

# ALMONDS

By Wilbur Reil



# **Almond Production in Yolo and Solano Counties of California**

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Yolo and Solano counties

## Forward:

This production manual was written to provide a concise guide for Almond farmers within Yolo and Solano counties and to provide a text for the Yolo/Solano Almond Mini Course held November 13, 2001. Some practices reported are unique to this area of the Sacramento Valley.

I have tried to present information that applies to local growing conditions. The principles and ideas conveyed are gained from over 30 years of experience in working and conducting research on Almonds.

I have been a Farm Advisor for the University of California in Yolo and Solano Counties for nineteen years. Previously I spent several years at the University of California, Davis campus, working with Almonds throughout the state.

For more information, readers may request the University of California, Division of Agriculture, Almond Production Manual #3364 from their local Cooperative Extension Office.

Cover: Photos by Jack Kelly Clark and Wilbur Reil



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Almonds can grow on a wide variety of soils, although they do best on deep, well-drained soils. Generally they grow best on sandy loam, loam or clay loam soils. Heavy clay soils that are not well drained are considered poor soils for almonds. Almond roots extend to a depth of four to five feet and drainage is important throughout the root zone. Land to be planted to almonds needs to be level enough to eliminate any low spots where water will accumulate. Land should be either ripped or if structural differences within the soil subsoiled or individual planting sites backhoed to loosen the soil and eliminate stratified layers. If the soil structure is stratified with sand or heavy clay layers root and water movement through the root zone will be restricted. Roots require both water and oxygen for proper growth; therefore loose friable soil extending throughout the root zone is needed so there is movement of water and oxygen throughout the root zone. Soil provides anchorage as well and it is required that the roots grow throughout a large area so they can provide that anchorage. Land that has been previously planted to trees may require fumigation. Root samples can be taken to determine nematode counts but it is difficult to take samples to determine if there is phytophthora or oak root fungus present in the soil that might damage future plantings. Past experience, evaluation of the trees and tree losses that have occurred previously are better indications of whether or not you have Armillaria or phytophthora problems within the soil. Soils that have not been planted to trees for a long time generally do not need to be fumigated in Yolo and Solano Counties.

It is important to plant almond trees high. Trees should be either planted at the same depth but preferably higher than what they grew in the nursery. They can be planted on ridges or berms. Soil then is mounded up to cover all the roots at planting time. On heavy soil that is not well drained planting the trees on berms or mounds allows water to drain away from the trunk allowing better aeration and better growth of the trees. If water accumulates around the tree trunk the trees can die, whereas, trees planted on mounds or berms will live and grow well. Berms or mounds need to be created at the time of planting or before planting. Proper soil preparations should be done the year preceding planting. Planting can occur in the winter or early spring if all farm work is accomplished when the soil is dry the proceeding year. Because of winter rain and wet soil, soil preparation in the winter is difficult. Waiting till early spring to do soil preparations can delay planting into late spring, which usually causes poor tree growth.

## **ROOTSTOCKS**

There are several rootstocks that are used for almonds. They include Peach-Almond Hybrid rootstock, Almond rootstock, Peach rootstock and Marianna 2624 Plum rootstock. Each rootstock has a place although no new orchards are being planted to almond rootstock because of difficulty of propagation. There is also a serious problem of one of the developing trees coming from the rootstock instead of the variety grafted on top and the rootstock tree producing bitter almonds. I will not consider it as a currently planted rootstock.

Peach-Almond Hybrid rootstock (there are several different ones) are clones which are vegetative propagated or seedlings are used very successfully where we have good deep soils. It will form a large tree that is quite vigorous and should be planted at wider spacing. It is excellent to use in areas, such as Yolo County, where we have boron in the water provided the soil that it is planted in is not too heavy. Under heavy soils, tree losses can be excessive. Especially wet winters can cause a considerable loss of trees within the orchard.

There are primarily two Peach rootstocks used: Lovell and Nemaguard. Nemaguard has resistance to root knot but not to any other nematodes. Lovell does not have the resistance to the root knot nematode. Root knot nematode is a problem in sandy or sandy loam soils primarily in the San Joaquin Valley. We normally do not have root knot nematode problems in Yolo or Solano Counties. Either Lovell or Nemaguard rootstock can be used within the county. At one time we thought that Lovell was a better rootstock for this area but more recent evaluations show that both Lovell and Nemaguard seem to perform equally well within the county.

Marianna 2624 is a plum rootstock and only certain almond varieties are compatible. The rootstock will tolerate wet conditions better than other rootstocks. It would be the choice on heavy clay soils or soils that waterlog in the spring. Nonpareil, the most highly desirable almond variety is not compatible on Marianna 2624. There can be a Havens 2b plum inter-stem grafted between the Nonpareil and the Marianna 2624, but those trees usually are not satisfactory and very few have ever been planted. Other problems can develop on Marianna rootstock too. There are a group of mycoplasma's, or virus like diseases, that can develop in the almond on Marianna 2624, such as, mild etch, brown line and tomato ring spot virus. These mycoplasmas cause poor productivity, incompatibility of the graft and in some cases death. There are some unexplained incompatibilities that also have occurred and are thought to be related to this complex. Butte variety on Marianna 2624 will have a certain amount of incompatibility that develops that may kill trees while other trees tend to grow out of it. Other varieties have also expressed problems and generally show up in a weakened tree in the second, third or fourth year. The tree will usually grow normally a year after and not express the problems later. This lowers the production for one or two years. Generally it is the healthiest trees grown that have the serious problems.

In areas of the county where there is excessive boron in the irrigation water, Peach rootstock may grow well, but will not bear a consistent heavy crop. Therefore either Peach-Almond or Marianna 2624 is recommended. If the soil is a loam soil or a lighter textured soil, Peach-Almond is preferable. Where we have Armillaria root rot, Marianna 2624 is tolerant or somewhat resistant to Armillaria. It is also more resistant to the Phytophthora crown and root rot.

## VARIETIES

There are many almond varieties that are currently being propagated, sold and planted. Most varieties have a place within the industry and many of them will continue to be propagated. Others will probably be discarded because better varieties will be introduced. Nonpareil is the best variety currently being propagated and planted. It is a very old proven variety.

The California industry has been developed with it being the primary variety because of the diversity the kernel can be used for. It is an excellent variety and in most cases should be considered as the principal variety to be planted. All almond varieties currently propagated require pollination by honeybees. Orchards are planted with a single row of one variety adjacent to a row of a different variety. In many cases we will use a third variety within the orchard. In Nonpareil plantings, generally fifty percent will be Nonpareil. Every other row will be Nonpareil alternated with a variety that blooms at the same time or slightly ahead of Nonpareil and a variety that blooms slightly after Nonpareil. This allows the Nonpareil bloom to be completely covered with pollen for maximum production of the variety. The tree is somewhat large and spreading. It blooms in the middle part of the season and the pollen is cross compatible with many other varieties. I will not cover the incompatibilities in this section, but there are a few varieties that are not compatible with others, so before making your final selection on varieties you should look at all possibilities including the variety compatibility with one another, the bloom overlap and the harvesting of the variety so that you don't have mixed nuts. Nonpareil harvest is early. It makes an excellent product when harvested. We do not have a perfect variety to pollinate Nonpareil especially at the start of its bloom. Currently we are using Sonora.

Sonora is a high quality nut. It blooms three to five days before Nonpareil and will cross-pollinate Nonpareil quite well. It sometimes will not set a very heavy crop, probably because there is nothing that pollinates it at the beginning of it's bloom, so many of these early flowers do not set.

Varieties that are planted to cover the later part of the Nonpareil bloom are varieties such as Carmel. Carmel is a high quality nut, it fits in the market and it grows much like Nonpareil though the tree is slightly smaller in size. The tree is subject to brown rot infection. The one problem that it has had in the past is genetic bud failure. Currently there are certain lines of Carmel trees that have a very low incidence of bud failure. It is being replanted in many blocks to pollinate the later part of the Nonpareil bloom.

Butte is another variety that has been used to pollinate the later part of the Nonpareil bloom. Butte is a small nut that is used for the salted-roasted trade. It is not as high quality as Nonpareil, Sonora or Carmel, but for the salted-roasted trade it has a good reputation. It is a spreading tree and tends to get more brown rot than other varieties mentioned. However, Carmel also gets some brown rot.

Another variety that is used in Yolo County is Price. Price is a good variety that blooms about one day after Nonpareil so it covers most of the Nonpareil bloom. It is a fairly high quality nut, although not as good as Nonpareil. The problem with Price is that it tends to alternate bear. Some trees will bear a heavy crop one year and will be light the next year. It does not have a heavy bloom some years, which means there is not as much pollen available to pollinate the Nonpareil.

There are several varieties used in Marianna 2624 rootstock plantings in wet soils. Butte is one that is used quite extensively along with Padre. Padre is a smaller nut that is primarily used in the salted-roasted trade. It is a tall, upright growing, fair sized tree. Mission can also be

used in that same mix and again it is a salted-roasting type nut. It is a hard-shelled, old variety. The tree tends to be upright but is a small tree.

Aldridge has been used extensively in some recent trials because of the possibility of heavy production and a reasonably good quality nut. It has been a disappointment in that, while the tree is upright and vigorous, the tree is hard to shape and the crouches are weak, so there has been considerable breakage within the tree itself. Only time will tell how the tree will adapt to conditions and how much acceptance it might have in the trade. All the other varieties tend to be new or have lost favor over the years and tend not to be planted anymore. There is one exception to that, Peerless blooms before Nonpareil and has been used in some of the old plantings. There are a few Peerless being planted but not extensively. Peerless was planted only for the in-shell market. It has a very thick shell and a low kernel percentage. The smooth attractive shell looks very nice and is sold in shell. Peerless can be fairly profitable for growers when hulled and handled carefully.

## SPACING

Almonds form medium to medium large trees and when grown on excellent soil will grow very extensively and form large trees. Plantings are also being made that will last for thirty or thirty-five years in many cases. With large trees on good soil, plantings are usually planted between twenty-two and twenty-five feet apart. At one time orchards were planted twenty-eight or thirty feet apart. The trend today is to put the trees closer together, especially trees down the row. Approximately eighteen to twenty-two feet per row width is needed to get the harvest equipment into shake the tree and to harvest the nuts. Twenty or twenty-two is even better than eighteen for the shaker to maneuver. Trees are planted closer together down the row provided shade does not become a serious problem. On upland soils, shallow soils, or on Marianna rootstocks where the trees will not get large, eighteen or twenty feet between rows and between twelve to sixteen feet down the row have been quite profitable.

In many of the plantings, trees are offset to allow for better bee flight between rows, rather than straight down the row. On younger trees, until they reach full canopy, spray penetration across rows is better when the trees are offset and not in a square planting. Many of the plantings are a diamond, triangle or an offset square-planting pattern.

## PLANTING

Almond trees are planted in the winter or early spring when weather permits. The soil should be moist but not exceeding wet. The hole is augured or dug with a shovel. The soil should be friable, so that when you back fill after putting the tree in the hole, the soil will settle around the roots. At the time of planting the hole should be augured or dug to the appropriate depth. I do not like to see the hole any bigger or deeper than will accommodate the roots. It is said jokingly, that roots should be planted downward when they go in the hole. When holes are dug with an auger the outside of the hole has dirt that falls back in. The hole then is not deep enough on the outside to accommodate the roots. If this dirt is not dug out or pushed towards the

center when the tree is planted the outside roots will curl up and point upwards. This can cause severe problems with root establishment and trees do not grow well or may die. When shoveling dirt into the hole make sure there is no air pockets under the crown.

Trees that are planted in the wintertime can be purchased bare root from the nursery. The roots need to be kept moist after they are dug. Freezing temperatures can kill the very small feeder roots. Trees that are planted in the spring should be placed in cold storage before the new roots have started. When planting starts, remove only enough trees from cold storage to plant that day. Do not remove trees that are going to be planted for the entire week at one time.

Trees should never be planted any deeper than they were in the nursery. Allow for dirt to settle around the tree and the tree to settle. I have seen trees settle anywhere from one inch to three inches deeper than what they were actually planted. Trees that are planted high, trees that are planted on a mound, or berm and the soil then mounded up around them to allow for drainage, especially if the soil is clayey, do better than trees that are planted flat and definitely much better than trees that settle into a hole after planting.

Trees that are planted in the winter in moist soil usually do not require additional water until after growth starts in the spring. They usually can grow six inches to a foot before additional moisture is needed. Growers should dig down and examine the soil near the roots to see if it is drying out. You don't want excess moisture in the early springtime, as it will cause severe drowning and damage to the root. Trees that are planted in the spring, if the moisture is ideal and the soil firmed back in around the roots usually will not require any additional moisture until the tree has started to grow. Soil that has a dry surface and is augured where some of the dry dirt falls in the hole at planting may require additional water around the crown. This will help to wet the dry soil that fell back in the hole and to settle some soil into air pockets. Be careful about applying too much water. Two or three gallons will usually be sufficient. I question if any trees need over five gallons. Measure the amount applied. Do not try to estimate the application. No additional water should be applied until needed after growth starts.

Almond trees that are grafted in the nursery should be headed back to thirty-two to thirty-six inches in height. If there are many lateral scaffolds that have developed, three scaffolds can be selected with two near the top and one originating four to six inches lower and headed at four to six inches if they are in the right location. On young trees with few side branches all the side branches are completely eliminated and new shoots can grow from buds on the trunk. Normally the tree is not staked. In some windy areas or where trees tend to blow over, one stake on the windward side or two stakes one on each side can be used. Stakes are being used more by some of the growers in the area.

There is a nursery that has started propagating almond trees in pots. These trees are generally five months old and can be planted anytime during the year. I have planted trees in the fall or late summer that have performed very well establishing themselves in the late fall and have good growth and have done very well the following year. In heavy soils, the soil is generally too wet to plant in the wintertime. The trees must be placed in cold storage for a period of time. Potted trees can be planted late the previous year, establish themselves and then start growing well in the following spring. Cold storage trees sometimes have problems

transplanting out of cold storage, especially trees that are on peach-almond hybrid rootstock. Peach-almond hybrid rootstock does not store as well as Peach or Marianna root trees do. Any trees coming out of cold storage should be examined very carefully for decay or rot that is on the root and diseased spots should be pruned off and the tree roots sprayed with a chlorine bleach spray. If ground to be planted has had trees in it previously, a treatment for crown gall is advisable to prevent crown gall from developing on the new trees.

## FROST

Frost damage can occur on almonds easier than on most other fruits because almonds bloom earlier than most trees usually blooming in mid to late February or early March. There is a greater chance for freezing weather to occur. They are also fairly susceptible to frost. Temperatures below twenty-nine degrees for thirty minutes can cause some injury and temperatures below twenty-six degrees for thirty minutes can cause complete loss of the crop. Certain varieties are more susceptible to frost than others. The duration that the cold temperature occurs can also play a role. A nut that is just beginning to form is the most sensitive to frost damage. There are a few things that growers can do, to make the orchard warmer. Water applied to the surface and wet orchard floors will raise the temperature. Frost protection can be applied in the form of solid set sprinklers or wind machines. Very few people now use what we call smokeless heaters that are not very smokeless. Solid set sprinklers; wind machines and heaters are quite costly and are not usually practiced in the two counties. We have had very limited frost damage occur on the almonds in the counties.

The grower can sometimes protect his trees with orchard floor management practices. Cultural practices can help with frost protection. Bare, firm, moist ground will be the warmest in an orchard. Shredded cover crop or low mowed cover crop on moist ground will be a little bit colder and dry, firm ground may be two or three degrees colder than bare, firm, moist ground. Freshly disked ground or ground with very high cover crop could be three or four degrees colder than bare, firm ground. If you have restricted movement of air drainage like a windbreak or some restriction to downward flow of air movement you could also have two or three degrees colder condition. Considerable differences can be achieved by just handling the cover crop properly.

## POLLINATION

As said earlier, almonds need cross-pollination. Bees are necessary to transport the pollen from one variety to another. Pollination is not the job that the bees are trying to do. The bees are trying to collect every pollen grain to take back to the hive to feed the brood and the hive. They just drop some pollen as they go along, which ends up pollinating the blossom. Planting varieties with good bloom overlap and in a pattern the bees will move from one variety to another will help. The main variety is planted in single rows. Adjoining rows are planted to varieties that bloom earlier and later than the main variety. Other planting schemes can increase cross-pollination, such as alternating trees of varieties down the row but they make harvest very difficult.

Applications of almond pollen to the orchards through blowers and spreaders have not worked effectively because almond pollen is very sticky and heavy and very difficult to distribute throughout the orchard. Pollen inserts within bee hives has sometimes shown slight increase in pollination, but practically it is better to plant the orchards so that the bees can do the job easier.

## PRUNING

Pruning is done for a number of reasons. It shapes the trees, helps develop strong limbs to hold crops and allows light to penetrate throughout the tree to help develop better fruiting wood. Pruning of young trees is done primarily to shape the tree and to develop strong scaffolds. When planting, a tree should be headed at approximately thirty-six inches to allow scaffolds to develop along the upper part of the trunk. Thirty-six inches will allow three scaffolds that can be selected above where a trunk shaker will grip the trunk of the tree. At planting time all the lateral branches should be removed completely or if there are three limbs that are separated on the trunk near the top that are growing in somewhat the right direction, about ninety degrees from one another they should be left and headed at two or three buds from the trunk. This can sometimes be used to develop the first primaries on good solid shoots. The first year the trees are allowed to grow quite vigorously and hopefully there will be a number of scaffold limbs that will develop on the original trunk. Generally no summer pruning is required although pinching out or removing growing tips on undesirable limbs will encourage more growth in the remaining limbs. At the first dormant pruning three scaffolds are selected. Ideally they should be at approximately ninety degrees angle from each other. You would like the strongest one to grow towards the north. This is the direction where the strongest winds come from. If possible you would like three strong limbs on the tree. The lowest limb should be selected three to six inches below the second and third limb. The lowest limb selection will determine whether all three limbs originate from the same spot or whether there is a good separation of the branches. The scaffolds should be approximately thirty to sixty degrees from vertical and should not have bark inclusion. Proper selection of strong scaffolds is very important to prevent limb breakage when heavy crops are produced. The limbs should not be headed unless they are very uneven in height. If uneven, the strongest limb that is also the tallest should be headed severely to balance it with the other limbs. It should be cut more severe than the other two limbs, which will then encourage the other two limbs to grow. The second year the three limbs are allowed to grow. Several secondary limbs will also grow from the 3 primary scaffolds selected. Dormant pruning at the end of the second year generally is the removal of water sprouts that are growing in the middle and any shoots that come off the trunk. Most secondary limbs that grow will be selected from each primary. Only crowded, crossing or extremely flat limbs should be removed. The center of the tree should be kept open.

During the third, fourth and fifth winter crossing limbs are pruned out and a few of the very crowded limbs are taken out to continue to let the tree develop outward and upward into a desirable bowl or vase shaped tree. I normally do not make heading cuts unless the tree is disproportionate and one scaffold is much bigger than the others. Generally most orchards that have excellent vigor have very limited amount of pruning done in the third to tenth year. Some crossing or crowded limbs and low limbs will need to be removed. Suckers or shoots growing

from the trunk are also removed. Pruning decreases the amount of crop that you produce on young trees. As the tree gets older and more mature, pruning is needed to manage light penetration within the canopy. It is also needed to rejuvenate new wood. On older trees, vigorous water sprouts are kept to replenish some of the old and low productive wood that is loosing vigor. The tree needs to be able to be forever young with new developing wood to replace the older less vigorous wood. Limbs that continue to turn down become non-productive over time and need to be removed by cutting to more vigorous shoots. With proper pruning and proper care orchards can be kept productive for many years.

## IRRIGATION

Irrigation water management is extremely important in almonds. Almonds require frequent irrigation throughout the summer months. Improper irrigation can involve applying too much or not enough water or not applying water frequently enough. Understanding the soils that the trees are planted on and the water holding capacity of the soil are important in determining the frequency of irrigation. Generally on most types of sprinkler irrigation or flood irrigation, water is replenished throughout the entire root zone each irrigation. On micro or mini sprinkler and drip irrigation the water is replenished frequently in a small area of the root zone. An orchard that has at least fifty percent of the total area covered with leaf canopy will require as much water as a full-canopied orchard. Much of the evaporation occurs on the sides of the smaller trees that make up for the open areas between trees. An orchard that has a cover crop on the orchard floor will require more water throughout the winter and early spring than an orchard that is clean cultivated.

Generally an almond orchard, in this area, requires between forty-two and forty-five inches of water per year. An inch of water would be the amount of water that would cover the total surface one-inch deep. This is more water than many of the other tree crops use. Most of the water is needed in the hot summer months of June, July and August. Irrigation systems are designed to apply adequate water during those three months. As much as eight or nine inches per month may be needed per month in those three months. Most soils in the county have high water holding capacity.

It is important to keep the trunk of the tree and the ground surrounding the trunk of the tree as dry as possible. Planting the tree on mounds or berms will allow water to quickly drain away from the trunk. Sprinkler systems should be designed to apply a minimal amount or no water directly to the trunk. Another consideration is that root diseases, primarily Phytophthora or Armillaria, requires free moisture to spread and requires moist conditions for growth. Normally if standing water or saturated areas do not last longer than twenty-four hours at one time very little Phytophthora will develop. After twenty-four hours, the longer the ground stays saturated, the more disease will develop. Systems should be designed to minimize or eliminate saturated conditions longer than twenty-four hours.

Orchards can be irrigated by many different methods. Furrow or border checks are an older method that tends to be less efficient than other methods. Generally more water has to be applied at the upper end and also will accumulate at the lowest point of the field saturating those

areas to provide adequate moisture in the middle two thirds of the orchard. Sprinkler irrigation is more efficient. The older type sprinkler systems, of moving portable aluminum pipe or the hose pull system, requires labor to move the system each day. The solid set sprinkler is costly to install. Micro sprinklers and drip sprinklers generally are very efficient when designed properly.

Water needs to be applied to the trees before they completely deplete all the available moisture in the root zone. While roots will extract water from all depths where growing, generally the water is depleted quickest from the upper part of the root zone. The trees then will extract water from deeper in the soil.

Generally, checking the top one to two feet for soil moisture can be effective in determining when to irrigate. Checking deeper moisture is important to evaluate how well the irrigation system is replenishing water.

Weather reports during the summer that list evapotranspiration are useful to determine the amount of evaporation that has occurred and the amount of water that is required to replenish the moisture. It does not tell the contribution of winter rains and the water holding capacity of soil. Winter rains in the Yolo and Solano area generally wet the soil to a depth of several feet providing adequate water throughout the root profile at the start of the season. In dry years irrigation may be needed during the winter months to provide moisture throughout the root zone. I like to use the formula that six inches of water is needed each month during December, January and February to get adequate water in the ground to start the season. A total of eighteen inches, which is the average rainfall in Woodland, is needed to have water penetrate to six or seven feet. The tree can draw from this reservoir as the season progresses to supplement needs during extremely hot days.

Growers have a very difficult time determining when to start the first irrigation in the spring. Generally a person should use a probe or a shovel and dig to determine how dry the soil is at one, two and three feet. If the soil is wet, irrigations in the early spring should be postponed until some of the soil moisture is used in the upper two or three feet. This decreases the chance of disease as well as establishing healthy roots deeper in the soil profile.

On Nonpareil, hull split usually starts the first or second week in July. A slight irrigation stress at this time will promote the abscission layer to form between the nut and the tree. This will make it easier to shake the nuts later. It also reduces the amount of hull rot. Hull rot can cause loss of production and dead spurs to occur on the tree. Hull rot is caused by two different fungi that can enter at the time the hulls splits and causes a toxin that kills the spurs. I said a slight stress occurring at that time is desirable to help on nut removal at harvest time. This slight stress is easy with drip irrigation by withholding about fifty percent of the desirable amount of water that the tree needs, at the first indication of any hull split on the trees. With micro sprinkler the stress must occur at least a week before that first indication of hull split of sound nuts. Blank nuts usually start to split one week before sound nuts split. It can also be timed by watching the trees along a paved road or an open field on the south side of the orchard where the sun reflection and the heat will cause the nuts to be advanced in maturity over the rest of the orchard. When the first blank nuts start to split, water applications should be reduced to about half. It is much harder to time the stress period on full coverage sprinkler systems and flood

systems to restrict water to half ET. This might mean irrigation in mid-June and only partial irrigations in late-June or the first part of July to accomplish the stress period. Water is also removed from the orchard before knocking of the trees. On drip or micro sprinkler it is usually only a matter of a few days that it needs to be removed before harvest. On full coverage sprinkler irrigation or flood irrigation it usually is two or three weeks before harvest that water is restricted. If there are early harvest and late harvest varieties within the same block, the early harvest varieties, such as Nonpareil, Peerless or Sonora are harvested first. The Nonpareils are harvested first and then the Sonora or Peerless are harvested. An irrigation application is then applied. With micro or drip, irrigation can be applied after each of the varieties are harvested. After harvest, additional irrigations usually are necessary in this area. Fall irrigation on dry years helps bud set and production the following year. On wet years irrigation late in the fall along with early rains can cause root disease problems.

## FERTILIZER

Almond trees require large amounts of nitrogen fertilizer each year. Nitrogen fertilizer is necessary in all soils in California and needs to be replenished annually. A one-ton almond crop removes approximately one hundred pounds of actual nitrogen. This needs to be replaced each year by either applying commercial fertilizer or by a cover crop. In some areas of the county, irrigation water contains nitrogen and can contribute nitrogen. The tree needs one hundred pounds of nitrogen. Generally, most of our application methods are only about fifty to seventy percent efficient. Therefore about two hundred pounds of actual nitrogen per acre per year is needed. I do not like to see it applied in a single application. A minimum of two applications and on lighter textured or sandier soils, three or four times throughout the spring and summer months is better. Roots need to be growing for the adsorption of the nitrogen to occur. Roots only grow at the times when leaves are present, therefore applications in the spring and summer, are ideal to apply the fertilizer. It takes as much as a month for the nitrogen to move from the roots into the upper part of the tree. Applications can be made through the irrigation system by either dissolving a dry product into the irrigation water or injecting liquid fertilizer. Applications can also be applied to the soil surface as a dry granule or liquid and then irrigated in. Legume cover crops that are grown for nitrogen need to be incorporated in the soil to obtain maximum benefit.

Leaf samples can be very beneficial to evaluation of long-range nutrition. Normally, a nitrogen leaf level over two and a half percent is ideal. The University of California recommendations said that 2.2 or 2.3 for the leaf level is adequate. Higher rates allows for all the trees within the sample block to have an adequate amount for excellent growth. On trees over 2.8, adding additional quantities of fertilizer is wasteful and in a few cases could injure production through growth stimulation leading to extensive shading in the interior part of the canopy.

Fertilizing young trees is important. Frequent light applications of nitrogen will be much better than one or two heavier dosages and will have less chance of burning the foliage. A thorough irrigation is necessary following application. On young trees, an application rate of about one ounce of nitrogen for year of age of tree, applied at any one time, is usually safe. That

means that if a tree is two years old, two ounces of actual nitrogen should be applied each application. In most systems you can apply fertilizer every two or four weeks at that rate. This will encourage tree growth. If most trees are growing very luxuriant with a few weak trees within a block, you can fertilize the weak trees and encourage them to catch up.

Potassium deficiency in the county is becoming more of a problem. Trees growing on soils high in magnesium may show deficiency. Leaf analysis in July can determine if it is low, borderline or adequate. Potassium is very difficult to apply so that the trees can absorb it. Potassium attaches to the clay particles in the soil and becomes unavailable to the roots. It should be banded in the tree row on non-tillage orchards in the fall. On tilled orchards it should be drilled in one or two bands between tree rows. It can also be applied through the irrigation system on drip irrigated orchards.

Zinc deficiency is showing up more, especially in older orchards. Zinc causes pale leaves, rosetting and little leaf symptoms. If no zinc was applied to the foliage, zinc can be analyzed in the summer leaf sample. A foliar application, either in the spring or fall will correct zinc deficiency. A fall application using about 25 pounds of 36% zinc sulfate applied in October will also remove leaves. On young trees this can help prevent blow over. A spring application using basic zinc can also be used to correct zinc deficiency.

## **WEED CONTROL**

Weed control is very important around the tree trunk and to eliminate competition to the trees. Weeds compete very strongly for nutrition and for water with young trees. It is imperative to have good weed management in young orchards to encourage the growth of the young tree. Weeds around the trunk of older trees are competitive and hold moisture that can cause root and crown diseases. A clean orchard floor is needed for harvest. There are many residual herbicides that can be applied to both non-bearing and bearing trees that can be used effectively. The important thing is to be able to identify the weed population and then select the weed control material that will be effective. There are also contact herbicides that can be applied and are effective. Most orchards have a sprayed strip to control the weed growth down the row so that any activity such as disking or mowing is done in a single direction. Orchards with berms or with micro or drip irrigation cannot be cross-cultivated or cross-mowed. It is imperative to have a clean strip to control the weeds in the tree row.

Some of the contact herbicides can go through the bark of very young trees and kill the tree. Care is necessary when applying contact herbicides to young trees to not injure the tree. When applying herbicides, the sprayer pressure should not exceed thirty pounds. Higher pressure will normally cause volatilization of the spray droplets that can drift onto foliage and cause problems.

Normally a cover crop is maintained between rows to help in water penetration, build soil structure and provide some organic matter that will add buoyancy to the soil. This can be a planted cover, planted every year, a planted cover allowed to reseed after the initial planting, or native vegetation that reseeds itself. Mowing in the early spring should not be close to the

ground, but should be four to five inches above the orchard floor. This will allow for more cover crop growth and will give better porosity, providing better water penetration.

## INSECTS

There are principally three insects that can be quite damaging to almonds. There are also complex of mites that we will consider at this time.

Peach Twig Borer is a pest that will cause serious damage to young trees by boring into the twigs and disfiguring the tree shape. It can also attack the nuts at hull split and shortly after hull split and cause damage to the kernel. Dormant sprays are effective controlling Peach Twig Borer. Sprays can also be applied at bloom time. Primarily Bacillus thuringiensis, or BT sprays have been effective applied at bloom time. Some people have been able to not spray at all. Determining the need to spray should be based on past insect damage history from grade sheets, whether you have sprayed in the past and trap counts.

Navel Orange Worm is a pest that attacks the nuts at hull split or after hull split, near maturity. Navel Orange Worm can be a serious problem. There is no effective spray that will completely eliminate Navel Orange Worm problems. Sanitation of the orchard by removal of the nuts from the tree after harvest is the best control method. The nuts left on trees after harvest need to be either shook again or poled. Getting all the nuts on the ground during harvest time or in the winter will break the cycle. In order to survive the Navel Orange Worm must lay eggs and complete the first generation in the spring on the mummy nuts. If there are no nuts left on the tree, you can break the cycle and will not have a serious problem with Navel Orange Worm at harvest time. In this area birds after harvest and during the winter can effectively remove the last mummy nuts giving complete eradication and low NOW infestations. High numbers of nuts left at harvest cannot be cleaned up by birds in the winter.

San Jose scale can also cause problems in the area. San Jose scale is a very small insect. It can be monitored in the winter to see if it is a problem. The very vigorous new shoots that are cut from the top and center of the tree in the winter will have a red spot or discoloration if San Jose scale is present. It can also be monitored on the spurs and shoots within the canopy of the tree. If there is a problem, a dormant spray with oil and an insecticide is very important to help clean it up.

Mites are a problem in the counties some years, especially years where there is extreme heat in late spring or summer. There are several mites that can be a problem. The Brown Almond mite can be a problem in early spring. It will cause the leaves to turn silvery. European Red mite will be a problem in late spring on certain years. Both of these mites are controlled by dormant spray.

Two-spot mite or Pacific mite, are web spinning mites, that over winter on the ground or in cracks in the trunk. Dormant sprays do not control them. These mites usually develop in years when hot weather occurs in spring or early summer. They cause webbing upon the leaves and if severe, will cause defoliation, and decreased crop the following year. Sprays for mites can

be required in the summer if a population is building. Low rates of the miticides that are currently being sold are better to apply than extremely high rates. Extremely high rates of miticides cause a population to crash very quickly. The predators that might be feeding in the orchard then have no mites to feed on and they move outside the orchard or die. A resurgence of the mites then occurs causing renewed high populations. Allowing the predators to build on a low population of mites will then maintain a healthy population of predators to keep damaging mites populations low.

## DISEASES

The root diseases are covered under rootstocks. Foliar and blossom diseases are a major problem with almonds in Yolo and Solano Counties. There is a complex of several different diseases. The principal three that occur in the county are Brown Rot, Shot Hole and more recently Anthracnose.

Brown rot has been a serious problem with certain varieties for many years. It infects the blossom from popcorn until petal fall. It is a disease that we normally have to spray once or twice per season to control. All sprays used are protectant sprays with no eradicate type action. They have to be applied before the disease gets started rather than after. We usually apply the first spray at popcorn to very early bloom. We can then wait and see what kind of weather is occurring. All these diseases require rainfall or free moisture to invade or infest the blossom and to cause death of the shoots or nutlets. Additional sprays are needed if rain occurs.

The second disease, Shot Hole usually attacks leaves and nutlets causing the nutlets to drop. It can also attack larger nutlets and cause gum pockets to occur in the nut itself. The attack on leaves causes leaf drop that devitalizes the tree. Generally a spray is applied at petal fall to control Shot Hole.

Anthracnose has occurred in a few orchards, primarily orchards that are damp, have solid set sprinklers, are vigorous and have closed canopies. A third spray may be applied for Anthracnose. Anthracnose is usually a disease that occurs after petal fall through early spring. It likes warmer weather to get started.

All three diseases are worse in years when we have rainfall occurring at bloom time, petal fall and small nut stages.

## VERTEBRATE PESTS

Ground squirrels can be a problem with almond orchards; both from living in the surrounding habitat next to orchards and also living within the holes they dig within the orchard. Control is best when there is a low population. First gassing of the holes in early spring when there is dampness works well to reduce the primary number. Later baiting has done a good job.

Gophers can also be a problem digging in the orchard and causing damage to the orchard floor. This can cause problems at harvest. They can also chew on the small trees and roots and

girdle the trees. Either a mechanical tractor pulled baiter or a hand probe, has worked well to apply bait.

Crows are a problem for three months just before harvest and at harvest time. The crows are an asset to clean up the mummies after harvest, but before harvest they can be a serious problem. Crow populations can be discouraged with various sound guns, bird calls, or wind driven balloons or driven from the orchard with a distress call tape recording. They are smart birds and will become familiar with sound if it continues to occur at the same place. If it is moved around the orchard and changed to different frequencies, sound can be effective to discourage crows.

## HARVEST

Almonds are harvested off the orchard floor. They are shook when all the nuts have split. Many of the hulls will still be green when the trees are shook. Good weed control and orchard floor management are necessary before shaking. The orchard floor needs to be smooth, with no ruts or cracks. Nuts are shook on the soil and allowed to dry for several days until dry. They are then blown and swept into windrows, picked up with a harvester and delivered to the huller.

The huller can either remove the hulls from the shell and kernel or remove the hull and shell together from the kernel. The kernel is what is then delivered. For varieties such as Peerless and some Nonpareil and Carmel that are sold in shell, a premium is paid for deliveries in shell. Hullers that just removed the hull, sometimes gives a much better product to store or to sell in shell. Varieties must be kept separate because they are used in different trades. Once a product is hulled it is then delivered to the buyer/handler.

Almond hulls have feed value. When they are dry they are sold for livestock feed and are used quite extensively for dairy and cattle feed yards.

## MARKETING

Approximately one half the almonds in the state are sold through cooperative marketing, where growers actually own the company. The other half are sold to the independent buyer/handlers that market in competition. They are probably a hundred fifty or two hundred buyers within the state; many of them are quite small.

The nuts are delivered in shell or as a shelled product to the handler/marketer. The marketer will then either package them in shell for marketing to Europe, India and China, usually in the fall and early winter, or will sell as shelled nuts. Some Nonpareil is sold in shell to India, where they are hand cracked because of cheap labor. The finished product does not have marks on the skin that machine cracked nuts do.

Prices are paid to the grower except for Peerless based on the shelled product or the kernel weight that is delivered minus the pests, blanks, gum and off grade type kernels. Prices paid by the cooperative are usually a certain percentage of the price anticipated. It is paid shortly after delivery of the nuts. Several payments are made over the next two years to the grower on the remaining product. Other buyers will sometimes pay for almonds at the time of delivery. Others will pay in several payments over a year. Most do not pay as high a return when they pay the total amount at delivery, but pay higher returns if it is paid over a long period of time.

### **Additional References:**

- Almond Production Manual, University of California, Division of Agriculture publication #3364
- University of California, Cooperative Extension, 2001 Sample Cost to Establish an Almond Orchard and Produce Almonds: Sacramento Valley
- University of California, Integrated Pest Management, Almond Pest Management Guidelines
- Integrated Pest Management of Almonds, University of California, Division of Agriculture publication #3308

\*Contact your local Cooperative Extension to obtain copies.