per Day = $\frac{\text{Tree Canopy Area (square feet)}}{400 \text{ square feet}}$ x Monthly Values for 8 year old trees.

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
1523 East Valley Parkway, Suite 201
Escondido, California 92027
Phone 745-2061

<![endif]>

Soil acts as a reservoir for the moisture necessary to satisfy the plant's needs. The influence of gravity on soil moisture causes it to drain downward. Soil texture and structure determines the rate at which water moves to lower levels. The attentive grower or grove manager will take pains to acquaint himself with the behavior of irrigation water on and in the soils of the growing areas of the ranch.

Over-irrigation is a frequent problem in avocado orchards. Excess moisture causes a lack of aeration, resulting in root rot, or accentuating the spread of root rot in infected soils. Good irrigation water management will prevent either insufficient or excessive soil moisture. In years of heavy rainfall, buried drain lines may solve the problem of excessive soil moisture and prevent tree loss.

Careful attention to irrigation is necessary to produce good results with avocado trees. During the summer and fall, when temperatures are high with a strong, dry wind blowing, it will be necessary to irrigate continuously with a drip system to supply enough water to replace the water lost through leaf transpiration. Under Santa Ana conditions, the tree roots may not be able to absorb the water fast enough to prevent wilting of the leaves and stems of new, young growth, even when the water supply is adequate. This wilting is not so evident on older growth that has hardened off, but trees will still be under stress. Hass trees are the most sensitive to these conditions, and wilting may be evident by the early afternoon. By the next morning, however, the moisture has been restored and the new growth appears normal.

During the winter rainy season, drip irrigation may be reduced considerably when rainfall is sufficient to provide for the tree's needs. After a 3" rain it may not be necessary to irrigate for

two weeks, providing temperatures remain cool with no strong, drying winds. Read your tensiometer or use your soil tube to determine the moisture level of the soil.

Tip burn on leaves appears as a dying back on the leaf tips and margins, and is the result of excess chloride in the irrigation water. This accumulation of salts in the root zone is transmitted to the leaves, particularly in the fall of the year before beneficial rains take place. You can reduce the problem by applying extra irrigation water at least three times during the irrigation season to leach salts below the root zone. Usually an extra one-half of an irrigation treatment will suffice.

Determining Soil Moisture

There are several ways to determine loss of soil moisture.

A. Tensiometers are favored by many growers and some university researchers. These instruments measure the soil moisture condition rather than the quantity of water in the soil. The instrument consists of a ceramic cup, a body or tube, a vacuum gauge, and a reservoir. Colored water is placed inside the tube through the opening at the top of the reservoir to ease monitoring of water level in the tube.

Movement of moisture in and out of the ceramic cup causes tension on the column of water in the tube. This is shown on the dial of the vacuum gauge. Most gauges are calibrated in centibars from 0-100, the lower readings indicating wet conditions. Readings above 80 are not reliable.

For avocados, a tensiometer station should have a 12" and a 24" instrument placed within 6" to 1' of each other inside the wetted area. Stations should be set up in both the driest (usually the highest) and the wettest areas to balance the irrigation. When properly placed, these instruments will measure the amount of energy that a plant exerts to extract moisture from the soil. They should be placed in an area where the tree roots are active.

The shallow instrument tells when to irrigate. The deep instrument tells how long to irrigate. The length of time to irrigate is determined by the number of hours required to cause the deeper instrument to respond to the water being applied. When the deep instrument's reading drops to 10, there is sufficient moisture 24" down. Using drip irrigation, tensiometer readings of O to 15 indicate adequate moisture is available for good tree growth. When the shallow instrument shows a reading of 15, it is time to irrigate, because the drip system does not provide as large a reservoir of moisture for the tree as a sprinkler with its larger coverage area. Using a sprinkler system, a reading of 0 to 30 indicates adequate moisture, but when the tensiometer reads 30, it is time to irrigate.

Poor quality
Figure 19. Instruments used to measure moisture contents in soil. Shown are 12- and 24-inch tensiometers and a soil tube for taking core samples.

These instruments are easily damaged because they are rather delicate. Covering them with an old bucket or a picking box may protect them from grove operations and also from any possible cold damage that might occur during an unusual freeze. As the trees grow and emitters are added

or sprinklers are changed to increase the wetted area, tensiometer stations will need to be relocated appropriately.

If you plan to invest in and use tensiometers to measure soil moisture, it is probably prudent to ask the tensiometer company field man to participate in planning the location and installation of the instruments at the selected stations, even though you know that they will have to be relocated several times until the trees mature. You will also want to acquire a service kit to enable you to check the vacuum and to renew the colored water in the instrument. By regularly taking readings, charting the data, and servicing the instruments, a grower can come to a better understanding of his or her land.

B. A soil tube is a T-shaped instrument made of quality steel and available in any good grower supply house. On its tip end it has an extra hard cutting edge to remove a core sample from the soil into the lower segment of the tool (the tube) so that it can be examined. A word of caution concerning this fine tool: growers often damage their soil tubes by forcing them into dry soil. There must be some moisture in the soil to permit the use of this instrument.

To determine the soil moisture remaining before irrigation, use a shovel, auger, or other method of determining soil moisture, and sample the soil at six- to twelve-inch intervals in the root zone. Table 8 may be used to estimate the percent of water depleted, based on the soil texture. The amount depleted is the net amount that should be replaced by irrigation. The gross amount of water to be applied is determined by dividing the net amount by the irrigation application efficiency for the field based on the irrigation system and management.

Twenty-four to 48 hours after irrigating, the depth of water penetration can be checked at various points throughout the field by probe or auger to determine the uniformity of the application and the adequacy of irrigation.

The most common way to estimate available soil moisture is by the “feel” method.

Table 8

GUIDE FOR ESTIMATING DEPLETED SOIL MOISTURE BY THE "FEEL" METHOD

Soil AWC depleted	Feel or Appearance of Soil			
	Coarse Texture	Moderately Coarse Texture	Medium Texture	Fine and Very Fine Texture
75 - 100 percent depleted	Dry, loose, single grained, flows through fingers.	Dry, loose, flows through fingers.	Powdery dry, sometimes slightly crusted, but easily broken down into powdery condition.	Hard, baked, cracked, sometimes has loose crumbs on surface.
50-75 percent depleted	Appears to be dry, will not form a ball with pressure. 1/	Appears to be dry, will not form a ball. 1/	Somewhat crumbly, but holds together from pressure.	Somewhat pliable, will ball under pressure. 1/
25-50 percent depleted	Appears to be dry, will not form a ball with pressure.	Tends to ball under pressure, but seldom holds together.	Forms a ball somewhat plastic, will sometimes slick slightly with pressure.	Forms a ball, ribbons out between thumb and forefinger.
0-25 percent depleted	Tends to stick together slightly, sometimes forms a very weak ball under pressure.	Forms weak ball, breaks easily, will not slick.	Forms a ball, is very pliable, slicks readily if relatively high in clay.	Easily ribbons out between the fingers, has slick feeling.
0 percent depletion (soil is at field capacity)	Upon sqeezing, no free water appears on soil, but wet outline of ball is left on hand.	Upon sqeezing, no free water appears on soil, but wet outline of ball is left on hand.	Upon squeezing, no free water appears on soil, but wet outline of ball is left on hand.	Upon squeezing, no free water appears on soil, but wet outline of ball is left on hand.

1/ Ball is formed by squeezing a handful of soil very firmly.

Because the core sample will reveal moisture conditions as well as clay pockets in the soil, the soil tube can be used to identify problem areas for special water management.

In avocado growing areas, the high ground is likely to be thin and porous, while on the lower levels and in the swales the soil is apt to be tighter and less permeable. In any event, with avocados, we are primarily concerned with the available moisture in the first two feet of soil. Remove the soil from the tube and squeeze it in the palm of your hand. If one can make a satisfactory “ball” of the sample, in much the same way that children’s modeling clay can be balled, it indicates that there is sufficient moisture in the soil for good tree growth. If the soil crumbles when compressed, the tree has insufficient moisture available and should be irrigated. Samples should be taken at both the one- and two-foot depths, using the same procedure for each sample. With a little practice and careful observation, the grower can soon map his grove for the different types of soil that are found on his land.

This writer favors the use of a soil tube for measuring soil moisture, especially coming into or leaving the rainy season, when there is sufficient moisture to avoid damaging the tool. During the wet season, the soil tube should be used on the sunny side of the tree because this soil dries out faster.

C. The soil augur is also a T-shaped instrument, and is similar in appearance to the soil tube described previously. It is seldom found in stores but is a more versatile tool inasmuch as it can be used in dry soils without injury to the tip. It is easy to make, or have made, is lightweight, and can be conveniently carried and stored. It is used in the same way as the soil tube, described previously.

To make an augur, take a 4' length of ½" pipe or reinforcing steel and another 18" length of the same material. Weld the short length in the center to one end of the long piece. Buy a 3/4" steel bit (for boring holes in wood) and grind off the 3/8" tip used to draw the bit into the wood. Weld the shaft to the other end of the long piece. To use it, simply twist the bit into the ground to the required depth, remove the soil from the bit, and test as indicated for the soil tube.

Note that the ½" pipe is lighter to carry than the solid steel shaft but is not as strong and more easily bent.

D. An evaporation pan is a plastic tray, such as the one used for dishwashing, commonly available in supermarkets, drug stores, and general merchandise stores. It need not have any specific dimensions but should be a minimum of 4" deep to allow for a volume of water large enough that the water doesn't evaporate completely between readings. The pan should be placed in the grove so that the prevailing winds pass over it. It should be as nearly level as possible and located so that it will be in direct sunlight part of the day and shaded the other part. A piece of 1" mesh hardware cloth should be placed over the pan to prevent animals and birds from depleting the water supply, which would give false readings. By occasionally adding a small quantity of common household bleach, the scum that collects on the pan and the water can be controlled.

The amount of moisture lost in the evaporation pan is a good indicator of the moisture removed from the soil by foliar evaporation. The moisture loss in the pan should be checked at regular intervals, preferably once a week on the same day at the same time. The water loss from the pan can be determined in two ways:

1. By making marks ½" apart on the inside edge of the pan. For example, if 1" of water has evaporated, the soil might require a two-hour irrigation to replenish the soil moisture. The type of irrigation system used and the soil type will make considerable differences in the length of irrigation time.

2. Using a standard measure, determine how many cups of water are needed to refill the pan to the required level. If, say, 8 cups are needed, it might indicate a 4-hour irrigation; if 4 cups are needed, a 2-hour irrigation.

Though not quite as accurate as the tensiometer, the evaporation pan is easy to use, and even the most casual observer can soon become familiar with its meaning.

Water Conservation Practices

Our avocado and citrus growers have been practicing water conservation for a long time because of the high cost of water. For many growers, it will be difficult to become more efficient than they are already. However, there is always something we can do to "tighten up" and affect some savings. The following practices can lead to water savings if you do not already have them in place.

1. Control weeds in the area of the trees' root system.

2. Use mulches (straw, manure, wood chips, sawdust, compost, etc.) to prevent water loss from the soil surface. Mulches also help prevent the runoff of irrigation water and serious soil erosion.

3. Learn the daily water requirement of the plant. Apply only the required amount, either by daily application with drip irrigation, or weekly application with sprinklers.

4. Irrigate in the early morning, late afternoon, or at night to obtain the best watering pattern and uniformity of water distribution. Do not irrigate with spitters or sprinklers during windy periods, as this increases the evaporative losses.

5. Repair leaks in irrigation lines and valves. Replace worn orifice tips of sprinklers.

6. Control gophers. Destroy gopher and mole runs that take water away from the root zones of trees.

7. Leaching for salinity control should be done carefully. Salts in soils and irrigation water decrease the ability of plants to take up water. As salts become concentrated in the soil, the result is poor uptake of water by plants and a toxic effect on plants. Frequent irrigation with periodic leaching is a must for avocados.

8. Maintain good fertilizer practices, as a healthy tree is a more efficient user of moisture.

9. Install tensiometers as a guide to proper and efficient irrigation.

10. Learn how to measure the water applied.

Salt Accumulation and Leaching

The irrigation water used in our avocado groves contains dissolved salts, especially chlorides, which accumulate in the soil and produce the common malady on tree leaves during the late summer and fall known as "tip burn." These salts impair the normal functions of the plant, but if the salts are in a sufficiently diluted state they are much less apt to be picked up by the plant. Salt accumulation may be reduced by several deep, leaching irrigations that will push the salts below the first two to three feet of the soil where 90% of the roots are located. A rule of thumb for leaching might be a 25% to 50% increase in irrigation time three times during the irrigation

season. Winter rains are usually sufficient to leach the salts below the root zone, but anything less than a 2" rain may only move them into the lower portion of the root zone. Unless there is sufficient rain to leach the salts below the root zone, it is best to continue the normal irrigation schedule.

A method sometimes called "water bumping" may be used to more efficiently leach the salts below the root zone. This process is accomplished by giving the trees a normal irrigation, and two days later a second normal irrigation. The first irrigation wets the soil to the usual depth but the second "bumps" the water, with its accumulated salts, down below the root zone. This method has been found to greatly improve water penetration, particularly in the heavier soils.

Measuring Irrigation Water

Efficient water management is very important. To become a better water manager, you must be familiar with water measurements. Learning water measurement terms and how much water plants require will help you: 1) conserve water, 2) produce maximum yields from water used, 3) prevent poor growth because of insufficient water application, and 4) reduce drainage problems caused by too much water.

Irrigation water is measured in volume and rate of flow units. The commonly used volume units include cubic feet, gallons, acre-inches, and acre-feet. Rate of flow is the combination of volume units with a convenient unit of time. Those commonly used are: cubic feet per second, gallons per minute, acre-inches per hour, acre-feet per day (24 hours), and miner's inches. Because miner's inches vary in different localities, they may not always be a satisfactory reference. Data given in miner's inches can be converted to cubic feet per second or gallons per minute.

Table 9

APPROXIMATE EQUIVALENTS

Volume Units		Rate of Flow Units	
One acre-inch		One cubic foot per second	
= 3,630.	cubic feet	= 450.	gallons per minute
= 27,154.	gallons	= 1.	acre-inch per hour
= 1/12	acre foot	= 2.	acre-feet per day (24 hr.)
One acre-foot		One gallon per minute	
= 43,560.	cubic feet	= .00223	cubic foot per second
= 325,851.	gallons	= .00221	acre-inch per hour
= 12.	acre-inches	= .00442	acre-foot per day (24 hr.)
		= 1.	inch depth over 96.3 square feet in one hour
One cubic foot			
= 1,728.	cubic inches	One Southern California miner's inch	
= 7.5	gallons	= .02	cubic foot per second
= 62.5	pounds	= .02	acre-inch per hour
One gallon		= .04	acre-foot per day (24 hr.)
= 231.	cubic inches	= .80	Calif. statutory miner's in.
= 0.1337	cubic foot	= 9.0	gallons per minute
= 8.33	pounds		

APPROXIMATE FORMULAS FOR CALCULATING DEPTH OF WATER APPLIED TO A FIELD

$$\frac{\text{Cubic feet per second} \times \text{hours}}{\text{Acres}} = \text{Acre-inches per acre (depth in inches)}$$

$$\frac{\text{Gallons per minute} \times \text{hours}}{450 \times \text{Acres}} = \text{Acre-inches per acre (depth in inches)}$$

FERTILIZER ELEMENTS

Photosynthesis

Though not a fertilizer, the plant's ability to utilize these elements is directly connected with the manufacture of carbohydrates by the chlorophyll containing tissues (chloroplasts) when exposed to the sun's light and heat rays. In years of exceptionally cool winters and wet springs, we often note a yellowing of avocado leaves, a condition sometimes called winter chlorosis, which is due to the absence of photosynthetic activity because of a lack of sunshine. This condition will remedy itself when the rains diminish, the weather warms with an increase in the solar insolation. This winter chlorosis is pronounced in trees three to seven years of age but is not generally found in older trees.

Avocados enjoy a soil pH in the neutral range of 6.5 to 7.0, which is true for most agricultural crops. Growers have recognized that using only one fertilizing material continuously tends to make the soil unhappy in the pH department. Therefore, the use of only one source of nitrogen should be avoided. For example, growers who use inorganic fertilizers (nitrogen manufactured synthetically by man) can balance their applications by using calcium nitrate in the spring when the soil, water, and temperatures are cool.(Calcium nitrate performs well under cool conditions.) In the summer, growers can switch to urea because the warmth tends to speed up its biological conversion to the nitrate form. The cost of rotating fertilizers is about the same as using ammonium nitrate all through the growing season. If the soil in a grove has become overly acidic by the continued use of urea fertilizer, it may be brought back to neutral by the use of calcium nitrate, which tends to increase the alkalinity of the soil. Conversely, if the soil is too alkaline, ammonium sulfate will acidify the soil. Ammonium nitrate and urea will also produce an acidic condition to a lesser degree, which can bring the soil back to a neutral condition.

This chart shows how soil PH affects the availability of plant nutrients and the relative availability of plant nutrient elements at various pH levels. Growers will note that a pH between 6.5 and 7.5 fosters the maximum availability of the primary nutrients -- nitrogen, phosphorus, and potassium (N, P, and K) -- and a relatively high degree of availability of other nutrient elements.

Essential Plant Elements

Sixteen chemical elements have been proven to be absolutely essential for plant growth and reproduction. The major elements (or macronutrients) are needed in relatively large quantities by plants; the minor elements (or micronutrients) are no less essential but are needed in much smaller quantities. Carbon, hydrogen, and oxygen are the building blocks of carbohydrates and fats. These elements, plus nitrogen and sulfur, are found in proteins. Phosphorus is essential in the energy transfers of cells and also occurs in the cell genetic material. Calcium is a constituent of pectic materials, which help hold cells together. Magnesium is the central atom of the chlorophyll molecule in the cells of green plants. The role of potassium is not yet understood, although it has been clearly demonstrated that plants will not grow without it. (MLA: Is the

previous statement about potassium still accurate? Thanks, sm) Iron is required for the formation of chlorophyll and in the oxidation reactions of the cytochrome chain. Several of the other minor elements function in enzymatic reactions necessary for plant growth. The most important of the macronutrients are nitrogen, phosphorus, and potassium, with nitrogen as the most important element in soils. Although some plants fix nitrogen directly from the air, it is not known to be fixed by the avocado. These elements are usually supplied by growers to provide the nutrients for good crop production, either in the form of "complete" chemical fertilizers or from an organic source.

Table 10

MAJOR ELEMENTS FROM AIR AND WATER	MAJOR ELEMENTS FROM THE SOIL	MINOR ELEMENTS FROM SOIL
CARBON	NITROGEN	IRON
HYDROGEN	PHOSPHORUS	ZINC
OXYGEN	SULFUR	MANGANESE
	POTASSIUM	COPPER
	CALCIUM	CHLORINE
	MAGNESIUM	BORON
		MOLYBDENUM

Nitrogen (N)

Of the three macronutrients, the principal demand in avocados is for nitrogen. Nitrogen fertilizers come to us in a number of forms and percentages but primarily in the dry form. "Actual" nitrogen refers to the real quantity of nitrogen present after adjustments for form and percentage. For the grower who wants to determine the actual percentages and the cost of the nitrogen, Table 11 gives several sources of nitrogen together with the formula to compute the percentages and cost.

Of special interest to growers are the bacteria found in the soil which oxidize ammonia (NH_4) first to the nitrite form (NO_2) and then to the nitrate form (NO_3) for use by the plants. Nitrate is the form of nitrogen that plants use for growth and development. Nitrates are highly soluble and subject to leaching through the soil profile and therefore need to be replenished regularly through fertilization.

FORMS AND TRANSFORMATIONS OF NITROGEN

Dr. James P. Martin, Soil Microbiologist
University of California, Riverside

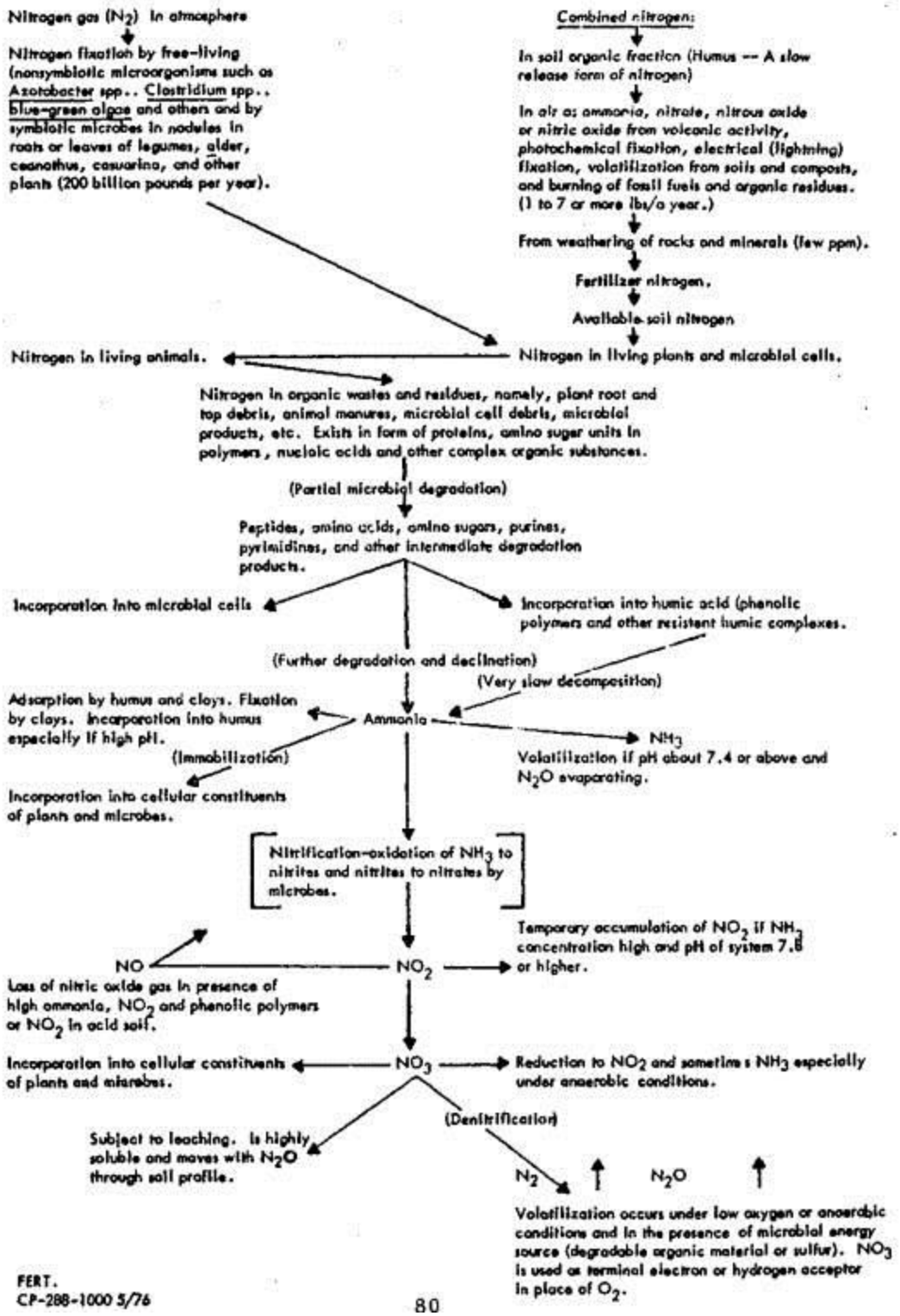

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Table 11
COMMON NITROGENOUS CHEMICALS

Material	Percentage Nitrogen	Pounds Needed to supply 100 lbs. of elemental nitrogen
Calcium nitrate	15.5	645
Ammonium nitrate	33.5	335
Ammonium sulfate	20.5	488
Anhydrous ammonia (gas)	82	122
Urea	45-46	217-222

To find cost per pound use this formula:

$$\frac{\text{Cost per ton} \times 100}{\text{percent nitrogen} \times 2000 \text{ lbs.}} = \text{Cost per pound of elemental nitrogen}$$

Example: Ammonium nitrate, $86.00 per ton, 33.5% nitrogen, gives:

$$\frac{\$86.00 \times 100}{0.335 \times 2000} = \$0.13 \text{ per pound of elemental nitrogen}$$

Example: Urea, $200 per ton, 46% nitrogen

$$\frac{\$200 \times 100}{0.46 \times 2{,}000} = 21.7¢ \text{ per pound of elemental nitrogen}$$

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Phosphorus (P)

This element promotes root growth, fruit development, and maturity, and seems to contribute to the plant's general hardiness. Most of the sandy loam and clay loam soils seem to have sufficient phosphorus for the avocado; however, in the inland areas among the coarser granite soils, lack of phosphorus can be a limiting factor for good growth, and fertilizers containing phosphorus should be applied. This element tends to remain immobile in the soil until used by the plant.

Potassium (K)

The role of this element in avocado nutrition is not clearly understood. It is believed to make the plant more resistant to diseases, cold, and adverse conditions in general. It is relatively immobile in the soil.

FERTILIZING

When young avocado trees have been in the ground for about four weeks, a fertilizing program should be started. If young trees are treated liberally with fertilizer, mulch, and water, it is quite possible for the tree to put on two year's growth in one year.

Fertilizing Through Drip Systems

Nitrogen fertilizers can easily pass through an emitter or a sprinkler. Fertilizers that are often referred to as "complete" (N-P-K), such as 15-15-15, 16-20-0, and 10-10-10, come in prilled or pelleted form and will clog the irrigation system. Liquid forms, which include P and K and are mixed in bulk by a fertilizer firm, are made from materials that are soluble and will pass through an irrigation system readily. These fertilizers are inserted into the irrigation water by a mechanism at the water head that injects them, either by a pump or by water pressure differential, into the system.

As a rule, drip irrigation systems include a fertilizer injector (also called an applicator), and if so, the nitrogen requirements can be divided into 40 applications per year to correspond to the typical number of irrigation weeks in the year. The same amount is applied once in each of those 40 weeks. This is a fertilizing plan trees will like. Ranches with systems that lack injectors should be encouraged to insert them in their systems because of labor savings and tree response.

Fertilize cautiously. If you correctly plant and carefully water young trees and the trees fail to exhibit good growth, you may need to apply nitrogen. You can supply this by following the fertilizer schedule for drip irrigation in table 12.

TABLE 13.NITROGEN FERTILIZATION OF AVOCADOS.

TREE AGE	NITROGEN PER TREE PER YEAR	AMOUNT OF MATERIAL PER TREE PER MONTH FOR 8 MONTHS				
		Dry			Liquid	
		Urea (46% N)	Ammonium Nitrate (33% N)	Calcium Nitrate (15.5% N)	Ammonium Nitrate Solution (20% N)	Urea-Ammonium Nitrate Solution (32% N)
		(pound)			(fluid ounces)	
1	1/10	0.03	0.04	0.08	0.76	0.45
2	1/5	0.05	0.08	0.16	1.51	0.90
3	1/3	0.09	0.13	0.27	2.50	1.49
4	1/2	0.14	0.19	0.40	3.75	2.26
5	1	0.27	0.38	0.81	7.57	4.51

How to use table: Determine tree age and the factor for the material you plan to use. Multiply the factor by the number of trees to be irrigated. Add that number of pounds or fluid ounces to the injector tank of the drip irrigation system.

Example: You have 172 trees that are 3 years old and you want to use urea. For a 3-year-old tree, the factor for urea is 0.09. Therefore, 0.09 x 172 equals 15.5 pounds of urea. As a rule, about 7 pounds of dry material can be dissolved in 1 gallon of water. If you use urea-ammonium nitrate solution, the factor is 1.49. Therefore, 1.49 x 172 trees equals 265.3 fluid ounces or 2 gallons of urea-ammonium nitrate solution. (Note: 1 gallon contains 128 fluid ounces.)

Fertilizing by Hand and by Sprinkler System

In a sprinkler system, regrettably, there is not apt to be a fertilizer injector to introduce the fertilizer into the system. This necessitates feeding by hand -- a costly, long-term labor proposition.

Hand feeding is the broadcasting of dry (prilled) fertilizing materials under the tree near the drip line and within the sprinkler irrigation pattern. Most of the tree's feeder roots are out and away from the tree trunk, so fertilizer placed near the trunk will not benefit the tree. As the trees are irrigated, the fertilizer on the ground is dissolved by the water and is made available to the tree.

February is a good month to fertilize avocado trees if you are on a twice-a-year program. University recommendations for hand feeding avocado trees irrigated by a sprinkler system are given in Table 13.

As the trees become larger and older, growers can reduce the frequency of feeding and increase the dosage of individual applications. You can satisfy the trees' demand for (nitrogen) fertilizer through twice-a-year applications beginning in about the sixth year.

For adult Fuerte avocados, field research data suggests that about 150 pounds of actual nitrogen per acre per year will give the best production results. Too much nitrogen can be as detrimental to Fuerte production as too little is. Though research on the nitrogen requirements of Hass and other Guatemalan-type avocados has not been extensive, it is generally believed that twice the Fuerte recommendations may be about right for the Hass variety.

Table 13

1st year -	1 tablespoon of nitrogen fertilizer each 3rd irrigation
2nd year -	1/8 lb. nitrogen each year
3rd year -	1/4 lb. " " "
5-7 years -	1/2 lb. " " "
8-9 years -	3/4 lb. " " "
10-14 years -	1 lb. " " "
15+ years -	1½ lbs. " " "

It should be noted that there is a body of thought called "organic growing," or "natural growing," in which the use of synthesized sources of nitrogen are held in distain. The use of bulky organic material and/or concentrated organics is preferred. Examples of each are rabbit manure and blood meal, respectively.

On thin, Cieneba-type soils, the use of organic materials especially improves the soil environment by promoting better tilth, hastening humus build up, and enhancing water infiltration to the plant. The cost of labor and materials is high compared to the use of inorganic fertilizers, but young trees really enjoy such an environment.

When considering the use of organics for fertilizing avocados, supplemental nitrogen sources (such as heavy applications of blood or fish meal) may be necessary, because all of the other bulky organic materials may not provide the necessary requirements for nitrogen.

FERTILIZER-Analyses
CP-18-500-1/74
D. H. Close
Farm Advisor

Cooperative Agric. Extension
University of California
Bldg. 4, 5555 Overland Avenue
San Diego, California 92123

Table 14

AVERAGE ANALYSES OF FERTILIZERS

Bulky Organic Materials

Kind	Per Cent Nitrogen N	Per Cent Phosphorous P_2O_5	Per Cent Potassium K_2O	Organic Matter	Cu.Ft. per Ton	Pounds per Cubic Foot Total	N	O.M.	O.M.-N Ratio
Dairy manure, poor	.5			25	45	44.4	.22	11	50
Dairy manure, average	.7	.30	.65	30	55	36.4	.25	11	43
Dairy manure, good	.9			40	65	30.8	.28	12	45
Dairy manure, best	1.10	.55	1.90	50	70	28.6	.29	14	50
Steer manure	2.0	.54	1.92	60	70	28.6	.57	17	30
Horse manure	.7	.34	.52	60	75	26.7	.19	16	86
Hog manure, feed lot	2.0			60	70	28.6	.57	17	30
Hog manure, ordinary	1.0	.75	.85	30	60	33.3	.33	10	30
Sheep manure	1.6	1.50	1.50	50	70	28.6	.46	14	30
Rabbit manure	2.0	1.33	1.20	50	70	28.6	.57	14	25
Poultry droppings	4.0	3.2	1.9	74					
Poultry manure #1	2.5	2.50	1.2	60	55	36.4	.91	22	24
Poultry manure #2	1.6	1.25	.9	50	50	40.0	.64	20	30
Septic sludge	2.5	1.50	1.50	50					
Seaweed (kelp)	.2	.1	.6						
Alfalfa hay	2.5	.50	2.10	85					
Alfalfa straw	1.5	.30	1.50	82					
Bean straw	1.2	.25	1.25	82					
Grain straw	.6	.20	1.10	90					
Cotton bolls	1.0	.15	4.0	80					
Winery pomace	2.0			80					
Olive pomace	1.2	.8	.5	80					

Concentrated Organics

Kind	N	Per Cent P	K	O.M.
Dried Blood	13			80
Fish meal	10.4	5.9		80
Nitrogenic	6.5	3.4	.3	80
Tankage	7.0	8.6		80
Cottonseed meal	6.5	3.0	1.5	80
Bat guano	5.0			30

Zinc (Zn)

Although classed as a “minor element,” the metallic element zinc is essential for plant growth, and any discussion of fertilizing avocados must include it. After soil applications, zinc remains immobile in the soil and will stay right there until the shallow rooted avocado comes to get it. Without small but essential amounts of zinc, the tree may decline and even die.

Zinc deficiency is often called “mottle leaf” and occurs in many orchards in southern California. The earliest symptoms are a mottling of the leaves on a few of the terminal branches. The areas between the veins are a light green to pale yellow. As the deficiency progresses, the yellow areas get larger and the new leaves produced are smaller. In the advanced stages, a marginal burn develops on these stunted leaves, twig dieback occurs, the distance between the leaves on the branches is shortened, and the terminal shoot takes on a “feather duster” appearance. Tree yield is reduced and some fruits may be more round-shaped than is normal.

For soil application, growers should use zinc sulfate (ZnSO4) 36% granular, which comes packed in 50-pound bags. This is applied in an 18” wide band around the drip line of the tree and is watered into the soil. If any of the zinc fails to be in the watering pattern of the sprinklers, the rains will carry it into the root zone. The recommended application will sustain the tree for 3 to 5 years. Soil application is most effective during the months of June and July but may be applied anytime. The correction of zinc deficiency can usually be affected within one year when a soil application is used. Table 15 shows the recommended amounts of zinc sulfate containing 23-28% metallic zinc. Reduce amounts by 1/3 if zinc sulfate containing 31% or greater metallic zinc is used.

Table 15

Age trees - years	Pounds per tree
2	1
5	3
10	5
15	8
20	10

Foliar application requires the use of zinc sulfate dust, which is dissolved in water and sprayed on the foliage. Zinc deficiency can be corrected faster with foliar application provided the tree has sufficient foliage. Leaf uptake of zinc is most satisfactory when spring flush leaves have nicely expanded, which usually means spraying should occur in late May or June. With a continuous annual maintenance spray program, foliar application may prove the cheapest method of zinc application in the long run, even though in heavy crop years it may be desirable to apply zinc twice a year. Growers should be cautioned that zinc sulfate dust hardens into rock if an unused bag is left on the shelf, so it should be used immediately after opening.

The avocado industry has recently moved into using helicopters and fixed wing aircraft for foliar application of zinc because it tends to be cheaper and easier, and eliminates the grower's need to own a spray rig.

Chelated forms of zinc may be applied through the drip watering system, but this is a relatively new method. The industry is still awaiting data on the benefits of zinc when applied to trees through an injector. Chelated forms of zinc may correct a deficiency, but appear to have no advantage over zinc sulfate and are more costly.

Other Nutrients

We have not recognized other nutrient deficiencies in California avocados, but as we move into more of the Cieneba-type soils or thinner soils, the need for more of every nutrient has become apparent. Be aware that needless applications of phosphorous can induce zinc deficiency or cause it to become more severe.

In the last 15 years in north San Diego County, growers have planted up the slopes and into the Cieneba-type soils that are excessively well drained and very shallow. These soils are quite satisfactory from an avocado point of view, but may require more of everything that the tree wants, i.e. moisture, nutrients, and mulch to improve the tilth of the soil. Under these conditions, growers have found more potassium deficiency than in the soils planted to avocados in the past. Therefore, when a leaf analysis is ordered, phosphorous and potassium should be part of the analysis report in addition to nitrogen and zinc.

Leaf Analysis

Leaf analysis has progressively become a more useful tool in crop management, as it provides growers with a recommendation for the following year's fertilization program. Although nitrogen is usually the deficient element in our soils, growers are urged to order annual analyses that include nitrogen, phosphorous, potassium, and zinc readings. A written report, which indicates the nutrient deficiencies, is returned to the grower. Leaf analysis is usually begun near the end of the tree's fourth year in the ground.

Table 16
RANGES OF ELEMENTS IN AVOCADO LEAVES

Ranges for mature trees*

Deficient:			Excess:		
Elements		Unit	Less than	Adequate	More than
Nitrogen	(N)	%	1.6	1.6 -2.0	2.0†
Phosphorus	(P)	%	0.05	0.08-0.25	0.3
Potassium	(K)	%	0.35	0.75-2.0	3.0
Calcium	(Ca)	%	0.5	1.0 -3.0	4.0
Magnesium	(Mg)	%	0.15	0.25-0.80	1.0
Sulfur	(S)	%	0.05	0.20-0.60	1.0
Boron	(B)	ppm‡	10-20	50-100	100-250
Iron	(Fe)	ppm	20-40	50-100	?
Manganese	(Mn)	ppm	10-15	30-500	1,000
Zinc	(Zn)	ppm	10-20	30-150	300
Copper	(Cu)	ppm	2-3	5-15	25
Molybdenum	(Mo)	ppm	0.01	0.05-1.0	?
Chloride	(Cl)	%	?	?	0.25-0.50
Sodium	(Na)	%	-	-	0.25-0.50
Lithium	(Li)	ppm	-	-	50-75

*Based on analysis of the most recently expanded and matured, healthy, terminal leaves from nonflushing and nonfruiting terminals sampled during mid-August to mid-October. (These are normally leaves from the spring growth cycle.) Values expressed on a dry-matter basis.
†Values above 2% N will not increase yield in most varieties; however, a reduction in yield of the Fuerte variety may occur above that level.
‡ppm, parts per million.

Many agriculturists are available to aid growers in the area of plant nutrition. Prudence suggests securing the services of a specialist well before August because specialists and the testing labs are likely to be very busy producing reports until the Christmas season. Because testing and writing reports is a time consuming process, growers should not be dismayed if the report does not reach them before 15 January. This time lapse should not present any problem because growers should not begin fertilizing before 15 February in any case. So, to be on the safe side,

arrange for your testing in July so that the firm performing the service can properly book the time.

Leaves for testing are selected from 15 August through 15 October from the most recently expanded and mature, healthy, terminal leaves from non-flushing and non-fruiting branches. Leaves must be from the spring growth cycle and not from the summer growth flush. These leaves are sent to the laboratory where they are dried and analyzed for nutrients, the report giving the fertilizer recommendations for the next year is derived from this analysis for the grower. Of course, growers can train themselves to make the leaf selections, but it is usually best to employ a firm specializing in this field so that the material will give a more accurate reflection of the needs of the grove.

The major consideration for the typical avocado growing area will be nitrogen expressed as a percent (%) of dry matter. Table 17 shows the percentages for several varieties of avocados.

Table 17
SUGGESTED NITROGEN LEVELS IN AVOCADO LEAVES

Variety	Percent nitrogen in leaf*
Fuerte	1.6 to 2.0
Zutano	1.6 to 2.0
Hass	about 2.0
Bacon	about 2.0
MacArthur	2.0 (if attainable)

*Levels in 5- to 7-month-old spring-cycle leaves from mature trees.

WEED CONTROL

Weeds are the bane of growers of all crops (Fig. 20). They rob moisture and nutrients from the cultivated plants, obscure gopher mounds, and provide a haven for snails -- all things that are detrimental to healthy crops. On the other hand, some crops benefit from the companion planting effect of weeds that seem to enhance the growth of a particular crop. They provide significant erosion control by breaking up heavy raindrops, while their roots permit the water to percolate to lower depths than would otherwise be the case. Over the years, weeds will provide mulch for the soil that will greatly improve the tilth. As the mulch breaks down, it will add humus to the soil and gradually build a layer of topsoil. Weeds also provide a habitat for beneficial insects. When the overhead tree canopy becomes so dense that sunlight cannot penetrate to the grove floor, weeds and grasses tend to die out.

In our southern California climate, excessive weed growth may pose a fire hazard during the dry summer and fall months, so weeds must be controlled. On some of the very steep slopes that are now being planted, this creates a serious problem. Several methods of weed control will be explored, but all are basically manual or chemical non-tillage methods that reduce damage to the tree’s shallow roots and control soil erosion.

Poor quality
Figure 20. Bermuda and other grasses and weeds are out of control in this Macadamia grove.

By machinery

On slopes that are not so steep as to preclude the use of equipment, weeds may be mowed. Mowers come in many types: the sickle bar, the gas powered, hand pushed lawnmower, or the heavy duty machine, such as the "Bush Hog," which can cut 6' or more at a time and is tractor drawn. A relatively new type of mower, called a "Weed Eater" or "Green Machine," is gas-powered, handheld, carried with a strap over the shoulder, and equipped with saw blades or mono-filament nylon cords. Some of the more expensive models can use both interchangeably. While using mechanically powered machines definitely saves time over the hand control methods, it is prudent to be very careful around young trees, irrigation risers, drip tubing, and anything else that can be quickly damaged when the mower gets too close to it.

By hand

Hand control methods may include cutting weeds with a scythe, a sickle, a weed whip, or a hoe. This writer is one of those growers who favor the use of a "push hoe," especially around young trees, because there are fewer disturbances of the roots and mulch as contrasted with weed pulling or conventional hoeing. It is also easier, requiring one to go only 1/8" below the soil surface to do a good job. On steep hillsides it is tough to beat a very short man with a very long machete.

By herbicide

The primary method of herbicide application is a sprayer. Sprayers range in size from hand-held units and backpacks to truck-towed or self-propelled rigs capable of spraying a large area with each fill. Regardless of the size, most sprayers have some type of an agitator to keep the materials in suspension and provide even coverage. After use, the sprayer should be emptied of any residual spray material and thoroughly washed out before storage, even for so short a period as overnight. Otherwise, the spray will clog the lines, making it nearly impossible to clean them out sufficiently so that sprays may move through them again.

Herbicides that control unwanted plant growth are available from chemical supply houses and are generally applied with mechanical sprayers (Fig. 21). These spray rigs are mounted on a truck or trailer and are capable of being used for herbicides and pesticides, and give the operator a selection of nozzle pressures and patterns.

When purchasing herbicides, be sure to buy only materials that have been registered for avocados. Some hazardous chemicals, like Paraquat®, will also require a use permit from the Agricultural Commissioner's office in your area.

Poor quality
Figure 21.

Dorothy and Larry Bean preparing to apply herbicides to the weeds in their grove. Larry is driving his pride and joy, his homemade tractor.

Three classes of herbicides are useful to the avocado grower: 1. Contact killers such as weed oil and Paraquat®, which kill only what they touch. 2. Systemic killers that penetrate the plant tissues, translocate to the roots, and cause the whole plant to die. An example is Roundup®. 3. Princep, a pre-emergent spray, will kill seeds in the soil that would germinate the next season. Pre-emergent herbicides must be watered in, so their use should be late in the season to take advantage of the fall rains.

Surfactants or spreaders are added to the herbicides to avoid the "dewdrop" effect, permitting the material to better adhere to the plant and give coverage. Some of the contact and pre-emergent herbicides are compatible and may be used together to good advantage. Pre-emergents should not be used around young trees under two years of age. If weeds can be mowed a week before spraying with weed oil or Paraquat®, they will dry enough that less spray material is needed to effect a better kill. Growers on steep hillsides tend to strip spray the tree rows, leaving some weed growth in the aisles for erosion control. A good spray application around piping that emerges from the soil will make it more visible and thus avoid breakage and damage from machinery.

Since Roundup® has been registered for avocados and the "Herbie" spray system has come on the scene, growers have another weed control option to benefit from. Roundup® is less effective when plants are dormant but provides a good kill when they are in active growth. Read the label for best results.

TABLE 18

ORCHARD OPERATIONS CALENDAR

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Irrigation	//////////	//////////	//////////	//////////	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX	//////////
Fertilization	XXXXXXX				XXXX							
Minor Elements		XXXXXXXX								//////////		
Pest Control			//////////						XXXXXXXXXXXXX			
Replanting	Fumigate soil	XXXXXXXXXXXX										
Ant Control			XXXXXXXXXXXX	//////////	//////////	//////////	//////////	//////////				
Leaf analysis									XXXXXXXXXX			
Rodents	Check Monthly	XXXXXXXXXXXX										
Weed Control												
Oil spray	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX											
Simazine		XXXX								XXXXXXX		
Mow	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX											
Frost Protection	XXXXXXXX								Check equip- ment	Test ther- mometersXX		
Topworking	XXXXXXXX											
Orchard Thinning	after harvest											
Pruning	XXXXXXXXXXX											
Harvest	FUERTE	FUERTE	HASS	HASS	HASS REED	HASS REED	HASS REED	HASS REED	BACON ZUT.	BACON ZUT. FUERTE		
Equipment Repair	AS NEEDED		/Frost// /Equip-/ /ment///						Check farm equipment			
Material	New Trees	Pest Control	/Frost/// /Equip-/ /ment///		/Pest/ /Con-/ /trol/					/Fer-/ /til-/ /izer/	Sprink-/ lers,/// Pipes///	
Record Keeping	Plans								YIELD		Summary Inven- tory	

XXXXXX Recommended Time ////// May be necessary

PESTICIDE USE WARNING—READ THE LABEL

Pesticides are poisonous and must be used with caution. READ the label CAREFULLY BEFORE opening a container. Precautions and directions MUST be followed exactly. Special protective equipment as indicated must be used.

STORAGE: Keep all pesticides in original containers only. Store separately in a locked shed or area. Keep all pesticides out of the reach of children, unauthorized personnel, pets and livestock. DO NOT STORE with foods, feeds or fertilizers. Post warning signs on pesticide storage areas.

USE: The suggestions given in this publication are based upon best current information. Follow directions: measure accurately to avoid residues exceeding tolerances, use exact amounts as indicated on the label or lesser amounts given in this publication. Use a pesticide only on crops, plants or animals shown on the label.

CONTAINER DISPOSAL: Consult your County Agricultural Commissioner for correct procedures for rinsing and disposing of empty containers. Do not transport pesticides in vehicles with foods, feeds, clothing, or other materials, and never in a closed cab with the vehicle driver.

RESPONSIBILITY: The grower is legally responsible for proper use of pesticides including drift to other crops or properties, and for excessive residues. Pesticides should not be applied over streams, rivers, ponds, lakes, run-off irrigation or other aquatic areas except where specific use for that purpose is intended.

BENEFICIAL INSECTS: Many pesticides are highly toxic to honey bees and other beneficial insects. The farmer, the beekeeper and the pest control industry should cooperate closely to keep losses of beneficial species to a minimum.

PROCESSED CROPS: Some processors will not accept a crop treated with certain chemicals. If your crop is going to a processor, be sure to check with the processor before making a pesticide application.

POSTING TREATED FIELDS: When worker safety reentry intervals are established be sure to keep workers out and post the treated areas with signs when required indicating the safe reentry date.

PERMIT REQUIREMENTS: Many pesticides require a permit from the County Agricultural Commissioner before possession or use. Such compounds mentioned in this publication are marked with an asterisk (*).

PLANT INJURY: Certain chemicals may cause injury or give less than optimum pest control if used: at the wrong stage of plant development; in certain soil types; when temperatures are too high or too low; the wrong formulation is used; and excessive rates or incompatible materials are used.

PERSONAL SAFETY: Follow label directions exactly. Avoid splashing, spilling, leaks, spray drift or clothing contamination. Do NOT eat, smoke, drink, or chew while using pesticides. Provide for emergency medical care in advance.