Choosing Appropriate Sites for Alfalfa Production

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Most of the agricultural areas of the arid Southwest are well suited for alfalfa production. Because of the nearly ideal climate and soils in many southwestern areas, the alfalfa yield potential is greater than in any other geographic region in the United States. The long, warm summers and relatively mild winters make for an extended growing season. In California, the length of the frost-free period typically ranges from 314 days in the Imperial Valley to 307 days in the Sacramento Valley. Most of the soils are alluvial and are fertile and deep, which is ideal for alfalfa production.

One of the first steps before embarking on alfalfa production is selecting the proper site. This is a critical step because site conditions can limit both yield and profit potential. The characteristics of a site may also affect alfalfa quality as well as stand persistence and ability to combat weed competition. When alfalfa is grown on sites that provide adequate rooting depth, nutrition, aeration, and water and have no salinity or alkalinity problems, growers using good management practices can produce hay yields of 8–10 tons per acre (19–22 Mg/ha\(^{-1}\)) per year or higher (Fig. 2.1). Greater management skills are required for profitable alfalfa production on marginal or undesirable sites. Remember, the better the site, the higher the yield potential. Some site limitations can be overcome or reduced, but the cost may be high, affecting future profitability. If site conditions are poor, alfalfa production may be unprofitable even under optimal management.
Soil and Water Factors Affecting Site Selection

Consider the physical and chemical properties of the soil, the likelihood of waterlogging, and the quantity and quality of available irrigation water when selecting a site for alfalfa (Table 2.1). For surface irrigation, the topography and associated leveling costs are also important. Also assess biological factors, such as the presence of diseases, weeds, or nematodes, as well as crop rotation plans before planting alfalfa on a site.

Examine Soil Properties

The first step to determine the suitability of a site for alfalfa is to know the soil types present. Alfalfa can be grown on a wide range of soil types, from sands to heavy clays, and there is a wide variation in soil types throughout the Central Valley and Low Desert regions of California.

TABLE 2.1

Physical characteristics of ideal, marginal, and undesirable sites for alfalfa production

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Ideal</th>
<th>Marginal</th>
<th>Undesirable¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil texture</td>
<td>Sandy loam, silt loam, clay loam</td>
<td>Loamy sand, silty clay</td>
<td>Sand, clay</td>
</tr>
<tr>
<td>Soil depth (ft)</td>
<td>&gt;6</td>
<td>3–6</td>
<td>&lt;3</td>
</tr>
<tr>
<td>Soil chemistry⁵</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(pH)</td>
<td>6.3–7.5</td>
<td>5.8–6.3 and 7.5–8.2</td>
<td>&lt;5.8 or &gt;8.2</td>
</tr>
<tr>
<td>Salinity (ECₑ in mmho/cm)</td>
<td>0–2</td>
<td>2–5</td>
<td>&gt;5</td>
</tr>
<tr>
<td>Exchangeable Sodium Percentage (ESP)</td>
<td>&lt;7</td>
<td>7–15</td>
<td>&gt;15</td>
</tr>
<tr>
<td>Boron (mg/L)</td>
<td>0.5–2.0</td>
<td>2–6</td>
<td>&gt;6</td>
</tr>
<tr>
<td>Frequency of water logging or high water table</td>
<td>Never</td>
<td>Only during dormant period</td>
<td>Sometimes during periods of active growth</td>
</tr>
<tr>
<td>Slope</td>
<td>Nearly level</td>
<td>Slightly sloping to 12% slope</td>
<td>&gt;12% slope</td>
</tr>
<tr>
<td>Water quality</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>pH</td>
<td>6.5–7.5</td>
<td>7.5–8.2</td>
<td>&gt;8.2</td>
</tr>
<tr>
<td>ECₑ</td>
<td>&lt;1.3</td>
<td>1.3–3.0</td>
<td>&gt;3.0</td>
</tr>
<tr>
<td>SAR</td>
<td>&lt;6.0</td>
<td>6.0–9.0</td>
<td>&gt;9.0</td>
</tr>
</tbody>
</table>

¹ These sites are considered unsuitable for profitable alfalfa production unless reclaimed or specialized management is employed.

² Values are based on saturated paste extract analysis and are adapted from Lancaster and Orloff (1997).

Note: These categories are approximate and should be modified when warranted by experience, local practices, special conditions, or irrigation method.
California. Sandy soils are common in many areas on the east side of the Central Valley, whereas heavy clay loam soils are typical along the west side. Organic soils may be found in the San Joaquin–Sacramento Delta area. A thorough knowledge of the soil type found in a field to be planted to alfalfa is important because soil type has a profound effect on crop management, including water-holding capacity, fertility and nutrient availability, and drainage.

Soil surveys, published by the USDA Natural Resources Conservation Service (NRCS), contain maps to assist growers with the identification of soil units found on the farm. Maps are available at NRCS offices or on the Web at http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx. Additional information is included on soil texture and changes in soil texture with depth, presence of hardpans, water-holding capacity, drainage, and infiltration rate. These soil survey maps and descriptions are generalized and may not provide the level of site-specific information desired. However, soil survey information is an excellent first step to ascertain the suitability of a site for alfalfa production. If the survey indicates that the site may have promise, have the soil and water analyzed for chemical characteristics (see Chapters 6–7: “Alfalfa Fertilization Strategies” and “Irrigating Alfalfa in Arid Regions”). Do this before planting alfalfa on the site.

**Understand Your Soil Texture**

The term “soil texture” refers to the relative proportion of sand, silt, and clay in soil. Soil texture affects the water-holding capacity and infiltration rate, the rate at which irrigation water will enter the soil profile. Clay holds the most water and sand the least. Usually, sandy soil has the fastest water infiltration rate and clay soil the slowest, but there are some areas in the San Joaquin Valley with sandy loam soils that “seal over,” severely limiting infiltration. Soil textural characteristics, as well as other factors such as quality of irrigation water, influence irrigation system design, irrigation practices, and nutrient management.

Alfalfa can be successfully produced on a wide range of soil textures, but sandy loam, silt loam, and clay loam soils are generally preferred. These soil types provide the best combination of water infiltration, water-holding capacity, and aeration for alfalfa.

More extreme soils, such as very heavy "adobe-type" clay soils or very sandy soils, make management more difficult. Sands and loamy sands have such low water-holding capacities that fields must be irrigated every few days, a task that is difficult with surface irrigation systems, but easily achieved with center pivot or linear move irrigation. In addition, uniform surface irrigation without excessive deep percolation is nearly impossible on very sandy soils.

Alfalfa production on very fine-textured clay soils can be challenging as well. Water infiltration and drainage are extremely slow in these soils. Aeration may be poor because the small pore spaces associated with fine soils limit the diffusion of oxygen to plant roots, impairing root growth. These soils may not drain adequately during winter or spring flood events. Seedling diseases and root diseases are more common on heavy clays. Drainage can be so slow that scald can occur during the summer irrigation season (see Chapter 10: “Alfalfa Diseases and Management”).

**Examine Soil Structure, Depth, and Profile**

The soil provides the rooting medium from which the alfalfa draws water and nutrients. It consists not only of sand, silt, and clay, but of organic matter and structural layers that influence crop growth and development. The deeper the soil, the more water and nutrient storage capacity the site provides. If soil profile characteristics are not well known, use a backhoe to dig several evaluation pits at least 4 feet (1.2 m) deep in a potential field. Examine the soil profile for soil textural changes and any potential...
A site should provide a minimum of 3 feet of rooting depth to be suitable for alfalfa production. A site should provide a minimum of 3 feet of rooting depth to be suitable for alfalfa production. Under the best conditions, alfalfa roots will extend 6–12 feet (1.8–3.6 m) deep or more. Unfortunately, not all soils are that deep. A site should provide a minimum of 3 feet (0.9 m) of unrestricted rooting depth to be suitable for alfalfa production. Like shallow soils, restrictive subsurface layers limit alfalfa production. The most common problems in the West are hardpans, claypans, sand, gravel lenses, and stratified or layered soils. These restrict alfalfa yields because they present a barrier to root penetration or inhibit water infiltration and drainage (Fig. 2.2).

Soil profile problems are not limited to compacted layers—changes in texture within the soil profile can have a similar effect. A clay layer within a sandy loam soil or a layer of sand within a loam or clay loam soil can restrict root penetration and soil water movement. An abrupt change in soil texture impedes the downward movement of water, even when water is moving from a clay soil into a sandy layer. Water does not move into a lower layer that has a coarser texture than the layer above it to any appreciable degree until the layer above is saturated. Consequently, a zone of poor aeration often forms at the interface between such layers and can even result in a temporarily perched water table. In general, the more abrupt the textural change, the greater the negative effects of soil layers.

Deep tillage can help reduce, but usually cannot eliminate, problems associated with hardpans, claypans, and layered soils. Deep ripping is effective to temporarily ameliorate hardpan problems. However, ripping alone is not enough to solve a claypan or layered-soil problem (Fig. 2.3). These problems are only solved by mixing soils to a depth below the restrictive layer. This is usually accomplished with a moldboard plow or slip plow. Major physical modification of soils is expensive (often in excess of $200 per acre [0.405 ha]), and alfalfa production seldom justifies the cost. When possible, select an alternative site free of restrictive subsurface layers.

Consider Waterlogging and Fluctuating Water Tables

Some areas of the Central Valley are subject to fluctuating water tables and intermittent flooding, especially sites adjacent to the Sacramento River or other major waterways. During years of above-average precipitation, the water table at some sites may be well within the root zone of alfalfa.

Alfalfa does not tolerate wet soil conditions during periods of active growth (Fig. 2.4). Prolonged saturated soil and perched or fluctuating water tables in the root zone can severely reduce yields and stand life. Oxygen depletion in the root zone and diseases of the root and crown, such as Phytophthora root rot, are usually the result of excessively wet conditions.

An intermittent or fluctuating high water table is usually more damaging than a stable high water table. With a stable high water table, the alfalfa roots are restricted to the well-aerated soil above the zone of saturation (capillary fringe) that may extend 1–3 feet above the actual depth of the water table. However, with a fluctuating water table, roots...
may grow below the high water table level when conditions are favorable, only to become damaged when the water table rises. Damage that occurs from waterlogging, reduced yield and even stand loss, depends on the time of year when waterlogged conditions occur and the duration. Waterlogging is far more serious during the growing season than during the winter when the alfalfa is more dormant. Furthermore, the longer waterlogging persists and the warmer the temperature, the greater the injury to the crop.

Deep tillage can improve internal drainage in some soils. Precise field leveling, such as laser leveling, or tile drainage may also help correct waterlogging problems, but the resulting increase in alfalfa production may be insufficient to recover the costs. Whenever possible, it is best to avoid sites prone to waterlogging or a fluctuating high water table.
Soil pH values 6.3–7.5 are recommended for alfalfa production because they favor activity of nitrogen-fixing Rhizobium bacteria.

Topography May Affect Success

The suitability of a field for alfalfa production can depend on its topography or slope. Most fields on the valley floor of the Central Valley and Low Desert of California are relatively level, and topography is not a concern. However, there are some locations, especially foothill areas, where slope or undulating fields may be a constraint. Nearly level fields are important for irrigation and water penetration. The relative importance of topography depends on the irrigation system. A level field with proper slope is far more important with flood irrigation than it is with sprinkler irrigation. Flood irrigation is precluded on fields with excessive fall or side fall. A typical slope for border-strip flood irrigated fields is 0.01–0.02 percent (a 1–2 foot fall per 1,000 linear feet), whereas sprinkler irrigation is feasible on fields with up to a 12–15 percent slope. Uneven or undulating fields may require extensive land leveling before producing alfalfa. This is costly and results in major cut and fill areas that often cause variable alfalfa growth.

Soil Chemical Properties Affecting Alfalfa

Soil pH

Soil pH is the measure of acidity or alkalinity of a soil. Soil pH affects nutrient availability and can indicate problems with soil structure. Maximum nutrient availability for most crops occurs when pH values are between 6.0 and 7.0. However, higher pH values (6.3–7.5) are recommended for alfalfa production because they favor activity of nitrogen-fixing Rhizobium bacteria. Soils with pH values below 6.0 are unsuitable. Liming before planting is highly recommended for acidic (low pH) soils, particularly if pH decreases with increasing soil depth. More detail on liming acid soils is found in Chapter 6: “Alfalfa Fertilization Strategies.” Soil pH values that are too high can also be a problem. Values above 8.2 are often associated with excess salinity and soil structural problems (see “Salinity and Sodicity,” below). High pH sites are relatively unproductive and can have problems with water infiltration unless reclaimed (see Chapter 7: “Irrigating Alfalfa in Arid Regions”). Both high and low pH soils occur in California’s Central Valley. However, pH problems in the Central Valley are usually mild enough that they can be dealt with through proper management.

Salinity and Sodicity

Excess levels of salts (saline soils) and sodium (sodic soils) occasionally cause problems in the Central Valley and Low Desert areas (Fig. 2.5). Soils formed in enclosed basins under low-rainfall or desert conditions are prone to salinity. Much of the southwestern portion of the San Joaquin Valley, characterized by alluvial soils formed by ancient floods and erosion of the saline coastal mountains, has salt-affected soils. Although salinity and sodicity do not entirely preclude the possibility of alfalfa production,
Alfalfa is moderately sensitive to salt. High salt levels may be toxic and can reduce water availability. Visual indicators of excess salt include slick spots, white or black crusts on the soil surface, marginal leaf burn, and the presence of salt-tolerant weeds. Laboratory analysis of soils is required to confirm visual symptoms and to determine the type and degree of salinity. When salinity is suspected, carefully sample fields at different depths throughout the root zone. Analyze samples from the different depths separately to determine the degree of the salinity problem at different depths and the depth where salts accumulate. The results can help determine the source of the problem and the best mitigation measures.

Soil salts are measured by making a watery paste of the soil and extracting the water, which contains the soluble salts. Total salinity is measured by determining the electrical conductivity (EC$_e$) of this soil extract. Salts conduct electricity; therefore, the higher the electrical conductivity of the soil extract, the greater the salinity of the soil. EC$_e$ values above 2.0 millimhos per centimeter (mmho/cm) can suppress alfalfa yields, depending on the specific ions in the soil–water solution. Alfalfa suffers a 10 percent yield reduction when soil salinity levels reach approximately 3.4 mmho/cm. In general, soils with EC$_e$ values above 5.0 should be avoided or reclaimed before planting alfalfa. If drainage is adequate, saline soils can be reclaimed by deep leaching. To achieve deep leaching, apply water in excess of crop needs. This is most easily accomplished by reclaiming the soil before planting alfalfa, or by applying water during the dormant season when alfalfa is not growing as actively. Barley or other salt-tolerant annual crops may be grown during the process of reclamation and to assist in identification of saline “hot spots.” Proper drainage is key, because leaching is not feasible if drainage is poor.

Excess sodium can also be a significant yield-limiting factor. High sodium levels cause clay particles to disperse. This degrades soil structure; the soil surface seals, and water infiltration slows. Soils with an exchangeable sodium percentage above 15 are considered sodic. This means that more than 15 percent of the exchange sites (negatively charged positions on soil particles that hold onto positively charged elements and compounds) are occupied with sodium rather than beneficial elements, such as calcium, magnesium, or potassium. To correct such a sodic condition,
About 48 inches of irrigation water is needed over the season in California’s Central Valley, with greater amounts necessary under desert conditions.

Water Requirements of Alfalfa

When selecting a potential site for alfalfa production, be sure that there is an adequate supply of quality water available for season-long irrigation. Most (>99%) of the alfalfa in the arid Southwest is irrigated to supply between 70 and 100 percent of the total crop water needs. Both quantity and quality of irrigation water can limit alfalfa yields. Irrigation water must also be available at the appropriate frequency to avoid stressing the alfalfa.

Water Quantity

Irrigation water supply can limit site selection, sometimes more severely than soil limitations (Fig. 2.6). Alfalfa uses more water than many crops—primarily because of its longer growing season and the fact that it is a perennial crop and reaches full canopy cover sooner in the season. If water supplies are insufficient, yield will be reduced regardless of the effectiveness of other management practices. Water use in agricultural crops is measured as a depth of water assumed to cover the entire field area. Water use of alfalfa in the arid Southwest typically peaks in July; levels in the San Joaquin Valley average about 0.33 inches (8.4 mm) per day, and can climb to as high as 0.5 inches (12.7 mm) per day in the southern deserts (see Chapter 7, “Irrigating Alfalfa in Arid Regions”). The water supply must be sufficient to meet daily water use accumulated since the last irrigation, plus allow for nonuniformity in the irrigation system. Generally, about 48 inches (1,220 mm) of irrigation water is needed over the season in California’s Central Valley, and greater amounts are necessary under desert conditions. Three to 6 inches (76–152 mm) of water is typically applied per irrigation. The amount required depends on the climate of the area and the uniformity of water application. Failure to meet peak water needs results in reduced seasonal yields and profits. Growers should apply amounts sufficient to supply the evapotranspiration (ET) requirements, plus 10–25 percent extra for irrigation system losses, irrigation inefficiencies, and runoff. ET requirements for different zones are given in Chapter 7: “Irrigating Alfalfa in Arid Regions.” Adequate water supplies are
Nematodes usually do not kill alfalfa but can reduce plant vigor to such a degree that alfalfa production is unprofitable. The primary nematodes that damage alfalfa include root knot, lesion, and stem nematode. The same species that infest alfalfa may attack other plants as well—the root knot nematodes *Meloidogyne incognita* (Kofoid & White) and *M. hapla* Chitwood are most common, infecting cotton, dry beans, tomatoes, and many other agronomic crops. If nematodes are suspected, send a soil sample to a qualified laboratory that performs nematode screenings before establishing alfalfa. Avoid planting alfalfa in fields that have nematode species that attack alfalfa unless populations are so low that a problem is not anticipated or if highly resistant alfalfa cultivars are planted.
may reduce establishment and growth of new alfalfa if there is not a sufficient time interval between alfalfa crops (see Chapter 4, “Alfalfa Stand Establishment,” for more information on autotoxicity). Crop rotation also helps to prevent the buildup of damaging pest populations, including plant pathogens, nematodes, and some insects. Rodent pest populations, especially meadow voles (Microtus spp.) and pocket gophers (Thomomys spp.), can increase dramatically in alfalfa. The tillage associated with annual cropping disrupts their burrow systems and can nearly eliminate rodent pest problems. Crop rotation is also an effective weed management strategy. Some weed species, especially perennial weeds such as Bermudagrass and dandelion, can proliferate in an alfalfa production system. Rotating to a different crop can help reduce the populations of many problematic weeds. For example, controlling many broadleaf weeds is easier and less expensive in a cereal crop than in alfalfa.

**Herbicide Carryover**

When selecting a site for alfalfa production, take into account the previous crop and any residual soil-active herbicides that may have been used to control weeds in that crop. Refer to the herbicide label to determine if there are any plant-back restrictions that would preclude planting alfalfa. If there is any possibility that a harmful level of herbicide residue is present, have the soil analyzed before planting alfalfa. Analyzing soil for herbicide residue can be expensive. A less expensive alternative is to perform a bioassay. Collect soil from the field and place it in a small container. If possible, also collect soil from an untreated area with the same soil type. Seed alfalfa and observe the plants for initial emergence and vigor for a few weeks. If emergence or vigor is retarded, do not plant alfalfa.

**Rotational Benefit of Alfalfa to Other Crops**

Just as it is beneficial to rotate other crops between alfalfa plantings, alfalfa, a deep-rooted perennial, is an exceptional rotation crop between plantings of other crops. Its extensive root system improves soil tilth and soil structure by creating channels that encourage water penetration and biological activity in the root zone. Over the life of an alfalfa stand, considerable organic matter is added to the soil through leaf litter and the decomposition of alfalfa roots. This greatly benefits the growth and yield of subsequent crops, such as corn, tomato, wheat, or specialty crops.

One key value of alfalfa in a crop rotation is its ability to fix atmospheric nitrogen (N₂). This occurs through the symbiotic relationship between alfalfa and the bacteria (Sinorhizobium meliloti (Dangeard), De Lajudie et al.) that live in the nodules on alfalfa roots. Estimates for N₂ fixation of alfalfa range from 120 to 540 pounds of N per acre per year (134–605 kg ha⁻¹). A portion of this nitrogen, often assumed to be 40–60 pounds of N per acre (44–67 kg ha⁻¹), is available to crops that follow alfalfa in the rotation schedule. Higher amounts have been observed in some cases.

Even though alfalfa “makes” its own nitrogen needed for plant growth, it is also efficient at recycling nutrients. In the presence of high soil nitrate levels, the extensive alfalfa root system is able to capture these and other nutrients, thereby reducing leaching. This is especially important when alfalfa follows shallow-rooted vegetables or other crops that typically receive large applications of nitrogen-containing fertilizers that may remain in the lower root zone. Because of alfalfa’s many benefits in a crop rotation, the decision of which field or site on which to plant alfalfa should be influenced by the total cropping pattern, including what is planted before and after the alfalfa crop.
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