Dry Farming Wine Grapes

A Best Management Practice Guide for California Growers

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Preface

This work presents in-depth information on the fundamental principles of dry-farming wine grapes in California. However, every piece of land and every vineyard is unique, and so are the farming practices. This work is intended only as a guide to growers and to introduce techniques and the major factors influencing a dry-farming system. This guide should not substitute for expert advice.

Before adopting dry-farming methods or new farming practices, CAFF suggests contacting a local Natural Resources Conservation Service office, local UC Extension Advisor, or a trusted consultant or grower for additional information. Please see the Further Reading section and the Support Agencies section of this guide for resources and contact information.

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1. Introduction

Dry farming refers to crop production during the dry season without supplemental irrigation. Dry-farmed crops rely on the moisture held in the soils from winter rains to meet their water requirements for growth. Even though California has a semi-arid climate, in many areas of the state there is sufficient rainfall and the right soil conditions to dry farm many crops, most commonly, wine grapes. At its core, dry farming is all about conserving and retaining soil moisture to support the vines without supplemental irrigation.

Wine grapes have been dry farmed in California for more than a hundred years. Early European immigrants to California planted wine grapes across the state, largely without irrigation. Drip irrigation was introduced to the state in the 1970s and is now widely used. However, across the state, there are still dry-farmed growers with old vineyards that predate drip irrigation, as well as newly planted dry-farmed vineyards.

There are many benefits to dry farming. Dry farmers argue that the quality of the product cannot be beat. The flavors and colors of the grapes are more intense and express more of the characteristics of the vineyard site, all to produce high quality wine. There are also environmental benefits to dry farming. Dry-farmed growers are reducing water use by not irrigating. Further, as water resources in California become scarcer and more strictly regulated, growers will also find themselves exempt from these water regulations, since they are not using irrigation water, or, in most cases, water for frost protection.

Along with the benefits of dry farming, there are trade-offs and some drawbacks. The biggest challenge growers face is the potential for lower yields as compared to irrigated vineyards. The yield of a vineyard is dependent on many factors. Some dry farmers do report comparable yields to irrigated vineyards for premium wine grape production, between 3 and 4 tons per acre. But other growers, especially in the hotter and drier regions of California, report lower yields, in the range of 2 to 3 tons per acre, due to fewer vines per acre, fewer clusters per vine, and less available water. Obviously, if the intent is to produce a large yield of low-value grapes, dry farming is not recommended.

There is also an increased risk factor associated with dry farming. In hot and dry regions in California or in dry years across the state, growers using irrigation have the option to increase their water applications to meet vine water demand. Dry-farmed growers do not have this option; they are completely dependent on the weather. However, during the 2013-2014 growing season and drought in California, all the dry-farmed growers interviewed by CAFF indicated that their crop was unaffected by the drought. Since grapevines have a low water requirement for growth, the vineyards had received enough rain to support a high quality crop, even though annual rainfall was well below normal. Even with this increased risk, the natural resiliency of the grape vine remains a viable basis for vineyard management.

Dry farming is an old system of farming, it is the way crops used to be grown, and because of that, as new technologies have emerged, research and publications on dry farming have declined and are now very difficult to find. It is now largely up to those who are using these farming practices to teach others. Information for this guide was compiled from the few texts on dry farming and from statewide farmer interviews and interactions. Throughout the text are links to case studies that explaining the techniques of the specific dry farmers CAFF has interviewed.

Because farming practices vary considerably based on many factors, including vineyard location and grape variety grown, the practices in this guide should not be applied without considering the unique aspects of the vineyard location and farming goals. The practices in this guide should also not be considered in isolation from each other, but rather as a suite of practices that influence each other as a part of the dry farming system. For example, decisions regarding vine spacing, rootstock, and variety need to be made together, understanding the influence that each choice has on the other. This guide is meant to present the key aspects of dry farming and help answer the question: Is dry farming right for my vineyard?

2. Site Selection

When starting a new dry farmed vineyard, there are many aspects of the land and climate that should be taken into account. The interaction of soil, annual average precipitation, and average temperatures will have the greatest influence on vineyard setup and dry-farming techniques. For example, the hotter the climate is, the more water a vine will use in producing quality wine grapes, and this will affect vineyard setup and dry farming methods.

There is no acre limit for a dry farmed vineyard—the size of the vineyard depends entirely on individual farming goals. There are dry-farmed vineyards ranging from ½ acre to hundreds of acres. Dry-farmed vineyards are also located all across the state of California—though some areas are more difficult to dry farm due to heat and/or low annual precipitation or soil types. It all depends on the reality of the vineyard site.

If possible, observation of the land for at least one season before planting is recommended. Assuming a normal weather year, observing the following aspects of the land can help indicate vineyard site suitability for dry farming:[1]

- Direct observation of water flow and water pooling during rain events and observation of soil drying during the growing season will help determine where it is best to plant to have the right amount of soil water available for the vines. Extremely dry or extremely wet areas may want to be avoided.
- Observation of natural vegetation growth is an indicator of soil water availability. Healthy large trees and shrubs on the land suggest that there is available water in the soils. If trees are stunted or the land only has short-rooted grasses, then the soils are drier.[2]
- Direct observation of fog and frost can help inform planting, especially in coastal areas with large temperature swings and heavy fogs. Fog can provided extra moisture for dry-farmed vines during the growing season, but frost can be a challenge, especially without overhead sprinklers for frost protection. Areas prone to frost may want to be avoided.
- Digging soil pits on the land, at least 6 feet deep, allows for the observation of soil types, soil depth, the layers of subsoil, and the penetration of moisture.

Looking for further reading and examples from real growers? Read one of our case studies

Bucklin Old Hill Ranch
Dry Farming Acient Vines
http://agwaterstewards.org/index.php/practices/dryfarming

2.1 Soils

Soil type and depth is the number one concern for dry farmers. The soil is the sponge that soaks up winter rains and the reservoir that holds the moisture during the dry season. There are management tools that growers can use to increase and retain soil moisture, but starting with the right soil conditions is key.

All things being equal, deeper soils will hold more moisture. There is more soil volume to hold the winter precipitation. For example, a shallow soil with bedrock underneath will stop root growth and limit the amount of water the soil can hold. The right soil depth for a vineyard will vary depending on the conditions, but soils can be anywhere from a few feet deep to more than 20 feet deep.

The best soils for dry farming are deep clay-loam, silty-loam, or sandy-loam soil with high organic matter content. Water is held in the porous spaces between soil particles and organic matter. This is why a loamy soil, one composed of a combination of sand, silt, and clay particles with humus, will have the highest water holding capacity.[3] Soils composed entirely of sand will not be able to retain moisture- as the water simply drains out.

Table 1: Water Holding Capacity of Soils by Textural Class

Textual Class	Water holding capacity per inches per foot of soil
Course Sand	0.25-0.75
Fine Sand	0.75-1.00
Loamy Sand	1.10-1.20
Fine Sandy Loam	1.25-1.40
Silt Loam	1.50-2.00
Silty Clay Loam	1.80-2.00
Silty Clay	1.50-1.70
Clay	1.20-1.50

Source: Plant and Soil Sciences ELibrary. (2015). *Soils Part 2: Physical Properties of Soil and Soil Water.* Available at http://passel.unl.edu/pages/informationmodule.php?idinformationmodule=1130447039&topicorder=10&maxto=10

Conversely, soil that is too compact, like a pure clay soil, will hold water so tightly that plants cannot access the water, and the roots may not be able to penetrate downward through the hard clay. Table 1 shows the average water holding capacities of various soil textures. Highly fractured soils may be unsuitable for dry farming, as the fractures allow for the quick drainage of water.

Obtaining Soil Information

Soil composition and texture can vary extensively over only short distances and will vary with depth. It is likely that any vineyard location has multiple soil types and depths, which may make completing a soil survey difficult and time consuming. However, there are a few ways to get the information about soils.

Direct observation of the soils will provided information on soil depth and soil types. Core samples can be taken with a soil auger. This tool provides a vertical sample of the soils to show how the soil changes with depth. Because this is a hand held tool, it is easy to walk around a vineyard plot and take multiple samples to see how the soil varies across the site. Augers come in various depths to meet specific need; however, augering extensively to determine soil composition and depth across a vineyard block can be very labor intensive, depending on the size of the site

Digging a soil pit with heavy machinery or by hand is also a viable option. A soil pit will allow for observation to see the various layers of soil and how the moisture penetrates those layers overtime. The soil pit should be at least 6 feet deep to expose the subsoil where the roots of the vines will be.

One of the easiest ways to get information about soils is on the Natural Resources Conservation Service's (NRCS) Web Soil Survey. By using the map function, growers can look up specific pieces of land to obtain extensive information on soil types, soil properties, water holding capacity, and more. Reports can be downloaded and saved for reference at a later time. Visit the Web Soil Survey at: http://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm Be sure to contact NRCS if with any questions about the Web Soil Survey or how to use the soil data.

What Can be Done with Soil Information?

By knowing the soil types and soil depth of a vineyard plot, the water holding capacity of soils can be estimated- that is, how much water the soils can hold in reserve for the vines during the growing season. Estimation of water holding capacity can be done at home through equations or by using the values obtained from the NRCS Web Soil Survey.

The first step to estimate water holding capacity is understand the soil profile. This might be difficult without assistance for first timers. First, a sample of the profile must be taken with an auger or by digging a soil pit, and then the various soil textures and their depths must be determined. For example, part of a soil profile may look like Figure 1:

Figure 1:
Example Soil Profile with Texture and Depth

Once the soil textures and depths are determined, to find the water holding capacity, simply multiply the water holding capacity of the soil texture (Table 1) by the depth of the layer, and then add up the values of all the layers. Using Figure 1, the equations would be:

Clay layer = 1 ft deep x 1.5 = 1.5 inches of water holding capacity

Clay Silt Layer = 2 feet deep x 1.70 = 3.4 inches of water holding capacity

Silt Layer = 3 feet deep x 2 = 6 inches of water holding capacity

Total water holding capacity of soil example = 1.5 + 3.4 + 6 = 10.9 Inches

These are certainly back of the envelope calculations, but they will help generate an understanding of how much water the soils can hold and how much water will be available to the vines when these values are compared to with the annual precipitation. In the above example, the soil holds 10.9 inches of water. If this soil is in an area that receives 16 inches of annual rain, the soils will hit capacity and have an approximate 10.9 inches of water available for the vines after the rainy season. This is why it is important to know soil water holding capacity. Just because a vineyard receives high rates of annual rain, does not mean the soils are holding all of that water.

There are methods to increase the water holding capacity of a soil. The most common method is to increase the soil organic matter. Since the water is held in porous spaces in between the soil particles and the organic matter, increasing organic matter adds additional spaces for holding the water. A 1% increase in soil organic matter will increase water retention such that the top foot of soil can hold an additional 16,500 gallons of water per acre.[4] Building organic matter is a long process; new sources of soil organic matter include compost and cover crops, and these practices have additional benefits for dry farming, as discussed in later sections.

2.2 Climate

Average growing season temperatures and average annual rainfall vary dramatically across California. Unfortunately, the hotter regions of California also tend to receive less annual precipitation. Vine water use in these hotter and drier regions is greater than in cooler regions. California has set up a statewide system of weather stations and the weather information is available online as a part of the California Irrigation Management Information System (CIMIS). This information is free to anyone who registers and can provide excellent precipitation, temperature, and evapotranspiration data to aid in farming decisions. This information is available at: http://www.cimis.water.ca.gov

Precipitation is obviously very important for dry farming, vines cannot produce quality wine grapes without water, and precipitation is the only source of water for dry-farmed vines. As discussed in the soil section, with information on the soil's water holding capacity and annual average precipitation data, it is possible to estimate how much water will be available in the soils each year for the vines.

Just looking at annual precipitation alone can be deceiving. If the vineyard is located in an area in the North Coast that receives around 30 inches of annual rain, that may seem like more than enough rain to dry farm wine grapes. However, if the vineyard site has shallow soils that only hold 5 inches of water, then that may not be viable for dry farming. If the vineyard soils hold 15 inches of rain, then that may be sufficient for dry farming.

Is There a Right Amount of Precipitation for Dry Farming?

Unfortunately, there is no research so far that presents the right combination of annual precipitation, soils, and region for dry farming. Growers are dry farming all across California with varying levels of annual precipitation, with some growers stating that they need only 11 inches of rain to some needing more like 22 inches of annual rain. Grape vines have low water requirements and mild water stress can actually improve grape quality, which is something that even growers who are irrigating capitalize on by using Regulated Deficit Irrigation (RDI) techniques. This means that, with surprisingly little rain, growers are able to successfully dry farm. A conservative estimate is that at least 15 inches of annual rain are needed to dry farm. But there are a few things to do to find out more information about dry farming in a specific climate:

Talk to neighbors and regional grape growing associations (see Support Agencies section for a complete list). Find out if there are any dry farmers in the vicinity, and then go visit that and compare vineyard conditions and techniques.

Draw on personal experience growing irrigated wine grapes in the area by reviewing past irrigation schedules. Were their years when vines were over watered? Year when irrigation was unnecessary?

Lastly, complete some back of the envelope calculations—but these can get a little complicated. A Water Balance or Water Budget is the process by which the water inputs and outputs for a vineyard are tallied using soil data, precipitation, and vine water use through evapotranspiration equations as a percentage of safe water stress. Once completed, a Water Balance will provide estimations at to whether or no there is sufficient water in the soil to meet the vines' requirements over time. If interested in completing a Water Balance or Budget for a vineyard, please contact a UC Farm Advisor, NRCS staff, or trusted consultant for assistance.

Fog

In coastal areas of California, fog can provide moisture to the vines and mitigate heat effects during the growing season. This should not be considered a significant source of water for vines. But the cooling effect and the moisture brought in by the fog to the surface of the soils and to the vines can be beneficial, especially for dry-farmed vines, by helping the soils retain moisture and the vine reduce its evaporative losses. Coastal climates and fog have a unique influence on all styles of wine grape growing. All things being equal, fog is beneficial to dry-farmed wine grapes.

Frost

Frost protection can be a huge problem for vineyards anywhere in California. Many dry-farmed growers also want to combat frost without using water (growers often use overhead sprinklers for frost protection). There are a few common methods for frost protection that do not involve over head sprinkling:

- Before planting, select a site that is not prone to frost, like an upper hillside, and this will eliminate the need for frost protection.
- Wind machines: Growers can set up large wind machines in the vineyards to keep the air moving and prevent the frost from settling.
- Double Pruning: Buds at the end of a cane grow first. To avoid frost damage, during vine dormancy, prune off any excess canes, but do not prune the canes that will be used for fruiting next year; leave these canes long. In the spring, the buds furthest out on the cane will grow first and get hit by the frost. Once the threat of frost is over, prune the vine back to the number of buds for fruiting and because these buds grew in later, they are unaffected by the frost.[5]

All of this Site Selection information will help determine if and how to dry farm a vineyard site. For example, climate and soils will influence vines spacing, rootstock selection, variety, and inform cultural practices. Knowing the vineyard conditions will help with all other decisions.

3. Vineyard Setup

When starting any vineyard, one must carefully plan and design that vineyard to fit the land and climate, as well as meet production goals. Setting up a dry-farmed vineyard has its own tricks that are different from an irrigated vineyard. The number one priority in establishing a dry-farmed vineyard in a semi-arid climate is maximizing the vine's natural ability to find adequate water from the soils to support premium wine production. With careful planning, growers can give the vines the best advantage from the underground up.

For further information on vineyard setup and establishment, read our case study:

Paul Bernier Vineyards
Dry Farming Winegrapes
http://agwaterstewards.org/index.php/practices/dry_farming

Variety Selection

Under the right conditions, it is likely that almost any vine can be dry farmed. However, it is clear that the most robust and naturally vigorous varieties are more well suited to dry farming in California. Varieties that prefer consistently moist soils or temperate and constant conditions are not optimal for dry farming in California.

Wine grape varieties for a specific vineyard should be picked first based on temperature parameters. Many researchers have worked to develop temperature parameters specific to each wine grape varietal, and these are used to match climates to variety. Any questions about matching varieties to climate should be directed to a local nursery, local wine grape growing association, or UC Farm Advisor.

Once it has been determined which varieties are best for the vineyard's climate, it is time to consider which are best suited to dry farming. Based on the California experience and farmer interviews, there are certain varieties that have been proven to be excellent vines for dry farming, both reds and whites. These include:

Red Grape Varieties

Alicante Bouchet
Carignane
Cabernet Franc
Cabernet Sauvignon
Charbono
Cinsault
Counoise
Grenache
Mission
Mourvèdre
Négrette
Petite Sirah
Petit Verdot
Pedro Ximénez
Tannat
Tempranillo
Zinfandel

White Grape Varieties

Chardonnay
Gewürztraminer
Grenache Blanc
Marsanne
Riesling
Roussanne
Sauvignon Blanc
Trousseau Gris
Viognier

This list is by no means exhaustive, but does represent most of the current dry-farmed varieties in California. Zinfandel is by far the most popular dry-farmed grape in the state. There are some growers in California who are dry farming Pinot Noir; however, this is a notoriously hard grape to dry farm here, as it likes consistently wet soils. Growers have also reported difficultly in dry farming Merlot and Barbera in California.

Rootstock

Rootstock selection is one of the most important factors in dry-farming wine grapes. Growers must pick a rootstock that is capable of growing deep roots to search out the water sources in the soils, these are known as 'drought tolerant' or 'water thrifty' rootstocks.

There are many things for growers to consider when picking a rootstock that is suitable to the vineyard site. Dry-farming goals are one consideration of many, including:[6]

- Rootstock resistance to soil pests, such as phylloxera and nematodes
- Rootstock suitability to soil types, soil depth, and available nutrients
- Rootstock suitability to soil chemistry, including calcium levels, acidity, lime content, and salinity
- Rootstock suitability to vineyard design, including vigor of the fruiting variety, density of planting, and training system
- Rootstock suitability to available soil moisture and dry-farming goals.

Dry farmers in California use a variety of rootstocks based on their vineyard conditions, but the most commonly used rootstocks are hybrids of two types of wild rootstocks which grow some of the deepest and most vigorous roots, *V. rupesteris* and *V. berlandieri*[7] (see Box). The most commonly used rootstocks for dry farming in California are:

- St George (*V. rupestris)*
- 110 Richter (*V. rupesteris* x *V. berlandieri*)
- 1103 Paulsen (*V. rupesteris* x *V. berlandieri)*
- 140 Ruggeri (*V. rupesteris* x *V. berlandieri*)

Some growers are using *V. riparia* rootstocks, but only if their soils have a high water table or high moisture content. On extremely saturated soils, a rootstock like St. George may actually be too vigorous. It is therefore important to understand the water content of the vineyard soils when picking a rootstock.

Included here is a comparison table (Table 2) with the characteristics of commonly used rootstocks in California, including their drought tolerance, which is a good indicator of rootstock suitability for dry farming.

Box: Wild Rootstocks

Vitis berlandieri: This species of grape is native to southern Texas and New Mexico, and has a good tolerance against soils with high lime contents. This species is usually crossed with other species to create a disease and lime tolerant rootstock.

Vitis rupestris: This species of grape is native to the southern and western United States. The vine naturally grows in full sun, is bushy, and vigorous. *V. rupestris* have extensive root systems to anchor the bushy and large vine.

Vitis riparia: This species of grape is widely spread throughout the United States and is an American climbing or trailing vine. The vine has shallower roots and grows in areas with adequate soil moisture. This vine has good resistance to phylloxera, is adaptable to cold climates and many soil types.

Table 2: Comparison of Commonly Used Rootstocks in California

Rootstock Name	Species	Drought Tolerance	Salinity Tolerance	Lime Tolerance	Vigor	Soil types	Phylloxera Resistance	Nematode Resistance
St. George	rupestris	High in deep soils	Med-high	Med	High	Deep soils	High	Low
110 Richter	berlandieri x rupestris	High	Med	Med	Med	Hillside soils and acidic soils	High	Low
1103 Paulsen	berlandieri x rupestris	Med-High	Med	Med	Med-High	Drought and saline soils	High	Root knot: Med-High Dagger: Low
140 Ruggeri	berlandieri x rupestris	High	Med-High	Med-High	High	Drought and acidic soils	High	Root knot: Low- Med Dagger: Low
SO4	berlandieri x riparia	Low-Med	Low-Med	Med	Low-med	Clay soils with moisture	High	Root knot: Med-High Dagger: Low-Med
Teleki 5C	berlandieri v riparia	Low	Med	Med	Low-Med	Clay soils with moisture	High	Root Knot: Med-High Dagger: Low-Med
Kober 5BB	berlandieri v riparia	Med	Low-med	Med	Med	Clay soils with moisture	High	Root Knot: Med-High Dagger: Med
101-14 Mgt	riparia x rupestris	Low-Med	Med	Low-Med	Med	Clay soils with moisture	High	Root knot: Med-High Dagger: Med
3309 Couderc	riparia v rupestris	Low-Med	Low-Med	Low-Med	Low-Med	Deep soils	High	Low
1616 Couderc	longii v riparia	Low	Med-High	Low-Med	Low	Best on fertile soils	High	Root knot: High Dagger: Med
Ramsey	champinii	Med-High	High	Med	High	Sandy and infertile soils	High	Root knot: High Dagger: Low-Mede
Dogridge	champinii	Med	Med-High	Med	Very High	Sandy and infertile soils	Med	Root knot: Med-High Dagger: Low-Med
Freedom	1613 x dogridge	Med	Low-Med	Med	High	Sandy/ Sandy loam	Low-Med	High

Sources:
California Sustainable Winegrowing Alliance. California Code of Sustainable Winegrowing, Third Edition Christianson, L. (2003). Rootstock Selection. Available At: http://iv.ucdavis.edu/files/24347.pdf

Spacing

Although not an absolute rule, it has been generally observed that the spacing between the vines and rows in a dry-farmed vineyard is larger than that of an irrigated vineyard. Each dry-farmed vine needs access to a large volume of soil to seek out soil moisture; to that end, the vines need to be spaced farther away from their neighbors.

The optimal vine spacing for a vineyard will depend on the average growing season temperatures, soil moisture content, and water use of the vine. Soils with higher moisture content can support vines with a tighter spacing. Higher soil moisture contents could come from deep soils, high water tables, or annual precipitation.

Regions that are hotter and drier require the largest spacing between vines and rows to allow the vine enough soil volume to support premium wine production. If the vines are crowded and unable to get the water needed for production, irreparable harm can be done to the vines, jeopardizing the crop.

Vine spacing can vary within regions and even within vineyard sites. Some growers will use a larger vine spacing on hill sides to accommodate drier soils and to account for tractor slippage, and then a tighter spacing on the flatter and wetter areas of the vineyard.[89] Comparing two large wine regions, Table 3 shows examples of common vine spacing. Vines in the North Coast of California, which gets more rain and more mild summers, are spaced closer together than in the Central Coast, where the summers are hotter with fewer inches of annual rain.

Table 3: Examples of Vine and Row Spacing in Dry-Farmed Vineyards in the North and Central Coasts of California

Region	Common vine and row spacing (in feet)
Cooler Regions: North Coast/Coastal Areas	8x8, 9x6, 5x7, 4x8, 10x5, 8x12
Warmer Regions: Central Coast/Inland Areas	12x8, 9x9, 10x10, 12x12

Source: Grower interviews

Trellis System

Any trellis system can be used for dry farming,[10] likely with the one exception of Vertical Shoot Position (VSP), as VSP was designed specifically as a method to decrease the spacing between vines. The trellis system should be chosen based on variety selection and cultivation practices. For example, for a Bordeaux varietal like Cabernet Sauvignon or Chardonnay, a wire trellis is appropriate. If growing Zinfandel, a Rhone, or Spanish variety, then head training may be a better option. It is important to match the variety with the correct trellis and training system. Local UC Farm Advisors can help ensure that the trellis, training, variety, and vineyard plot are all well suited.

The majority of dry-farmed growers head train their vines. This requires no trellis system, only a stake to support young vines that can then be removed as the vine grows and is able to support itself. This is a traditional European form of growing brought over by Italian immigrants and used by the earliest grape growers in California.

Although head training is not necessary for dry farming, it is by far the most commonly used system by California dry-farmed growers for three reasons:

- Without any wires and trellis systems, growers are able to cross cultivate the rows of their vineyards, allowing for additional benefits to soils health and moisture.
- Head training limits the growth of the vine. By keeping the vine smaller, it uses less water, naturally creates a more balanced vine, and is more amenable to dry farming. However, the smaller vine does restrict the vine to a smaller crop load, which must be taken into account.[11]
- Setting up a head trained vineyard is less expensive then setting up a wire-trellised vineyard, as there is less infrastructure.

No matter what trellis system is being used in a dry-farming system, it is especially important to make sure that the vines are pruned and trained correctly to manage the vines' water use and that the vines are not over cropped.

Vineyard Establishment

Once vineyard has been designed, it is time to plant. Rootstock planting and grafting schedules are the same as with irrigated vineyards, consult nurseries and UC Farm Advisors for more information.

Rootstocks and young vines of dry-farmed vineyards are often watered for the first 1 to 3 years. This allows the vines to grow strong roots without struggling during establishment. Growers in California report that they generally water two or three times a year that first year; once at planting, once during the summer growing season, and perhaps once in the fall. Methods of watering vary among growers and include:

- Roll out temporary drip tape
- Hand watering by using tractors to pull water tanks through the vineyard
- Hand watering by placing a five-gallon bucket with a hole in the bottom over the vine. The bucket is filled to the top and the water will slowly infiltrate into the soils. The bucket is then removed and used for another vine.

Methods of watering depend on available equipment, size of vineyard, and accessible water sources. Almost every dry-farmed grower interviewed in California waters his or her vines for at least the first year. Some growers water for additional years depending on their observations of their vines, winter precipitation, and growing season heat.

Vine Replacement

Vine replacement in a dry-farmed vineyard is treated much the same as planting a new vineyard. Should a vine die, the old vine and root system are removed. New vines are planted using the same methods that were used to plant the initial vineyard, watering the first year and up to three years, as needed.

Converting an Irrigated Vineyard to a Dry-Farmed Vineyard

Converting a vineyard from irrigation to dry-farming methods can be done and has been done by many growers in California. Of course, this presents its own challenges. Irrigated vineyards are often designed differently from dry-farmed vineyards, and when converting a vineyard, a grower must work with what has already been planted.

Step one is to gather all the information about the vineyard and climate such as rootstock types, spacing, varietals, average precipitation, and average temperatures. The age of the vines will also be a factor, older vines will have deeper root systems already established and may be easier to convert to dry farming.

If it can be avoided, simply turning off the irrigation on a vineyard is not a recommended method to convert an irrigated vineyard to dry farming methods. This could shock the vines and damage the crop. It is instead recommended that the amount of water used for irrigation is slowly dialed back each year to test the resiliency of the vines and allow them to adapt to the new watering system.

For further information on converting a vineyard, read our case study:

Wolff Vineyards,
Converting from drip irrigation to dry farming
http://agwaterstewards.org/index.php/practices/dry_farming

Use the experience of irrigating the vineyard to determine how much the irrigation can be reduced each year, as well as soil information and annual precipitation; it may take a few seasons to convert a vineyard. In addition to reducing irrigation, growers have also had success with deep ripping the top 6 to 12 inches of soil around the base of the vine in the spring. This will tear up the surface roots of the vine and force the vine to grow deeper roots to find the soil moisture.

How many seasons it will take to convert a vineyard from irrigation to dry farming depends on the vineyard. Areas with greater annual precipitation, soils with good water holding capacity, and deeper rootstocks will likely take less time to convert. If the vineyard is planted on a riparian rootstock in a dry area with tight vine spacing, then it may be very difficult, if not impossible, to convert to dry farming.

Cost Comparison

Establishing a dry-farmed vineyard will cost less than establishing an irrigated vineyard. If planting a dry-farmed vineyard that is head trained, there will be fewer costs, as growers do not have to install an irrigation system or a trellis system (although each wine will have to be staked). So what kind of money are we talking about? Although costs will vary due to region of the state, according to UC Davis Cost Study Reports costs will range:

$1,000- $3,000 per acre for the irrigation system
$5,000-$10,000 per acre for the trellis system

When establishing a dry-farmed vineyard, growers have neither of these two costs. One grower in Paso Robles indicated that it cost him about $6,000 an acre to plant his vineyard, as opposed to $30,000 an acre for irrigated vineyard. So what are the other costs? Drilling and putting in a new well and leveling land before planting the vineyard to accommodate the irrigation system and trellis system. Although individual costs will vary, it is important to note that the smaller upfront capital costs can be very important when starting a new vineyard.

4. Cultural Practices

By far, cultural practices vary the most among vineyard sites. Although there are some key practices that dry farmers use to support vines, use of these practices depends on the characteristics of the vineyard. In most vineyards in California, due to the semi-arid climate, the principle behind the cultural practices will be the same: reduce the loss of water from the soils to produce a better crop.

Water is lost from the soil due to surface run-off, evaporation/transpiration from the soils and the crop, and deep percolation into the groundwater. Fortunately, there are cultural practices a grower can use to minimize run-off and managing the water loss from soils and crops, and in this section are the most common methods.

In some cases in California, the vineyard might be in area that has too much water and cultural practices will be geared towards increasing drainage or reducing water levels in the soils. Over watered grape vines will be too vigorous in their growth causing more pruning work and over saturated roots can actually drown a vine. Areas with large amounts of water in the soils may occur near rivers beds, in areas with high water tables, at the bottom of hills, etc. Growers in this situation may want to experiment with permanent cover crops and no-till methods.

Cover Crops

Most dry farmers plant winter cover crops. Cover crops provide a few key benefits:

- Winter cover crops increase the infiltration rate of winter rains and reduce runoff, increasing soil moisture content
- Winter cover crops slow erosion and topsoil loss during heavy winter rain events
- When mowed down and disked into the soils in the spring, cover crops can be an important source of nutrients and organic matter for the soils

To use cover crops, first pick a cover crop mix that is right for the soils and will add necessary nutrients. For example, using nitrogen fixing plants as cover crops, such as legumes or mustard, can be an important source of nitrogen for the vineyard. Cover crops are seeded in the fall after harvest and grow all winter and into early spring. Soon after the winter rains stop, cover crops are mowed and then the crop detritus is disked into the soils to incorporate the organic matter and nutrients. Because the cover crop will likely be seeded every year, experimenting with cover crops mixes is very easy.[12]

Most dry farmers remove their cover crops from the fields before the dry season in California. This is done to reduce evaporative losses from the soil and competition for soil water sources. Cover crops will be using the soil moisture for their growth. Once the cover crop dies or goes dormant, if it is left in the soil, the roots and stocks will act as a channel, allowing the soil moisture to evaporate more readily from the surface- which may or may not be a problem for certain vineyards. In addition, most growers till and cultivate the soils during the season, necessitating the removal of the cover crops.

If the vineyard is in an area where there is too much water in the soils, then experimenting with a permanent cover crop may help. A permanent cover crop that is mowed periodically during the growing season will use the soil moisture for growth and increase evaporative losses. This will decrease soil moisture. This, of course, means that the grower will have to practice no-till growing methods.[13]

No-Till Dry Farming

A few dry farmers are experimenting with permanent cover crops and no till practices. No-till practices are just as it sounds, growers are producing their crops without disturbing the soils through tillage. Growers have shown that dry farmers can implement these practices, though it is not as common as winter cover crops and tillage. These growers have found that the water losses at their vineyards from cover crops do not adversely affect their vines because the soils have enough moisture to support both the cover crops and the vines, and the vines roots are far deeper than the cover crops, meaning that the vines are accessing water that the cover crops are not.

No-till practices are being used in hot dry regions, like Paso Robles, and also in wetter cooler regions like the North Coast. To start a no-till practice, permanent cover crop is seeded in the fall. The rows are then mowed in the spring to manage the cover crop. During the summer months, the cover crop will likely go dormant due to lack of water and heat, and at that time, the grower does not need to cultivate the rows at all. When the winter rains come back, the cover crop will start to grow again.

Depending on the cover crop mix and vineyard site specifics, the cover crop may need to be reseeded occasionally. One grower recommends mowing and incorporating the cover crop through tillage into the soil once every five years, allowing the grower to reseed the cover crop, increase soil organic matter, and reduce soil compaction. While still other dry farmers indicate that they practice no-till methods one year but might till the next year, depending on soil needs.

It has been suggested for a long time that dry farmers must till and cultivate their soils to maintain and trap soil moisture; however, as more and more growers are proving, to till or not to till is a far more fluid concept for dry farmers. Growers are proving that they can make both systems work, and really everything in between.

No-till has a few benefits for the growers:

- Reduces tractor work, saving time, energy, and money
- Reduces soil erosion, especially on hillside vineyards
- Sequesters soil carbon

For further information on no-till and permanent cover crops, read our case study:

Harrison Vineyard
Dry Farming to Control Soil Moisture and Vine Vigor
http://agwaterstewards.org/index.php/practices/dry_farming

Tillage

Although some growers are experimenting with no-till dry farming, most dry-farmed growers use soil tillage and cultivation practices to help manage the soil moisture during the growing season. Tillage breaks up soil clumps, aerates the soils, and controls soil compaction. Deep plowing to both prepare the soil before planting the vines and during the season will help keep the soil clump free, improving soil structure. [14] Tillage also gives the grower some amount of control over the soils moisture content through managing soil evaporation.

Water in soils moves from the deeper soil layers, from 2 to 20 or more feet deep, to the surface via capillary action, meaning that, as the sun dries out the top layer of soil, water from below moves up and is evaporated off the surface. The process can be beneficial for vines; although vines have deep roots to access water stored down in the soil profile, the most active roots are in the top few feet of soil. Soil water movement can be good as it brings the moisture up to the most active roots. However, if too much capillary action allows the water to evaporate off the surface of the soil, this can leave the vines with less available water. Although growers want capillary action in their soils to move the water around, if it is excessive, it can limit available soil water.

During the growing season, most dry farmed growers create a dust mulch to seal in the soil moisture. Mulching refers to creating a barrier between the hot sun and the water in the subsoil of the vineyard. A mulch can be made from anything. But a dust mulch uses the vineyard soils as that barrier. To do so, growers will:

- Mow down the cover crops after the winter rains
- Disc the soils- this is a deep plow that incorporates the cover crops organic matter and improves soil structure. Deep plowing depends on the location, but it is at least 6 to 12 inches deep.
- Use a harrow (usually spring-tooth, but this depends on the vineyard) to create the dust mulch. The mulch should be 3 to 6 inches deep in California to protect against evaporation. By breaking up this top layer with the harrow, growers are changing the structure of the surface soil from what is below, this essentially breaks and stops the capillary action to the surface to control evaporation.
- Use a roller over the top to seal the mulch and the subsoil to conserve moisture.

The compaction of the roller encourages the subsoil moisture to come up to the surface layer of soils, and the harrowing and seal stops the evaporative losses.[15] Therefore, this practice can be, and is often, done a few times during the season by dry-farmed growers to bring additional moisture up to the vine's most active roots. Some cultivate their fields as many at 8 times per season, while others will cultivate only once or twice.[16] The number of cultivations a season depends on soil moisture. Every time this is done, growers will find that the top layer of soil mulch is dry and clumpy, but underneath, the soil is cool and moist, just as the vines require.

For further information on tillage,
read our case study:

Frog's Leap Vineyard
http://agwaterstewards.org/index.php/practices/dry_farming

Soil Fertility

Most dry-farmed growers use compost to increase soil fertility and provide nutrients to their vines. Growers can use a nutrient management plan to determine how much and what type of compost to apply to the vines. The nutrient management plan should also include cover crop usage. For assistance developing a nutrient management plan, please contact the local NRCS office, Farm Advisor, or trusted Certified Crop Advisor.

Compost application rates depend on the nutrient content of the compost and the type of compost used. Application method will also depend on the size of the vineyard and vineyard design. For smaller vineyards, hand application may be appropriate. With larger vineyards with enough space between rows, growers can use a spreader. Compost is typically applied in the fall after harvest or in the early spring before budbreak.[17]

Compost is an important source of nutrients for dry-farmed growers (as well as irrigated growers), soil and leaf samples can be taken in the vineyard to guide compost usage and determine if there are any other soil nutrient deficiencies or concerns that are not addressed by compost applications, such as boron or calcium deficiencies.

Animals in the Vineyard

Farmers have experimented with mixed herds of animals, most often sheep, in the vineyards to mow the cover crops during the winter and early spring before bud burst. Animals in the vineyard mow the cover crops, aerate the soils with their hooves, and provide fertilizer with their waste. It is important to carefully monitor a grazing herd, rotate them through the vineyard to prevent over grazing, and to make sure that the herd is pulled from the vineyard before they can do damage to the buds and vines in the spring time.

And if there aren't sheep on the farm, don't worry, herds of sheep can be rented!

For further information on the use of animals and vineyard cultivation, read our case study:

Tablas Creek Vineyard
Dry Farming Techniques
http://agwaterstewards.org/index.php/practices/dry_farming

Pruning and Cluster Thinning

Pruning and cluster thinning is used to balance the vegetative growth and the berry growth of the vines to produce high quality grapes and to keep the water use of the vine to a minimum. The more vegetative growth on the vine, the more water the vine will use, same with cluster development. Therefore, any unnecessary crop or vegetative growth needs to be removed to manage the vine's water use and support premium grape production. Growers must seek a balanced vine that has just enough vegetative growth to shade clusters and enough clusters to meet production goals.

Balancing a vine depends on the training method used and the appropriate crop and vegetative growth load to match the vines vigor to the soil moisture level. But the best method will combine pruning and cluster thinning to achieve desired goals. Each year, prune back the vine after the growing season, and cluster thin just before bloom to remove the flowers before they bloom and become grape clusters.[18] For tips on balancing a vine, please contact a local farm advisor.

5. Conclusion

Like any type of farming, dry farming is a system in which each decision made influences other decisions, and each decision is unique to the particular piece of land. Hopefully, this guide has been able to present the key concepts and fundamentals of dry farming to answer most basic questions on site selection, vineyard setup, and cultivation methods. For more information and individual consultation, please see the Further Reading and Support Agencies sections of this guide.

With the advent of new irrigation technologies in the 1970s, dry farming practices have become increasingly scarce among wine grape growers. However, more recently, growers are turning to these methods as a way to produce high quality wine grapes and because of concerns around reliable access to irrigation water. Currently, there are dry farmed wine grape growers all over the state of California, producing crops on vines that are more than a hundred years old or vines that are less than ten years old.

If interested in finding local dry farmed vineyard and wineries or for a complete list of case studies, please visit the following websites:

Community Alliance with Family Farmers, Dry Farmed Wines
http://caff.org/programs/dryfarm/wines/
Find dry-farmed wines from across California

Community Alliance with Family Farmers, Dry Farmed Vineyards
http://caff.org/programs/dryfarm/vineyards/
Find dry-farmed vineyards in California

California Agricultural Water Stewardship Initiative, Dry Farming
http://agwaterstewards.org/index.php/practices/dry_farming/
Find farmer case studies, information, and resources on dry farming

5. Further Reading

California Agricultural Water Stewardship Initiative, Dry Farming
http://agwaterstewards.org/index.php/practices/dry_farming/
Find farmer case studies, information, and resources on dry farming

California Irrigation Management Information System (CIMIS)
http://www.cimis.water.ca.gov
Find climate data and helpful information on plant water use

Community Alliance with Family Farmers, Dry Farmed Wines
http://caff.org/programs/dryfarm/wines/
Find dry-farmed wines from across California

Community Alliance with Family Farmers, Dry Farmed Vineyards
http://caff.org/programs/dryfarm/vineyards/
Find dry-farmed vineyards in California

General Viticulture
Winkler, A.J., Cook, J.A., Kliewer, W.M., & Lider, L.A. (1962) University of California Press, Berkeley, California.
Comprehensive textbook on viticulture of all types with a focus on California wine grape growing.

Rootstock Selection
Christensen, L. (2003) Pages 12-15 in: Wine Grape Varieties in California. University of California Agricultural and Natural Resources Publication 3419, Oakland, CA. http://iv.ucdavis.edu/files/24347.pdf
UC Davis Guide to Rootstocks in California.

California Sustainable Winegrowing Alliance
http://www.sustainablewinegrowing.org
Find resources and the California Code of Sustainable Winegrowing to assist with wine grape growing questions. Although information is not all geared towards dry farming, growers can still find valuable resources.

Dry-Farming: Its Principles and Practice
MacDonald, W. (1909). The Century Company. New York, New York.
A comprehensive guide on dry farming all crops from the early 20th century.

5. Support Agencies

Natural Resources Conservation Districts
http://offices.sc.egov.usda.gov/locator/app?state=CA
Find local NRCS office for on-farm assistance

UC Cooperative Extension Farm Advisors, Fruit and Nut
http://fruitsandnuts.ucdavis.edu/ce/locate_advisor/
Find local UC Farm Advisor with questions or for on-farm assistance

Contact local wine grape association for region specific information, support, to connect with other growers, or to learn about their educational programs.
A full list of regional grower organizations can be found at on the Wine Institute's Website:
http://www.wineinstitute.org/resources/external-links/regional-winery-grower-associations-of-california

[1] Rombough, L. (2002). The Grape Grower. Chelsea Green Publishing Company, White River Junction, VT.
[2] Osgood, D. 2014. Personal Communication K. Lambert: In person correspondence, David Osgood, Owner, Osgood Farms.
[3] Plant and Soil Sciences ELibrary. (2015). Soils Part 2: Physical Properties of Soil and Soil Water. Available at http://passel.unl.edu/pages/informationmodule.php?idinformationmodule=1130447039&topicorder=10&maxto=10
[4] Scott, H.D., L.S. Wood, & W.M. Miley. (1986). Long-term effects of tillage on the retention and transport of soil water. Arkansas Water Resources Research Center. Publication Number 125: (39)
[5] Hart, P. 2012. Personal Communication K. Lambert: In person correspondence, Phillip Hart, Owner, AmByth Estate.
[6] Christenson, L.P. (N.D.). Rootstock Selection. Wine Grape Varieties In California, UC Davis. Available At http://ucanr.org/sites/intvit/files/24347.pdf
[7] Walker, A. 2013. Personal Communication. K. Lambert: In person Correspondence, Dr. Andy Walker, Professor, UC Davis.
[8] Bernier, P. 2012. Personal Communication, K. Lambert: In person correspondence, Paul Bernier, Winegrape Grower, Sonoma, California.
[9] Hart, P. 2012. Personal Communication K. Lambert: In person correspondence, Phillip Hart, Owner, AmByth Estate.
[10] Walker, A. 2013. Personal Communication. K. Lambert: In person Correspondence, Dr. Andy Walker, Professor, UC Davis.
[11] Ibid
[12] Harrison, T. 2012. Personal Communication K. Lambert: In person correspondence, Terry Harrision, Winegrape Grower, Sonoma California.
[13] Ibid
[14] MacDonald, W. (1909). Dry-Farming: Its Principles and Practice. The Century Co. New York, New York.
[15] Ibid.
[16] Leeds, F. (2014). Presentation: Dry Farming, Everything You Need to Know, Napa Organic Winegrape Growing Conference. July 31st, 2014. Rutherford, California.
[17] Bernier, P. 2012. Personal Communication, K. Lambert: In person correspondence, Paul Bernier, Winegrape Grower, Sonoma, California.
[18] Cox, J. (1999). From Vines to Wines. Storey Publishing. North Adams, Massachusetts