Irrigated Alfalfa Management
for Mediterranean and Desert Zones

Buy Manual

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.

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FIGURE 2.1.

The climatic conditions in the southwestern United States are nearly ideal for producing alfalfa. Yields of at least 8 to 10 tons per acre (18 to 22 Mg ha^{-1}) are feasible on sites with adequate rooting depth, nutrition, aeration, water and proper 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

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TABLE 2.1

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

Characteristic	Ideal	Marginal	Undesirable[1]
Soil texture	Sandy loam, silt loam, clay loam	Loamy sand, silty clay	Sand, clay
Soil depth (ft)	>6	3–6	<3
Soil chemistry[2]			
(pH)	6.3–7.5	5.8–6.3 and 7.5–8.2	<5.8 or >8.2
Salinity ($EC_{e\text{ in mmho/cm}}$)	0–2	2–5	>5
Exchangeable Sodium Percentage (ESP)	<7	7–15	>15
Boron (mg/L)	0.5–2.0	2–6	>6
Frequency of water logging or high water table	Never	Only during dormant period	Sometimes during periods of active growth
Slope	Nearly level	Slightly sloping to 12% slope	>12% slope
Water quality			
pH	6.5-7.5	7.5-8.2	>8.2
EC_w	<1.3	1.3–3.0	>3.0
SAR	<6.0	6.0–9.0	>9.0

Note: These categories are approximate and should be modified when warranted by experience, local practices, special conditions, or irrigation method.

[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).

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.

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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

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impedance to root development, such as hardpans or other restrictive layers.

An ideal site has deep, uniformly textured soil with no drainage or salt problems. 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.

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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 reduce 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.

FIGURE 2.2

Hardpans and other restrictive layers can impede alfalfa root growth and development. Note the root turns sideways at the depth of the soil impediment.

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

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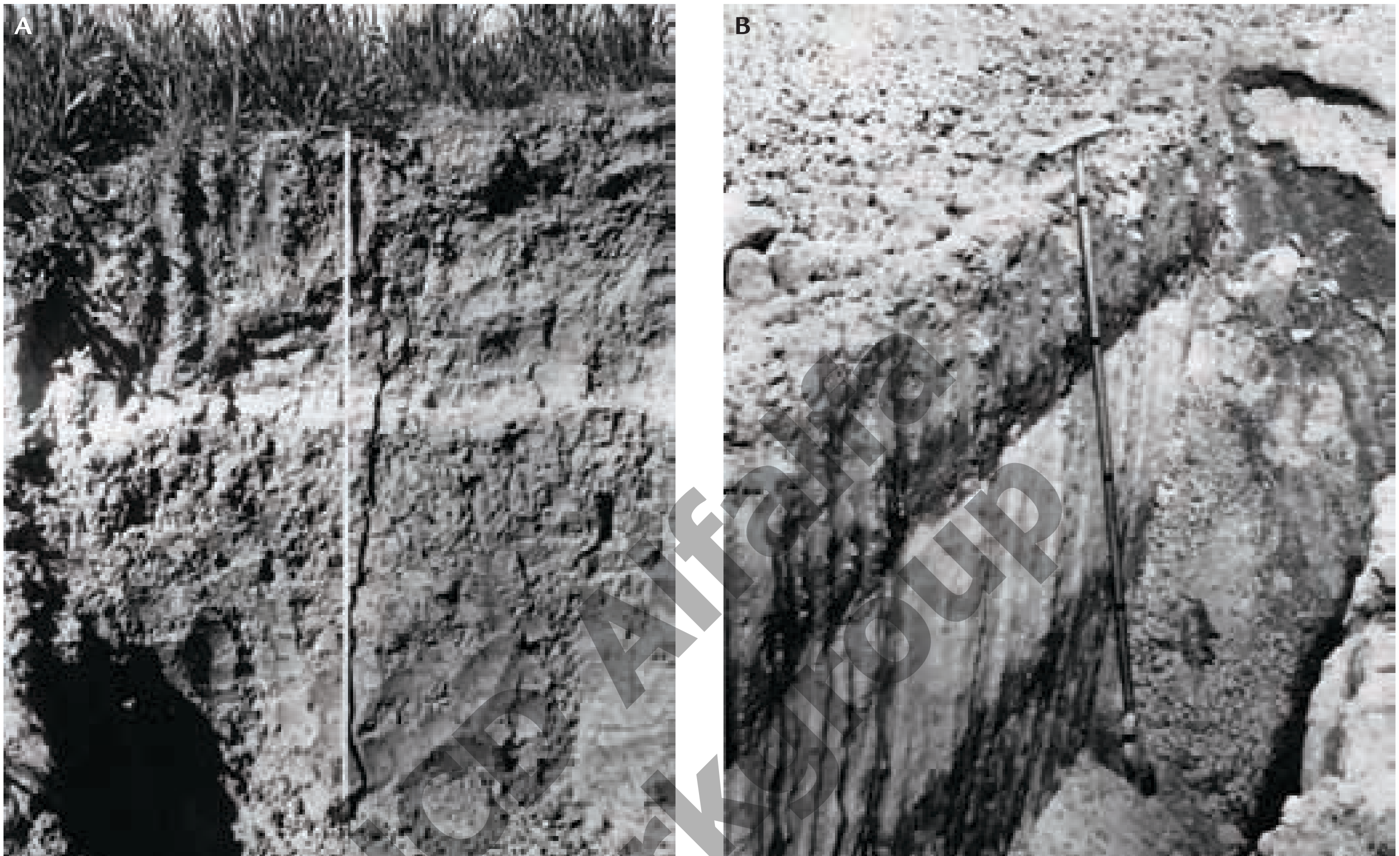
FIGURE 2.3

A dense clay hardpan, in this case at about 23 inches, can restrict root development and drainage. Claypans require mixing for a long-term solution because they will reform if only fractured by deep ripping (A). Stratified soils with an abrupt change in texture limit root development and water movement, like the layer of white sand below fine sandy loam in this photo (B).



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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.

FIGURE 2.4

Drainage characteristics are critical aspects of site selection. Excessive standing water can harm alfalfa stands especially during periods of active growth.

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 Fertility

The parent material of a soil largely determines its mineral content and fertility. The alluvial soils of California's Central Valley are relatively fertile, and typically phosphorus is the only nutrient that may be deficient for alfalfa production. Potassium, sulfur, and boron can also be deficient in some fields, but these deficiencies are more rare. These nutrient deficiencies are easily corrected through proper diagnosis and fertilizer application (see Chapter 6: "Alfalfa Fertilization Strategies"). Inherent soil fertility, although important, does not limit site selection in this region.

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.

Soil pH values 6.3–7.5 are recommended for alfalfa production because they favor activity of nitrogen-fixing Rhizobium bacteria.

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,

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they do present challenges. Steps for reclamation may be necessary.

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.

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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,

FIGURE 2.5

Excess salts can significantly reduce alfalfa production potential. Severely salt affected soils should be avoided.

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begin with a laboratory analysis to determine the gypsum requirement of the soil. Gypsum requirement refers to the amount of calcium required to displace sodium on the exchange sites. Sulfur can be used instead of gypsum to reclaim soils that are high in calcium carbonate. After an amendment has been applied and sodium replaced with calcium, the displaced sodium must be leached below the alfalfa root zone.

In general, it is best to avoid sites that are adversely affected with excess salts or sodium. The reclamation process usually requires several years and, in the case of sodic soils, a substantial investment in soil amendments is required. Subsurface drainage systems may also be required to effectively reclaim a site for sustainable economical alfalfa production.

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

About 48 inches of irrigation water is needed over the season in California's Central Valley, with greater amounts necessary under desert conditions.

FIGURE 2.6

Ample irrigation water supply is a prerequisite for a site to be suitable for alfalfa production in the arid West.

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essential; thus, if the site does not have a sufficient quantity of water, select another location for alfalfa.

Water Quality

Poor water quality is occasionally a problem in the selection of sites for alfalfa production. Water from wells may contain excess salt. Excess sodium or bicarbonates, or both, can cause infiltration problems. Excess selenium or molybdenum, or both, in the soil or water can cause feed quality problems to livestock. Some surface water sources contain excess colloidal clays, salts, or weed seeds that can present management and stand-life problems. See Table 2.1 for guidelines about water quality. Toxicities caused by foliar absorption of sodium and chlorides, most common during periods of very low humidity and high winds, can result from sprinkler irrigation but would not be a problem with flood irrigation.

Little can be done to improve irrigation water quality. In fact, soil reclamation efforts are unproductive if irrigation water quality is poor. The only cost-effective method of dealing with poor irrigation water is to find an alternative water source or blend the existing water with higher-quality water.

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Biological Factors Affecting Site Selection

Most people just assess the physical attributes of the location when considering the suitability of a site for alfalfa production. However, biological factors may be equally important and can render a site undesirable for alfalfa production.

Check for Likelihood of Diseases

Alfalfa is susceptible to numerous diseases. Some rotation crops are hosts for the same diseases that plague alfalfa. Examples of disease organisms that attack alfalfa that are also problems in common rotation crops include Verticillium wilt, Sclerotinia crown and stem rot, Rhizoctonia root rot, and Phytophthora root rot (see Chapter 10, "Alfalfa Diseases and Management," for more detail on alfalfa diseases and host ranges). If a disease that was present in the previous crop is also a problem for alfalfa production, it is recommended that a nonhost crop be planted before planting alfalfa. Similarly, if alfalfa is a host crop for a disease that also attacks a subsequent higher-value crop, plant another nonhost crop rather than alfalfa. Carefully check varietal tolerance to diseases, because this can vary considerably from one variety to another.

Check for Nematodes

When present in sufficient numbers, microscopic parasitic worms called nematodes are a serious alfalfa production problem (see Chapter 11, "Parasitic Nematodes in Alfalfa"). 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.

Nematodes usually do not kill alfalfa but can reduce plant vigor to such a degree that alfalfa production is unprofitable.

Crop Rotation Considerations

Rotating crops, as opposed to continuous cropping, is a strongly recommended agronomic practice. Planting alfalfa after alfalfa, commonly called back-to-back alfalfa, is not advised. Residues from old alfalfa crowns can be toxic to alfalfa seedlings; such residues 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 (N_2). 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 N^2 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 recyling 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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