# Alfalfa

metzer

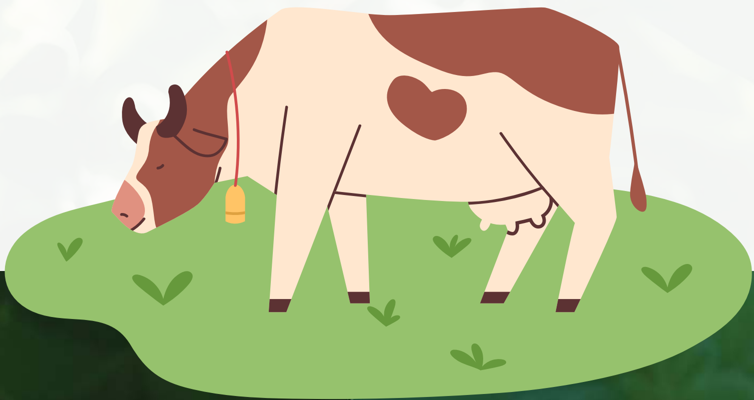
# Fantastic Feed:

## Growing Alfalfa with Drip Irrigation

Alfalfa (Medicago sativa), also known as lucerne, is a perennial flowering plant in the legume (Fabaceae) family. The word Alfalfa means “father of all foods” in Arabic. Alfalfa is cultivated worldwide as an important forage crop due to its adaptability and multiple uses, including grazing, hay, silage, and as a green manure and cover crop.

Known for its high nutritional value, alfalfa serves as a major protein source for livestock. The crude protein content in alfalfa dry matter is 15-25%, which is 1–1.5 times higher than that of maize (Zea mays L.), making it a preferred feed for cattle, horses, sheep, and other grazing animals.

As a legume, alfalfa has a distinct advantage over many other crops, mainly due to its ability to fix nitrogen from ambient air, through a symbiotic relationship with nitrogen-fixing bacteria that live in nodules on the alfalfa roots. This means that alfalfa can grow in nitrogen-poor soil, and can improve the soil’s fertility for subsequent crops.



Alfalfa has been cultivated for millennia. It is believed to have originated in western Asia and southeastern Europe, and was first mentioned in Mesopotamian records over 4,000 years ago. Moreover, it was one of the first forage crops to be domesticated.

Today alfalfa is cultivated worldwide from 36°S to 58°N and from sea level to 2,400m. The US is the world's leading alfalfa producer, with 53.1 million tons produced in 2020 over 16.2 million acres of harvested area, and an average yield estimated at 3.27 ton/acre (8.08 ton/Ha). Alfalfa is also commonly cultivated in many parts of Europe as well as the Middle East, Africa, South America, and Australia.

# Alfalfa plant morphology

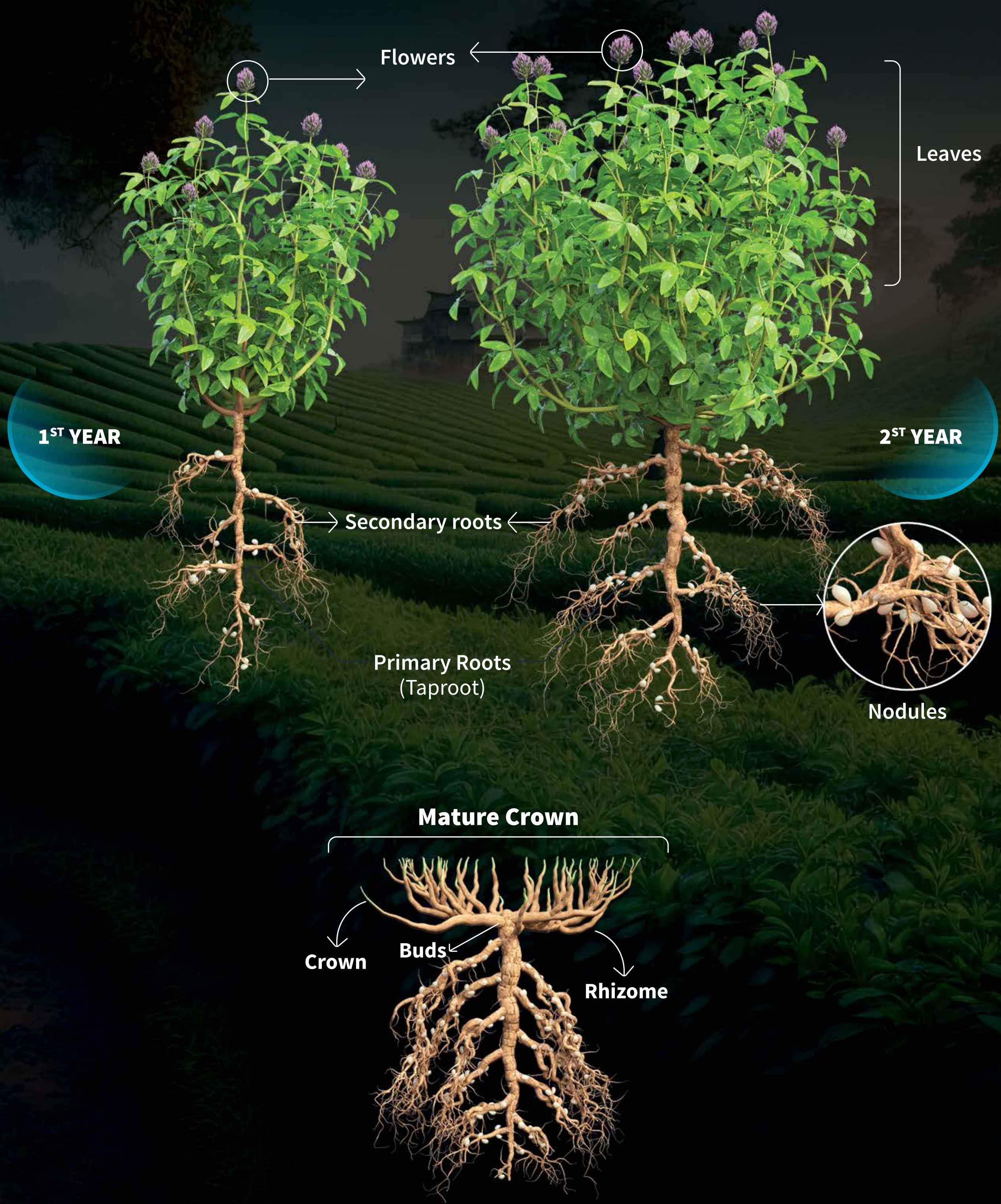
Alfalfa is a perennial herb, with varying morphology depending on stage of growth and environmental conditions. It can grow up to 3 ft (0.91m) tall. Its leaves are trifoliate, i.e., composed of three leaflets, which are arranged in a clover-like pattern. The leaflets are green and smooth, with a slightly hairy texture. The stems of alfalfa plants are round and hollow, and are also branched with hairy surfaces.

The alfalfa plant produces small flowers that grow in clusters called racemes, located on the tips of the stems. The flowers are hermaphroditic, containing both male and female reproductive parts. Normally, alfalfa flowers are light purple or violet, but there are also white, yellow, and blue varieties. The flowers are typically visited by bees, butterflies, and other pollinators. The alfalfa plant produces seed pods that contain small, brown seeds. These are used for propagation, and can also serve for human consumption, as a source of protein and other nutrients.

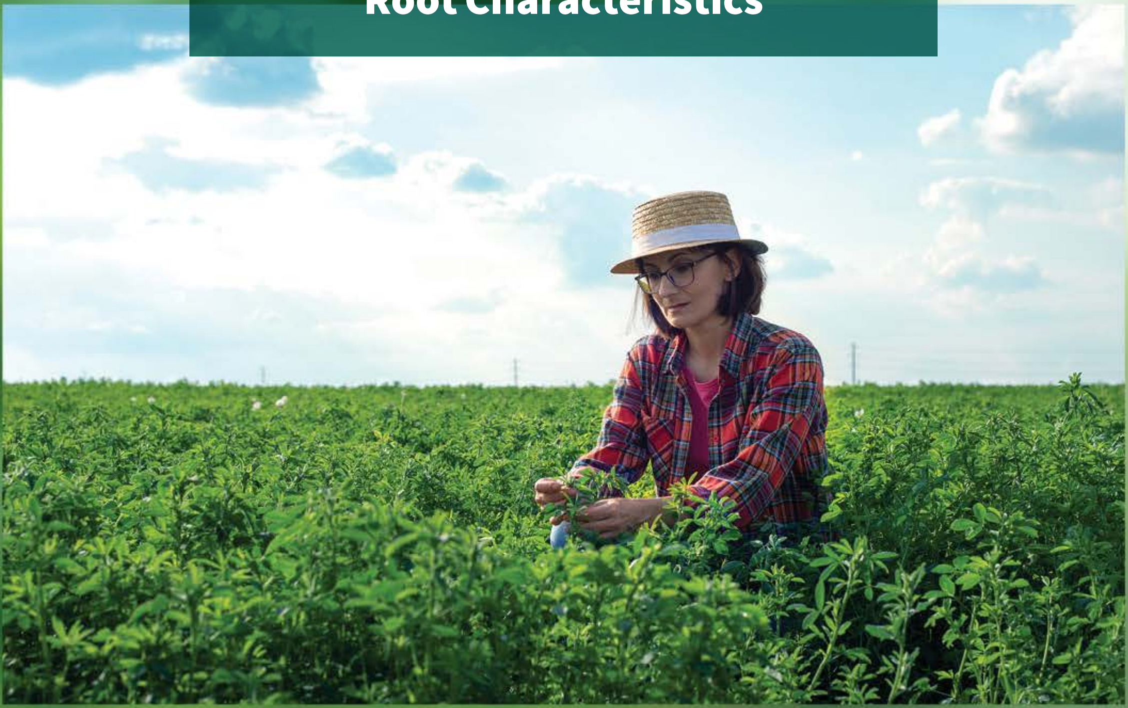
The growth of new shoots from axillary buds gives the young plant a branched appearance, especially if light is adequate and the stand is not too thick. Vigorous alfalfa plants often have three and even four secondary shoots in addition to the primary or central stem, which forms the characteristic first-year crown. The branches from the unifoliolate leaf bud appear first, followed by branches from the cotyledonary and first trifoliolate leaf buds. In the case of late seedings, severe companion crop competition, or high seeding rates, the crown may be formed of fewer branches. Under these conditions, the cotyledonary, unifoliolate, and first trifoliolate leaf buds may remain dormant or give rise to a branch rhizome or underground stem in the fall.

The lower internodes or nodes of the primary or secondary stems may produce adventitious or crown buds. Crown buds or dominant axillary buds either produce the vegetative regrowth following harvest in the seeding year, or may give rise to branch rhizomes in the fall. The branch rhizome is the structure from which new growth will initiate in the spring, unless winter injury occurs. The branch rhizome must be developed adequately in the fall before the first killing frost, or else the seeding will fail, even under ideal growing conditions.
The crown of the alfalfa plant increases in size in the second year. Branch rhizomes develop on last year's branch rhizome. These grow outward and upward, increasing the plant's circumference. After 2-4 years, the alfalfa plant's typical multibranched crown develops.

# Alfalfa agronomy



# Root Characteristics



Alfalfa has a deep, extensive root system that plays a key role in its ability to withstand drought, improve soil health, and fix atmospheric nitrogen. A fully developed alfalfa seedling does not guarantee plant establishment: to survive and become an established stand, it must continue to develop deeper roots and more leaves.

Alfalfa has a system of deep taproots that serve as the plant's primary roots. The taproot system can penetrate to a depth of 6-8ft or more, depending on soil conditions. Additionally, since the taproot is thick, woody, and fibrous, it also serves as the plant's primary anchor. Secondary roots, also known as lateral roots, branch off from the primary roots and grow horizontally. These roots are also thick and fibrous, and can spread out as far as the plant's leaf radius. Additionally, alfalfa has many fine hair roots which serve as its active feeder roots, located closer to the soil surface. These increase the root system's surface area, and facilitate the absorption of water and nutrients from the soil.
A special physiological organ in alfalfa roots is its nodules, specialized structures formed by symbiotic bacteria called Rhizobia. The nodules are responsible for fixing atmospheric nitrogen into a plant-available form in the soil. Additionally, Alfalfa roots can form mutualistic associations with certain soil fungi called mycorrhizae. These associations can improve nutrient uptake and the plant's stress resistance.
Alfalfa roots are known for their ability to penetrate and break up compacted or hardpan soils. This can improve soil structure, aeration, and water infiltration, which can benefit other crops grown in rotation with alfalfa.

## Alfalfa root zone water extraction depth

The effective rooting depth for alfalfa is about 6 ft (1.8m) where no restrictive layers or conditions exist. Given satisfactory moisture, an alfalfa plant will extract moisture as follows:


# Lifecycle and Growing Season

Alfalfa is a perennial crop with a lifecycle of 3-5 years or more. This lifecycle is a multi-year process that requires careful management and attention to soil health, fertility, and pests, using the most advanced irrigation system available. The exact timing of the alfalfa growing season will depend on factors such as temperature, precipitation, and soil conditions. Proper establishment, regular cutting or grazing, and crop rotation are all important to maintaining a healthy and productive alfalfa crop.

## The general stages of the alfalfa lifecycle

**Establishment normally** takes place in the first year. Alfalfa is typically seeded in spring or fall, and requires adequate soil moisture and temperature for germination. The seedlings will grow slowly and develop a deep root system before going dormant in winter.

**Vegetative growth** occurs in the second and after. The plant produces new stems and leaves, and the root system continues to expand. Alfalfa can be harvested for hay or silage several times during the growing season, typically starting in late spring or early summer.

**Reproductive growth** starts to take over after several years of vegetative growth. It is characterized by the formation of flower buds on the stems and the development of seed heads. The plant will produce fewer leaves, and may be less useful for forage production.

**Regrowth** occurs after each cutting or grazing. The plant regrows new shoots and leaves from the crown. Regrowth is important for maintaining yield and quality, as well as for suppressing weeds and other competing plants.

**Dormancy**

Alfalfa goes dormant in winter, typically after a hard frost. The aboveground growth dies back, while the root system remains alive and continues to develop.

**Crop rotation**

Alfalfa is typically rotated with crops such as corn, soybean, or small grains. This helps to maintain soil health and fertility, and allows for the use of different herbicides and pesticides to control pests and diseases.

**In order to allow for top-quality yields, Metzer's advanced irrigation solutions make sure to address every stage of your alfalfa crop's lifecycle.**

# Agronomic Conditions

## Flexible About Climate

Alfalfa can be grown in a broad range of climate conditions, and can tolerate both hot and cold temperatures. Due to its frost sensitivity, it is typically grown in regions with mild winters.

### 60-76°F
### OPTIMAL TEMPERATURE RANGE

The optimal temperature range for alfalfa growth is 60-76°F (15-24.4°C), with a minimum of 32°F (0°C) for winter survival. Alfalfa seeds germinate best at soil temperatures of 65-85°F (18.3-29.5°C). It takes them six days to germinate at a soil temperature of 40°F (4.5°C), but only two days at 65°F (29.5°C). The optimal temperature for alfalfa root growth during the first month is 69-76°F (20.6-24.5°C), depending on the dormancy class. Shoot growth is optimal at 72-76°F (22.2-24.5°C). Alfalfa stops growing when the ambient air temperature drops below 34°F (1.1°C).

### GROWING IN A WIDE RANGE OF CLIMATES

Due to its deep roots, alfalfa is tolerant to drought. However, it is capable of growing in a wide range of climates. Some species can grow without irrigation in arid regions with 200mm of annual rainfall, as well as in humid regions with 2,500mm. Optimal annual rainfall for alfalfa from 600mm to 1,200mm. In arid regions or during droughts, more irrigation may be necessary to ensure adequate water supply. It is also important to note that alfalfa is a deep-rooted crop that can access water from deeper soil layers, making it more drought-tolerant than some other forage crops.

**Day length affects alfalfa establishment less than temperature does. However, the photoperiod affects two key growth characteristics:**

1. The initiation of crown buds and stems, and
2. the allocation of photosynthates to the roots. Days that are longer than 12 hours favor shoot development, while days shorter than 12 hours promote root growth.

# Selecting a Suitable Site

Selecting the right site for alfalfa cultivation is critical, since site conditions can limit both yield and profit potential, affecting alfalfa quality as well as stand persistence and resistance to weed competition.

The better the site, the higher your yield potential. Given adequate rooting depth, nutrition, aeration, water availability, and no salinity or alkalinity problems, alfalfa growers can produce 8-10 tons/acre (19-22 tons/ha) a year.
On marginal or undesirable sites, greater management skills are required to reach profitability, and while some site limitations can be offset or overcome, the associated costs may affect future profitability and even result in a net loss.

# Selecting Soil

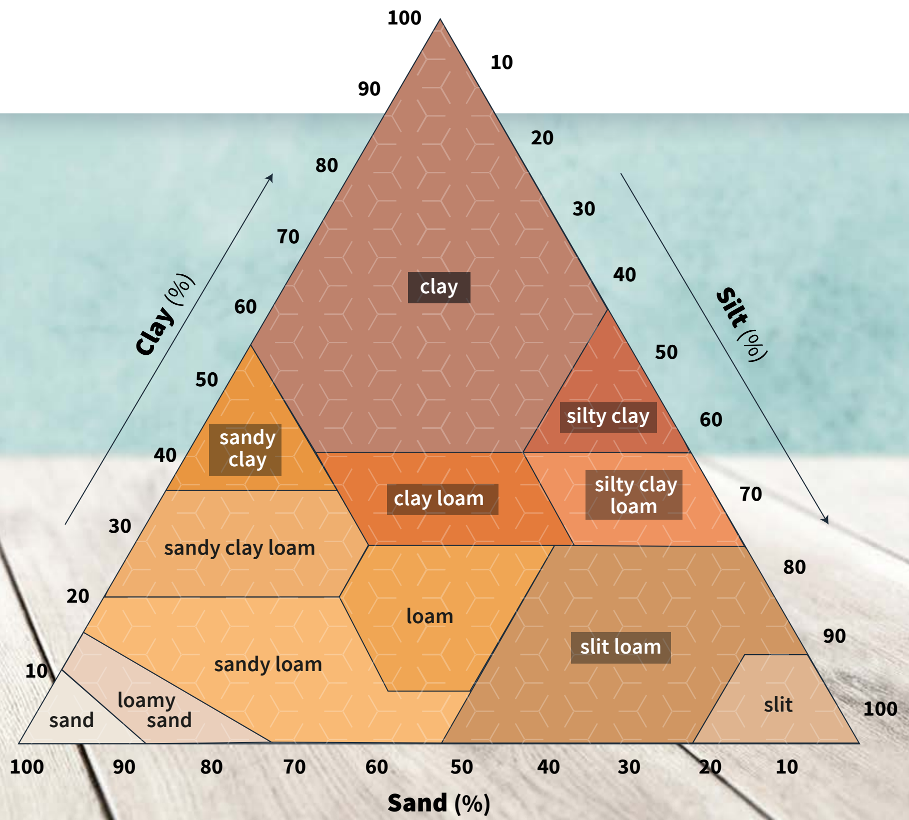
Since alfalfa doesn't tolerate prolonged droughts, the low water holding capacity of sands or loamy sands means that fields must be irrigated more often (i.e., every few days). And while it responds well to irrigation, alfalfa does not tolerate waterlogged soils and wet conditions, especially during active growth – which is why producing it on very fine-textured clay soils can be challenging as well. Soils with very slow water infiltration and drainage create ideal environments for diseases such as phytophthora root rot, which can kill seedlings, reduce forage yield, and kill established plants.

Growers can reduce some diseases associated with poor drainage by selecting alfalfa varieties with high levels of resistance, and by using fungicides for establishment. Poor soil drainage also reduces the movement of soil oxygen to the roots, and can cause soil crusting and ponding, which may lead to poor soil aeration, micronutrient toxicity, or ice damage in winter.

Damage from waterlogging, including lower yields and even stand loss, depends on the time of year and the duration of waterlogged conditions. Waterlogging is far more dangerous during the growing season than in winter, when alfalfa is more dormant. Furthermore, the longer waterlogging persists and the warmer the temperatures, the greater the injury to the crop. Deep tillage can improve internal drainage in some soils, but, if possible, it is best to avoid sites prone to waterlogging or a highly fluctuating water table.

## Alfalfa management

While alfalfa can be successfully cultivated on a wide range of soil textures, sandy loam, silt loam, and clay loam are generally preferable. These soil types provide the best combination of water infiltration, water holding capacity, and aeration for alfalfa. More extreme soils, such as very heavy clay soils or very sandy soils, complicate alfalfa management.

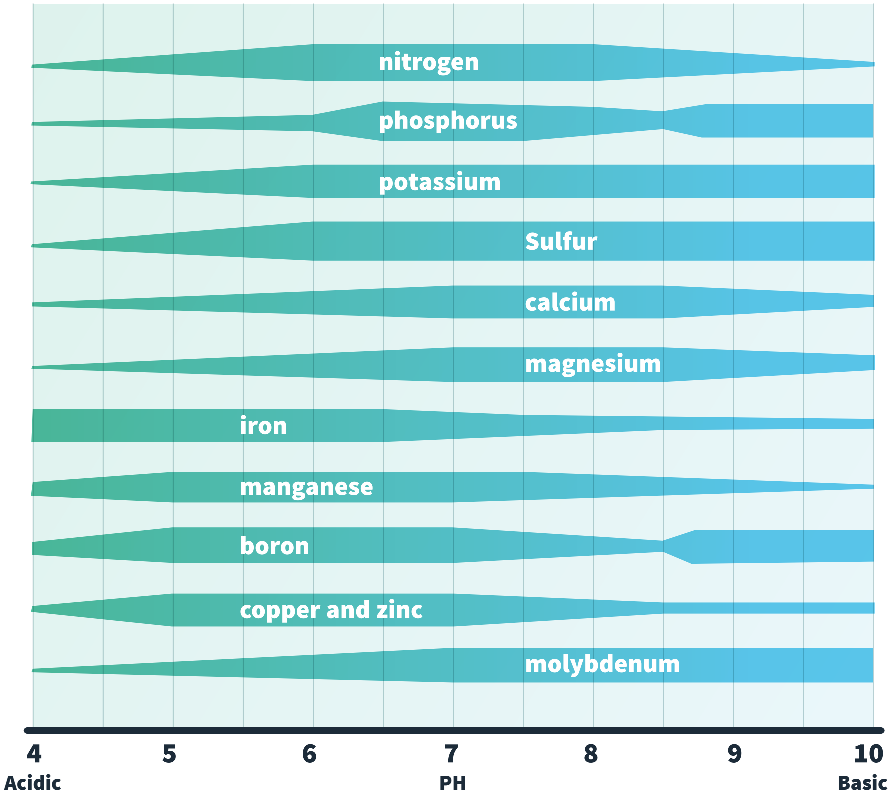


# Soil pH

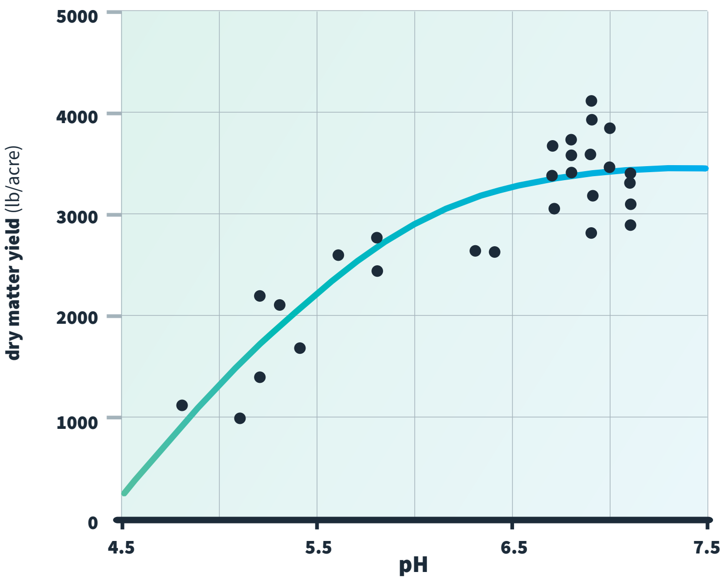

Soil pH is a key factor in the success of alfalfa plants, primarily due to its effect on nutrient availability and as an indicator of soil structure problems. For most crops, maximum nutrient availability takes place at soil pH 6-7.

However, to reach high alfalfa yields, pH values of 6.3-7.5 are recommended, since they promote the activity of nitrogen-fixing Rhizobium bacteria. Soils with pH below 6.0 are unsuitable for alfalfa cultivation. For acidic soils, liming before planting is highly recommended, particularly if pH decreases deeper into the soil. Excessive soil pH can also cause a problem, with pH values over 8.2 often associated with excess salinity and soil structure problems. High pH sites are relatively unproductive, and can present water infiltration problems.

## Available nutrients in relation to soil pH

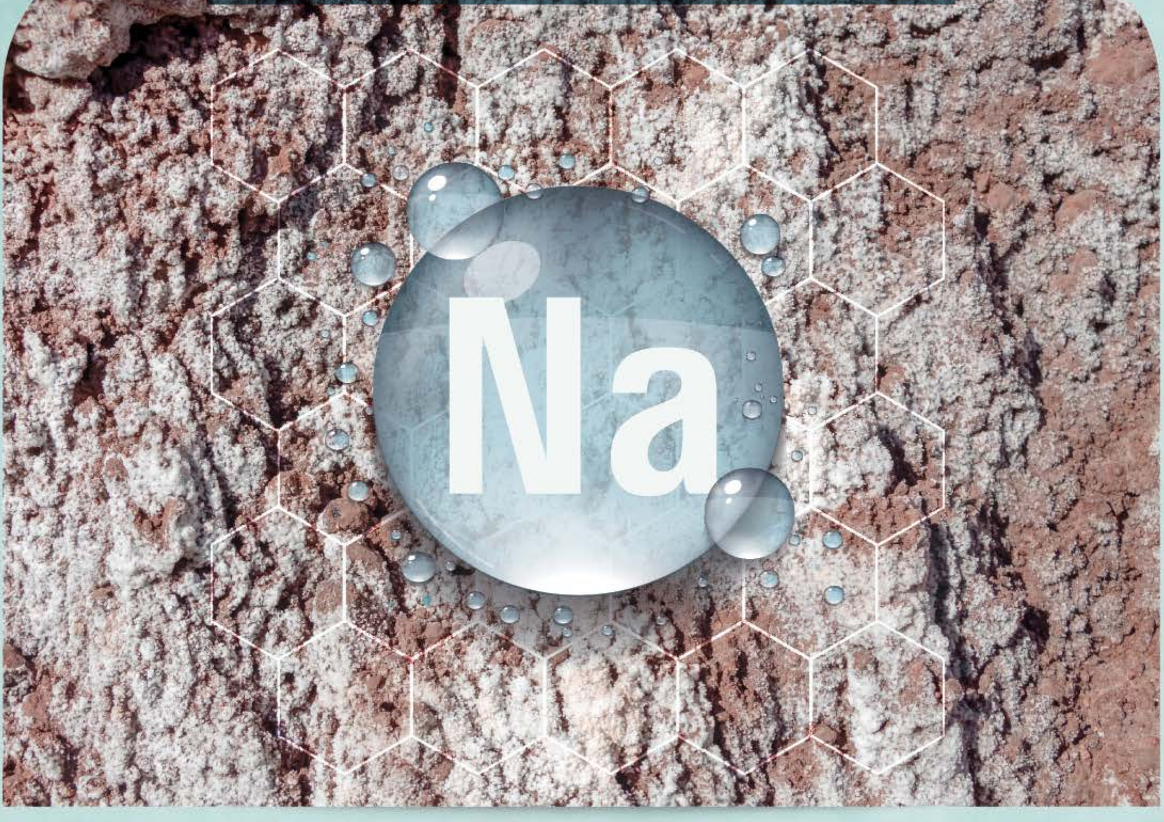



## First-cutting alfalfa yield relative to soil pH




Source: Wollenhaupt and Undersander, University of Wisconsin, 1991.

# Salinity and Sodicity




## ALFALFA IS MODERATELY SENSITIVE TO SALT.

High salt levels can be toxic and 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.

When salinity is suspected, lab analysis will confirm the visual symptoms and determine the type and degree of salinity. Carefully sample the field at different depths throughout the root zone. The results can help to determine the source of the problem and the best mitigation measures.
Total salinity is measured by determining the soil's electrical conductivity (EC). EC above 2.0 dS/m can suppress alfalfa yields, depending on the specific ions in the soil solution. When soil salinity reaches ~3.4 dS/m, alfalfa suffers a 10% yield decrease, and it is generally best to avoid planting alfalfa in soils with EC above 5.0.

Given adequate drainage, saline soils can be reclaimed through deep leaching. To leach salts down from the root zone, alfalfa growers should apply water in excess of crop needs. This is most easily accomplished by reclaiming the soil before planting, or by applying water during the dormant season when alfalfa doesn't grow as actively. Without proper drainage, leaching is unfeasible.

## EXCESS SODIUM CAN ALSO LIMIT YIELD.

High sodium levels cause clay particles to disperse, degrading the soil's structure and sealing its surface, which slows water infiltration. Soils with an exchangeable sodium percentage (ESP) over 15% are considered sodic, meaning that over 15% of exchange sites are taken up by sodium rather than by other beneficial nutrients such as calcium or magnesium.

To correct sodic conditions, lab analysis is needed in order to determine the soil's gypsum requirement, i.e., the amount of calcium required to displace sodium at the exchange sites. In soils that are high in calcium carbonate, sulfur can be used instead of gypsum. After applying and replacing the sodium with calcium, the displaced sodium must be leached below the alfalfa's root zone.
Generally, it is best to avoid sites adversely affected by excess salts or sodium. The reclamation usually requires several years, and in the case of sodic soils, a substantial investment in soil amendments.

## EXAMINING SOIL STRUCTURE, DEPTH & PROFILE

As the rooting medium from which alfalfa draws water and nutrients, soil consists not only of sand, silt, and clay, but also of organic matter and structural layers that affect crop growth and development. The deeper the soil, the better the site's water and nutrient storage capacity.

If the soil profile's characteristics aren't sufficiently known, use an auger to dig several testing pits at least 4ft (1.2m) deep in a potential field. Examine the soil profile for textural changes and any potential obstacles to root development –such as hardpan or other restrictive layers. An ideal site will have deep, uniformly textured soil with no drainage or salt problems.

### A soil survey is an important tool.

Testing the drainage rate of various field sectors helps to determine their suitability for planting and/or the preparations required. Before the rainy season, dig test pits 4.9 ft (1.5m) deep, or as deep as possible. After saturating the test sections, determine the rate of water seepage by the height of the water surface in the pit after 24, 48, and 72 hours. Mark the drainage rate in the various pits on the map.

### Soil depth and layering

are key parameters for successful alfalfa cultivation. Under ideal conditions, alfalfa roots will extend 6-12ft (1.8-3.6m) deep or more. Unfortunately, not all soils are that deep. A suitable site should provide at least 3ft (0.9m) of unrestricted rooting depth.

# Soil depth and layering

## RESTRICTIVE SUBSURFACE LAYERS

Like shallow soils, restrictive subsurface layers limit alfalfa production. The most common problems are hardpans, claypans, sand, gravel lenses, and stratified or layered soils. These present a barrier to root penetration and/or inhibit water infiltration and drainage. Deep tillage can help reduce, but usually not eliminate, problems associated with hardpans, claypans and layered soils. When possible, select an alternate site free of restrictive subsurface layers.

Sloping fields may contain low spots where water pools, making it difficult to maintain alfalfa stands. Soils should be deep enough to have adequate water-holding capacity. Alfalfa has a long taproot that penetrates deeper into the soil than the more fibrous, shallow roots of crops such as corn or wheat. Under favorable conditions, alfalfa roots can penetrate over 20ft (6m) deep, giving the plant excellent drought tolerance. Sloping fields that suffer from erosion may require erosion control practices, such as planting a companion crop or using reduced tillage to keep soil and seeds in place until the seedlings are sufficiently rooted.

## PHYSICAL AND CHEMICAL CHARACTERISTICS OF IDEAL, MARGINAL AND UNDESIRABLE SITES FOR ALFALFA PRODUCTION

| CHARACTERISTIC | IDEAL | MARGINAL | UNDESIRABLE [a] |
|---|---|---|---|
| Soil texture | Sandy loam, silt loam, clay loam | Loamy sand, silty sand | Sand, clay |
| Soil depth (ft/m) | >6 ft (1.8m) | 3-6 ft (0.9-1.8m) | <3 ft (0.9m) |
| **SOIL CHEMISTRY[B]** | | | |
| pH | 6.3-7.5 | 5.8-6.3 and 7.5-8.2 | <5.8 or >8.2 |
| Salinity-EC soil solution (dS/m) | 0-2.0 | 2.0-5.0 | >5.0 |
| Exchangeable Sodium Percentage (ESP %) | <7.0 | 7.0-15 | >15 |
| Boron (mg/L) | 0.5-2.0 | 2.0-6.0 | >6.0 |
| 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 methods.

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

b. Values are based on saturated paste extract analysis, and are adapted from Lancaster and Orloff (1997). Source: Orloff, S. B. “Choosing appropriate sites for alfalfa production.” Irrigated Alfalfa Management for Mediterranean and Desert Zones, 2007.

# Getting Your Field Ready

### INTENSIVELY MANAGED

Since alfalfa is intensively managed and harvested for 3-5 years or more, proper primary field preparation before planting is crucial. Appropriate planning and preparation will later benefit stand establishment and lifespan, reduce weed and disease problems, promote water use efficiency, and result in higher yields.

### PREPARATION

Preparation should begin about a year before seeding.
Perennial weeds can be particularly competitive, both during the seeding year and after. Weeds compete with alfalfa for light, water, and nutrients, and if uncontrolled, can diminish the nutritional value of the forage, reduce seedling vigor, and in some cases reduce alfalfa plant density to such a degree that the field has to be replanted.

### CONTROLLING WEEDS

While preplant irrigation and cultivation can eliminate some weeds, herbicides may also be necessary. Controlling weeds before seeding will help to ensure a long-lasting, productive alfalfa stand. Scan the field for perennial weeds and use appropriate control measures in the preceding crop, if one exists. To prevent herbicide carryover injury, be sure to follow herbicide preplant restriction intervals before seeding the alfalfa.

## To Till or Not to Till?

Tillage for alfalfa is carried out in very different ways, depending on time of year, region, and soil structure. For flat and uniform fields, conventional tillage is preferable, while no-till planting is better for rocky or steep slopes. Tillage can allow for soil amendments, such as incorporating lime, compost, and fertilizer into the soil to promote stand establishment.

# CONVENTIONAL TILLAGE AND PLOWING

Conventional tillage practices vary from farm to farm, but should consist of a primary tillage (moldboard plowing or chiseling) followed by disking. Primary tillage loosens the soil and helps to control perennial weeds, while disking controls weed regrowth, helps to level the land, and breaks up large clods. The final tillage should be some type of smoothing operation.

The ideal soil for conventional alfalfa seeding should be smooth, firm, and clod-free, for optimal seed placement using drills or cultipackers.

Avoid overworking the soil, as rainfall following seeding may crust the surface, preventing seedling emergence.

In conventional tillage, plowing is performed at a depth of about 30-50cm, while ripping at about 50cm is mandatory where hardpan exists. Ripping shatters compacted layers, but does not mix the soil, so the benefits of ripping may be short-lived in layered soils. In these soils, deep plowing with moldboard or disc plows is particularly effective, since it inverts and mixes the stratified layers.

Plows have the potential to loosen compaction, provided that the moisture content is such that the soil will crumble rather than form large clods. Since alfalfa seeds are very thin, proper clod sizing is crucial. The clods must be less than 2cm in diameter to provide proper soil-to-seed contact.

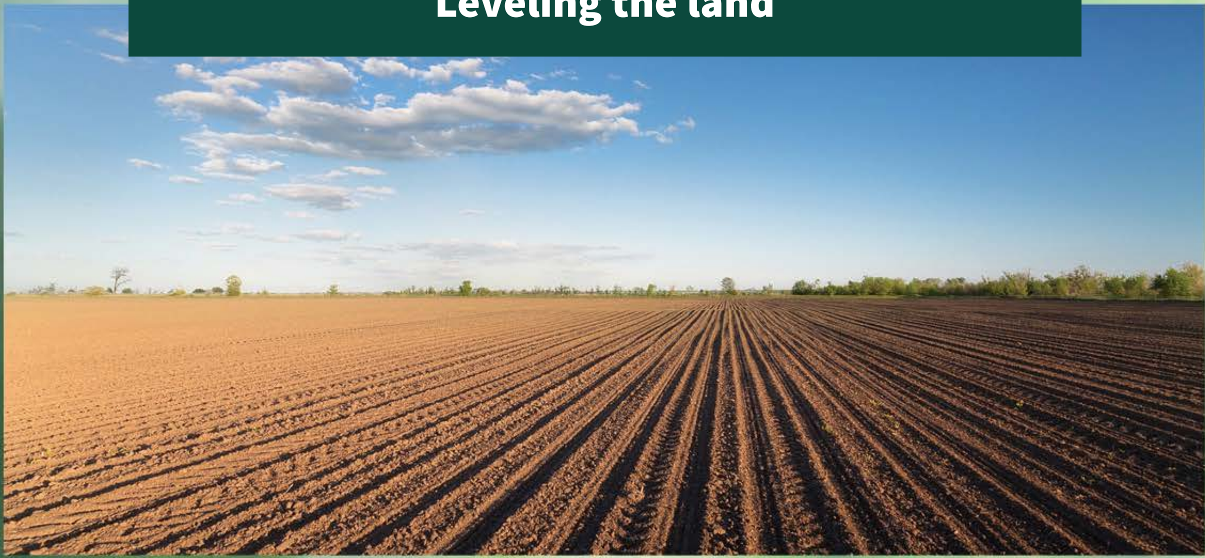
For deeper mixing, a slip plow can be used to reach depths of 5-6ft (1.5-1.8m). Slip plowing displaces and cracks more soil than ripping does, but requires correspondingly higher energy inputs. However, since a slip plow only mixes the soil in the trench that it makes, the mixing is not as thorough as that of moldboard or disc plows. For best results, follow slip plowing with moldboard or disc plowing, rather than use either operation by itself.

Soils require additional time, tillage, and/or irrigation to firm up or settle after plowing.

If possible, freshly-plowed soil should not be disturbed for several weeks, in order to avoid re-compaction. Even if deep tillage is deemed unnecessary, ripping to moderate depths of 20-32in (50.8-81.3cm) is generally cost-effective and recommended for reducing compaction due to agricultural operations in preceding crops.

In conventional tillage for planting alfalfa, seeding can be done with either a cultipacker or a grain drill.

# Leveling the land



Once deep tillage and plowing operations are complete, the field should be disked and planed. Leveling should be a two-step process. First, the field is leveled following any necessary deep tillage operation. Then, once irrigation borders are established, the area between them should be leveled and a uniform slope achieved. The final smoothing of the field is normally achieved with a land plane, in order to remove any minor irregularities in the soil surface. Eliminating high and low spots in the field will improve the efficiency of the irrigation system and prevent harvest problems.

Depending on rotation, laser-leveling the field may not be required every time a new alfalfa stand is established, but touching up the level and slope between irrigation borders is always recommended.

## Sustainable no-till planting

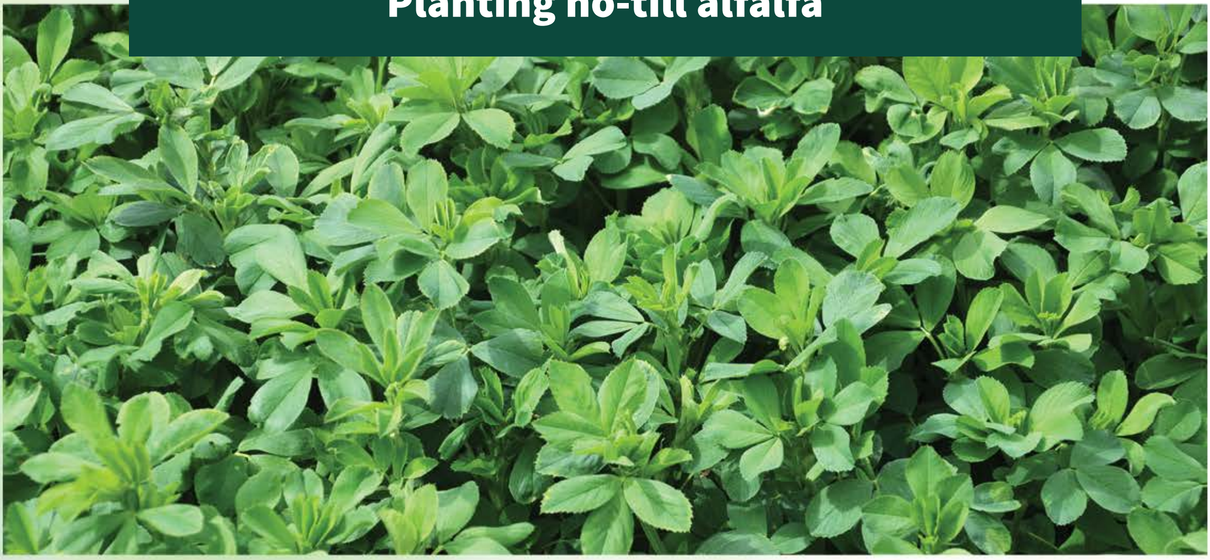
No-till planting consumes less time, energy, and fuel than conventional tillage. It can dramatically reduce soil erosion, retain moisture, boost soil health and microbiome activity, and reduce expenses.

Alfalfa can be no-tilled into previously killed sod. Before no-tilling, make sure to thoroughly eliminate all established and emerging weeds using non-selective herbicides, such as glyphosate (Roundup) or paraquat (Gramoxone). If your field is clean, herbicide may be unnecessary, so check before you spray.

It is best to consult a local plant protection expert or guide. Additionally, make sure there are no swaths of heavy chaff that might compromise seed-to-soil contact.

**One effective method** when planting no-till alfalfa into grass sod is spray-smother-spray: First, spray the growing sod with a non-selective herbicide. Second, no-till plant an annual forage crop, such as winter wheat or rye, to smother the regrowth of any grass sod or break-hard sod. Third, harvest annual winter forage crops. Fourth, spray herbicide before planting alfalfa. There is a growing practice of planting no-till alfalfa into row-crop stubble in spring, and into small grain cereals or forage sorghum in late summer.

# Planting no-till alfalfa



With alfalfa, seeding depth is more crucial than seeding rate, and the greatest mistake to avoid is placing the seed too deep. Any no-till drill can work, as long as the seed can be placed at ¼ to ½ inches (0.64-1.28cm) deep. The machinery should be able to place the seed at the correct depth with uniform spacing across all drill units, and press the seed into the soil gently so that it is covered and has good seed-to-soil contact.

**Make sure the drill is well-maintained.** Drill units should be tight and not wobbly. Check bearings and parallel linkages. Make sure all units are on the same plane. Coulters, if present, need to cut through residue but not below the planting depth, so as to avoid dropping the seeds too deep.
Double-disk or single-disk openers are most commonly used in no-till alfalfa seeding. Shoe types can also be used, but tend not to handle residue as well, create more soil disturbance, and can easily place the seed too deep.
Make sure the double disk openers are not overly worn and have the right point of contact.
The depth gauge wheel is often also the press wheel. It is crucial to set it to the right depth. There are also often doughnut-shaped washers to control seeding depth on the hydraulic cylinders: play with the number of washers and the press wheel settings to get the right depth. Two-inch wide closing wheels seem to work best, firmly covering the seed while still controlling depth. Narrower wheels lose the ability to control depth, while wider wheels do a poor job of closing the seed slot.

**To determine seeding rate**, use the seed charts on the drill as a first approximation, or do your own calibration. To check the actual seeding rate, you should also keep track of the acres planted and the quantity of seed used: it is easy to waste seed and money.
After planting, continue to monitor the stand and address any issues that arise. After about 5 weeks, the alfalfa plant should be 3-5in tall.

# Weed Out the Enemy!

The most common weeds in alfalfa fields are annual dicotyledon grasses and perennial dicotyledons such as thistle.
Alfalfa seedling are not competitive with weeds, but a good alfalfa stand is very competitive, which is why full weed control before planting and during alfalfa establishment is key. Many herbicides are available for pre-planting and post-emergence treatments.

Weeds generally do not pose a major problem for the first few years after the successful establishment of a well-fertilized, insect-free alfalfa stand. As the stand ages, however, the population often thins, and weeds begin to invade open areas. Summer, winter, and annual weeds alike can be a problem for established alfalfa, depending on management, the state of the alfalfa stand, and growing conditions. There are several herbicides available for controlling weeds in established alfalfa. The decision to use them should be based on the type and level of infestation, the desired alfalfa quality, and the alfalfa stand's density. Herbicides may help to improve the quality of a thin, weedy alfalfa stand, but will not help to rejuvenate the crop.
Herbicides for established alfalfa fall into two groups, depending on application timing. Post-emergence herbicides are applied during the growing season, while dormant season treatments are applied in winter, when the alfalfa isn't actively growing.
For spring seeding, weed control is essential to prevent seeding failure due to severe weed pressure. For conventional alfalfa planting, pre-emergence herbicide can be incorporated into the soil before planting. For no-till planting, only post-emergence herbicides should be used.
It is important to select an herbicide that is labeled for use in alfalfa, and to carefully follow label instructions for proper application.

# Seeding Methods

There are two common methods for planting alfalfa, each with its pros and cons: drilling and broadcasting (on ground or from the air). Given a well-prepared seedbed, a properly calibrated seeding rate, and uniform planting depth, either method can yield successful stands.

## Drilling

Most alfalfa sowing on irrigated soils is drilled. Compared to broadcasting, this method provides a more uniform depth, some reduction (up to 20%) in seeding rate, more uniform emergence, and the ability to place a starter fertilizer (low-nitrogen, high-phosphorus) with the seed.

Grain drills place alfalfa seeds in rows at a uniform depth. The seed typically drops behind a disk opener, and is covered by press wheels or a corrugated roller. Better drills have good depth control, which should be carefully calibrated for seeding depth. Drills with poor depth control should be avoided. If desired, fertilizers may be placed below the seed at planting.

One disadvantage of drilling is the unplanted gaps between rows, which provide an open area for weed invasion. To compensate, some growers drill in two perpendicular directions.

As with broadcast seeding, the seed must be covered and the soil around it firmed after planting. This can be accomplished using press wheels attached to the planter, pulling a cultipacker behind the planter, or in a separate operation using rollers or cultipackers.

## Broadcasting

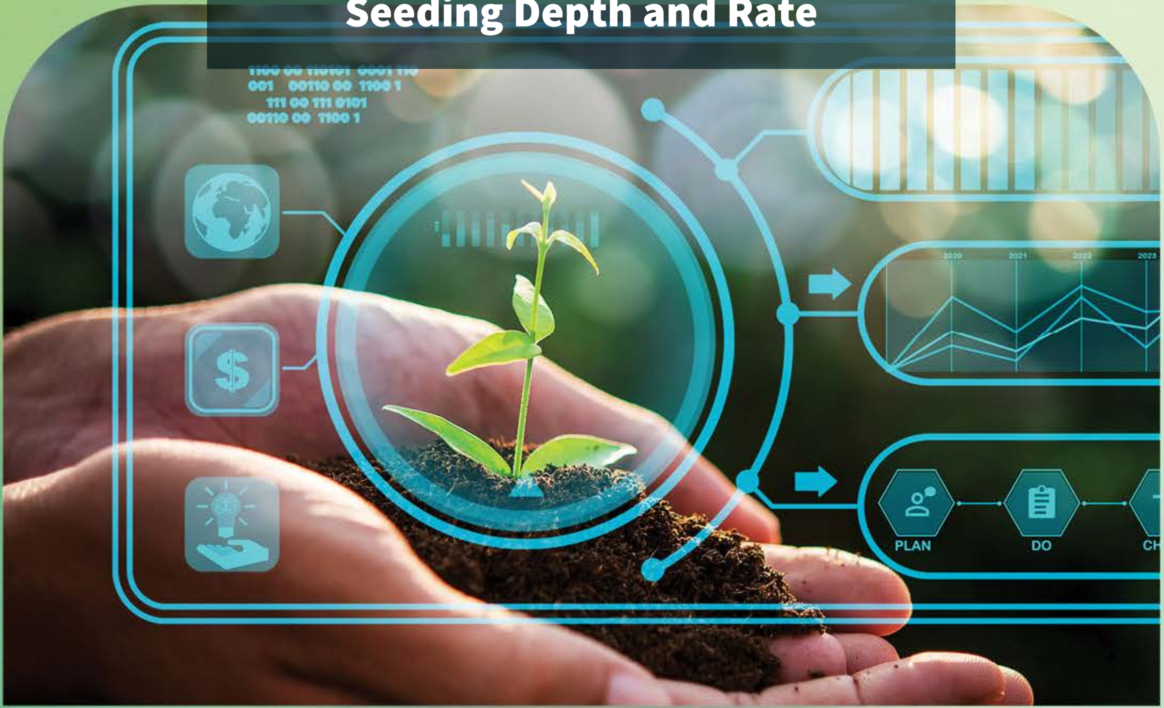
Broadcast seeding allows to sow large areas in less time. Its disadvantages include poor soil-to-seed contact; uneven planting depths (too shallow for the proper emergence of permanent root systems/too deep for germination); and often poor plant distribution. It is best used where soil conditions are optimal, the seedbed is properly prepared, and broadcasting and harrowing are followed by rainfall or irrigation.

Several kinds of seeders are used to broadcast seed evenly on the soil's surface. A cultipacker does an excellent job of planting alfalfa, as it has a roller in front to firm the soil at the optimal depth. Airflow applicators can be used to broadcast seed evenly on the soil's surface, sometimes in conjunction with other operations, such as fertilizer application.

With large acreages, or when the soil is too wet to support ground machinery, air broadcasting is a good option. While dropping seed from the air may is the least expensive method, there can be disadvantages. It may require more seed to compensate for gaps, and there is less control over seeding depth.

With all broadcast methods except for a Brillion seeder, seed must be covered after broadcasting to maximize germination and emergence. A cultipacker or ring roller is excellent for this. Firming the soil around the seed gives it greater contact with soil moisture and enhances germination. A spike-toothed harrow is not recommended, as it normally incorporates seed into the top 3in (7.6cm) of soil, which is too deep for optimal emergence and doesn't provide the desired seed-to-soil contact.

# Seeding Depth and Rate




Alfalfa is a small-seeded crop, requiring precise seeding depth. Seeds should be covered with enough soil to provide moisture for germination, while still allowing the small shoot to reach the surface.

Optimal seeding depth varies by soil type. Plant the seeds ¼ to ½ inch (0.64-1.28cm) deep on medium and heavy textured soils, and ½ to 1 inch (1.28-2.54cm) deep on sandy soils. Shallower seedings are possible given adequate moisture, while drier soils require deeper seeding.

Given good soil conditions and seeding machinery, the seeding rate for alfalfa should be between 12 to 15 lb/acre (13.4-16.8 kg/ha). Higher rates do not produce higher yields, and lower rates are normally used in arid regions. While the 12-15lb range may be more than needed under ideal conditions, the extreme variety in field and environmental conditions at seeding make it necessary for obtaining consistently good stands. For example, extended periods of cool, wet weather can cause high seedling mortality, while hot, dry weather at seeding time may reduce germination and seedling establishment.

A critical but often ignored step of the seeding process is calibrating the planter. Seed size can vary between alfalfa varieties, different lots of the same variety, and/or coated vs. raw seed. Thus, calibrate your seeding equipment for each new variety or lot, or if you use lime/clay-coated seeds.

Regular planter calibration is time well spent, and can help to avoid over- or under-seeding. Manufacturer-recommended settings are based on averages, and it is important to check the actual flow of seed through the planter before planting. Avoid relying solely on manufacturer recommendations or using last year's setting. Note that coated seed flows 5-30% precent faster through common seed metering units than does raw seed at the same planter setting.

# Effect of seeding rate

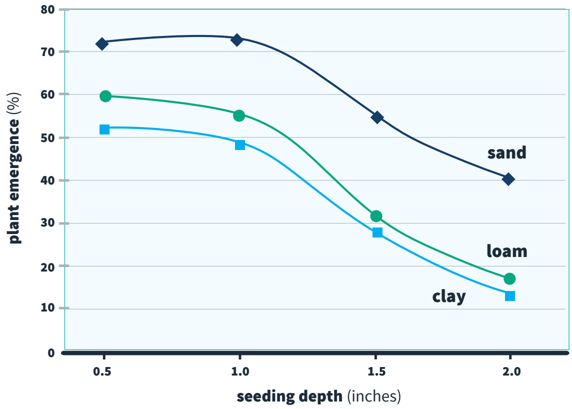
The distance between rows is normally 8in (20cm) or less. About a week after sowing, you will normally see the first sprouts. About two weeks after sowing, you will normally be able to count at least 270 new plants/ft$^2$ (25 plants/m$^2$). If you count fewer than 86-108 plants/ft$^2$ (8-10 plants/m$^2$) three weeks after sowing, you may have to consider plowing the field and sowing again.
In general, the number of alfalfa plants per hectare declines as the crop matures. In the first year, there are normally 270 plants/ft$^2$ (25 plants/m$^2$). However, at the end of the third year, this normally drops to 108 plants/ft$^2$ (10 plants/m$^2$).
Many growers add phosphorus fertilizer in the alfalfa sowing machine, as any phosphorus deficiency will inhibit alfalfa root development. If in doubt, consult a licensed agronomist.

### Effect of seeding rate on first-year alfalfa dry matter yields

| seeding rate (lb/acre) | dry matter yield (tons/acre) |
|---|---|
| 12 | 3.4 |
| 15 | 3.6 |
| 18 | 3.6 |

Source: Buhker, Proost and Mueller, University of Wisconsin, 1988.

### Alfalfa emergence from various seeding depths




Source: Sund et al., University of Wisconsin, 1966.

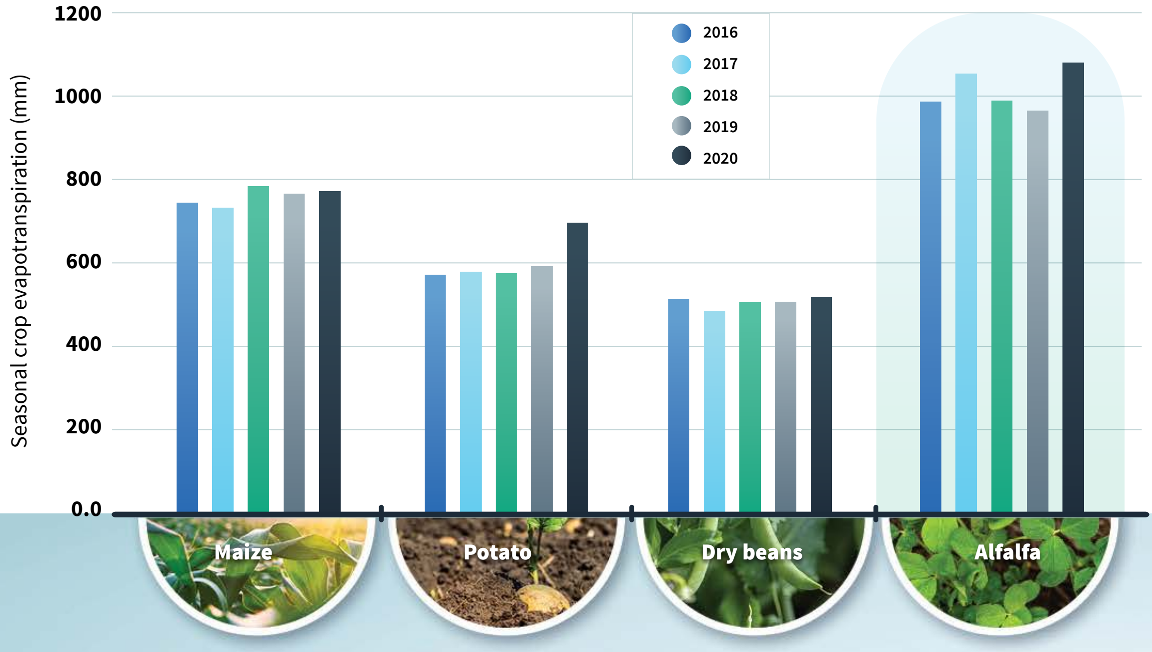
# Irrigation

## Alfalfa's water requirements

Agronomically, water stress is the most limiting factor for alfalfa production. Alfalfa's water requirements vary with local climate and precipitation patterns, and the amount of water transpired by the plant depends on factors such as temperature, humidity, wind speed, solar radiation, and the plant's phenological growth stage. Since it has a longer season compared to other common forage crops, alfalfa requires a large amount of water and has a high evapotranspiration (ET) rate. Thanks to its deep root system, alfalfa is well-adapted to drought under arid and semiarid conditions.

**Metzer's irrigation solutions for alfalfa are designed to provide you with the best of all worlds – including water efficiency, ease of operation, advanced fertigation, and yield quality.**

### Seasonal crop evapotranspiration (mm) of maize, potatoes, dry beans, and alfalfa for the 2016–2020 period



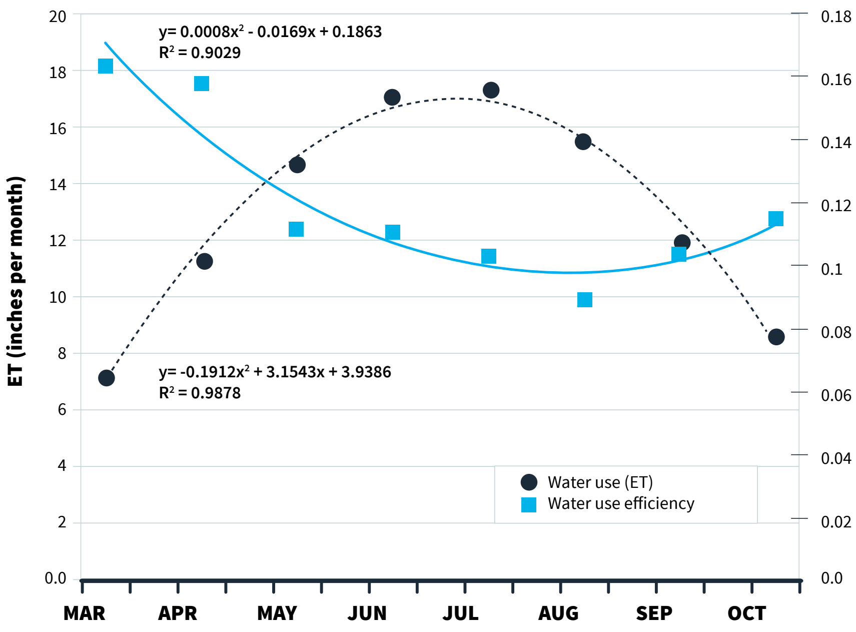

Source: Djaman, K.; Koudahe, K.; Mohammed, A.T. "Dynamics of Crop Evapotranspiration of Four Major Crops on a Large Commercial Farm: Case of the Navajo Agricultural Products Industry, New Mexico, USA". Agronomy 2022, 12, 2629. https:// doi.org/10.3390/agronomy12112629.

The daily evapotranspiration rate of alfalfa generally ranges from 0.1 to 0.35 inches (2.5-8.9mm), depending on weather and stage of growth. Alfalfa typically requires about 1,000mm of water per season, while seasonal ET varies significantly according to the climate and agronomic parameters of the soil and crop. One example of this wide variation is the Great Plains in the US, where alfalfa water demand ranges from 615mm to 1,448mm. Alfalfa evapotranspiration rate varies throughout the growing season, peaking at the height of growing season. $ET_0$ decreases from September to December, when winter air temperatures drop drastically, and the plants go into dormancy from November to February, with some variation between alfalfa varieties.

## Water Use and Yield: Getting More Crop Per Drop

Alfalfa water use is highest in midsummer, and lowest in spring and fall. As a result of this pattern, water use efficiency (WUE) – or crop yield per water unit – is greatest in spring. Maximizing WUE is thus accomplished by irrigating in spring. This also takes advantage of the moisture stored in the soil from winter and spring rains.

### Changes in alfalfa water use and water use efficiency over the growing season



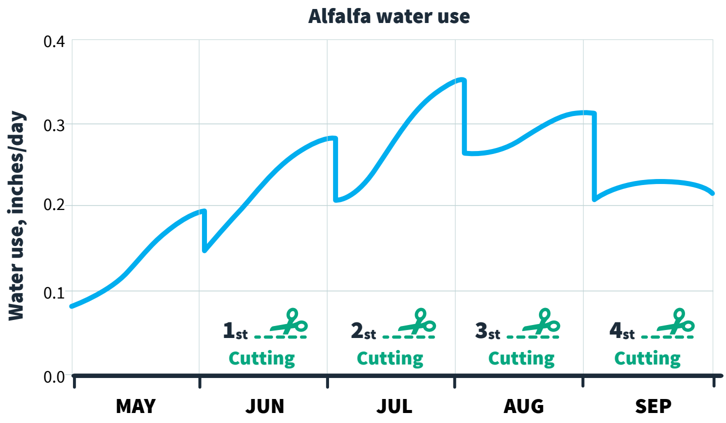

Source: Orloff, S., Putnam, D., Hanson, B., & Carlson, H. (2005, December). "Implications of deficit irrigation management of alfalfa". In Proceeding of California Alfalfa and Forage Symposium (pp. 12-14).

Alfalfa production is essentially a linear function of plant transpiration and stomatal conductance, which drives carbon dioxide uptake to build plant carbohydrates and biomass. Cutting schedules and nonuniform or poorly-scheduled irrigation can result in plant stress, which decreases transpiration, $CO_2$ assimilation, yield, and WUE.

**Metzer lets you make the most of your irrigation schedule, with the precision to control every drop of water that goes into your alfalfa crop.**

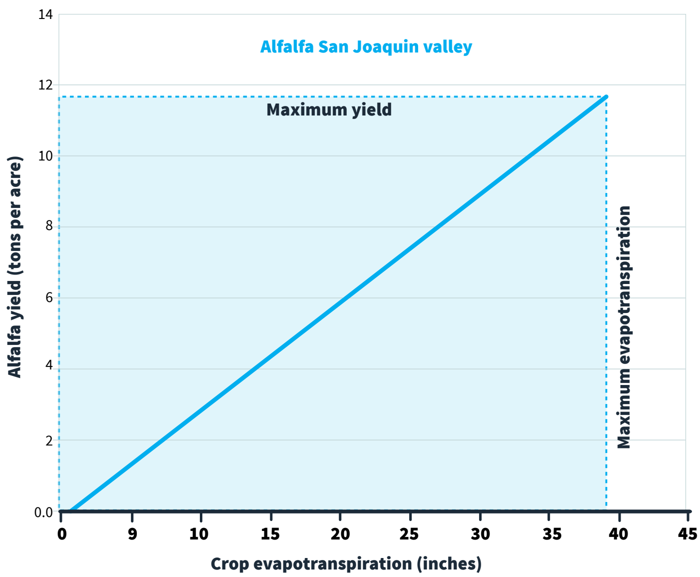
Water use may decrease slightly as harvest approaches, but drops sharply when alfalfa is cut, since removing most of the leaf area minimizes transpiration. Regrowth begins after harvest, and the water use cycle begins anew. This pattern repeats at each cutting (every 30-40 days, mainly depending on local weather, environment, and agronomic factors).

## Seasonal water use pattern for alfalfa in Nebraska




Source: Irmak, S., Hay, D. R., Anderson, B. E., Kranz, W. L., & Dean Yonts, C. (2007). "Irrigation management and crop characteristics of alfalfa". NebGuide G1778. University of Nebraska Lincoln.

## Effect of seasonal evapotranspiration on alfalfa yield for San Joaquin Valley of California




Source: Grimes, D. W., Wiley, P. L., and Sheesley, W. R. (1992). "Alfalfa yield and plant water relations with variable irrigation". Crop Science, 32(6), 1381-1387.

The water required to produce 1 ton of alfalfa can vary according to climate, soil type, irrigation method, and management practices. It generally stands at about 3-5in (76.2-127mm) of water per ton of production, regardless of the type of irrigation system.

Although alfalfa is a heavy drinker, some water savings can be achieved through deficit irrigation methods. Yield and net return can also be improved through irrigation scheduling that is based on monitoring soil moisture and weather conditions; optimizing the application rates; and minimizing water loss due to evaporation and runoff.

Most significantly, alfalfa WUE can be improved using hyper-efficient irrigation technologies such as subsurface drip irrigation (SDI), which saves the grower significant amounts of water.

Overirrigation of alfalfa benefits neither the yield nor the grower's bottom line. Moreover, excess water can increase pest and disease problems and shorten the stand's lifespan.

**SDI has the flexibility to address any set of conditions, allowing you precise control of root zone moisture and higher yields compared to other irrigation methods.**
**And for the very best in SDI, you'll find no better partner than Metzer.**

Alfalfa has no specific growth stage that is especially susceptible or impervious to water stress. It slows and goes dormant during water shortage, and resumes growth when water becomes available. Lack of moisture will reduce crop ET and yield: drought-stressed alfalfa matures earlier, with the quality peaking earlier and degrading more rapidly than under normal conditions.

# Water Quality

Compared to other forage grasses, alfalfa is adapted to a wide range of environmental factors, including irrigation with low-quality water – which in the case of subsurface drip irrigation may contain high levels of salt and/or organic matter.

One water source for alfalfa is reclaimed water or treated wastewater (TWW). TWW offers several advantages due to its high content of macro- and micronutrients (Mg, Ca, N, P, K, etc.) and soluble organic compounds. These allow the grower to use fewer chemical fertilizers, which thus require less production and transport, resulting in both financial savings and fewer greenhouse gas emissions. Furthermore, the nutrients and dissolved organic matter (DOM) in TWW increase the soil's microbial activity, which is essential for soil fertility and crop yield.

On the minus side, the soil can be negatively affected by the chemical composition of the irrigation water. TWW is typically characterized by poor chemical quality due to higher levels of DOM, total suspended solids (TSS), sodium absorption ratio (SAR), boron, electrical conductivity (EC), chlorine, and salinity. Sodium buildup can lead to poor permeability, affecting water distribution within the soil.

Since alfalfa is only moderately sensitive to salts, it is possible to irrigate it with moderately saline water. Growers using low-quality water should pay special attention to EC, Cl, and Na levels. Soil sampling and leaf analysis before and during growing season are crucial for avoiding harmful salinity effects – such as decreased yields and soil profile salination, especially at top layers. Iron, manganese, and the formation of lime or gypsum can potentially damage drip irrigation emitters. Another point to consider is that local health codes place strict limitations on permissible bacteria and pathogen levels in treated wastewater.

Although alfalfa can perform well when irrigated with highly-saline or low-quality water which isn't suitable for any other popular crop, it is best to consult an agronomist before using it.

**With a Metzer system in place, alfalfa growers can rest easy – thanks to an irrigation solution that accounts for any deficiencies in their water source, while also protecting their crop and allowing for optimal maintenance.**

# Irrigation and Fertigation Management

One key factor in achieving ROI on commercial alfalfa is scheduling and adjusting your irrigation and fertigation program based on crop variety, climate, the soil's water holding capacity, the crop's water demand, and more.

## Scheduling

Regular monitoring of the soil's water status helps to make smart irrigation decisions that supply alfalfa with its precise water demand. Irrigation scheduling can typically be done using one of two methods:

- Estimating root-depth water using the water balance method, also known as weather-based or crop evapotranspiration-based scheduling
- Directly monitoring soil water content using sensors throughout the field


**The best approach is to combine both methods.**

# The water balance method

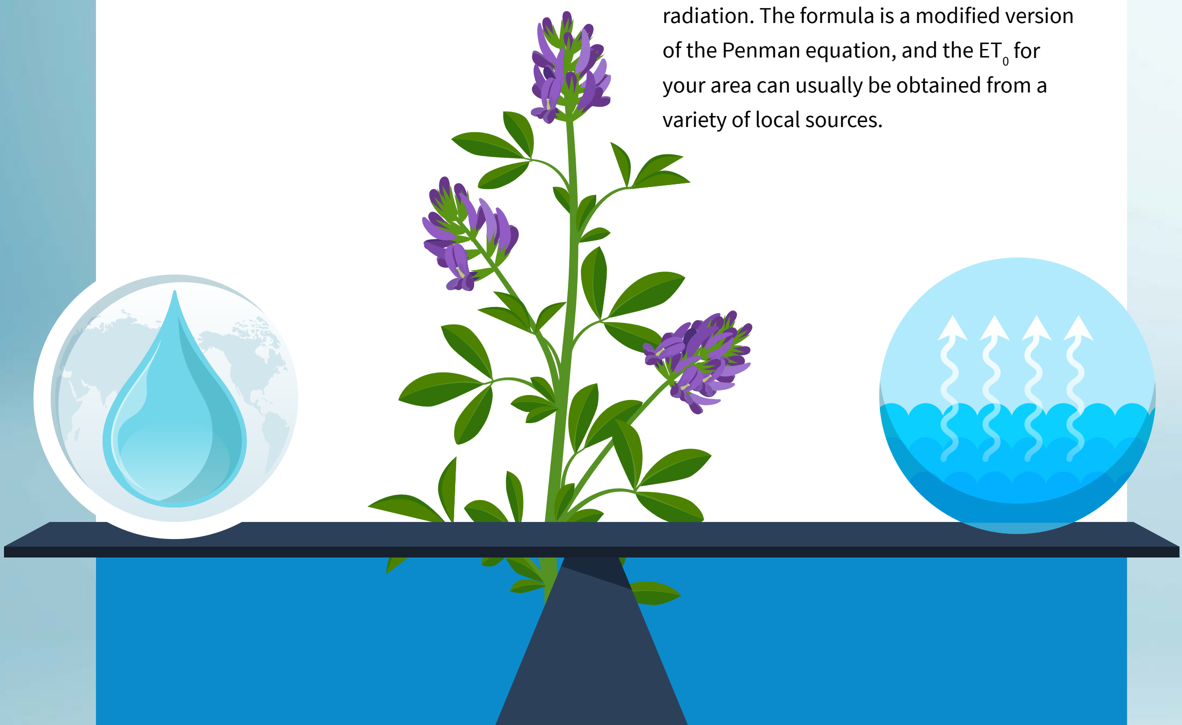
This evaluative method is chiefly used to maintain near-optimal levels of soil moisture for alfalfa, by keeping track or the crop's water use and irrigating to replace it. The method accounts for all incoming and outgoing water from the soil root zone, with the inputs being irrigation and rainfall, and the outputs being the crop's water use, leaching requirements, and any irrigation system inefficiencies.

## Evapotranspiration Rate (ET)

The crop's water use is also called its evapotranspiration rate (ET). Evapotranspiration combines water lost from the soil (evaporation) and water taken up by the plant and lost through the leaves (transpiration). The ET for alfalfa is determined by the plant's growth stage and the weather: Smaller plants tend to use less water, hotter or drier conditions cause the plant to use more, and winds and clouds can also have an effect.

## The Reference Evapotranspiration Rate ($ET_0$)

The reference evapotranspiration rate ($ET_0$) approximates the environmentally-induced evaporation rate from a given area of soil. It is most frequently calculated from weather data, and in some parts of the world it is still measured as evaporation from a calibrated pan of water. Data for calculating $ET_0$ includes temperature, relative humidity, wind velocity, and solar radiation. The formula is a modified version of the Penman equation, and the $ET_0$ for your area can usually be obtained from a variety of local sources.



**The crop's evapotranspiration ($ET_c$) is calculated by multiplying the crop reference ($ET_0$) by the crop coefficient ($K_c$), which describes the specific crop and growth stage:**

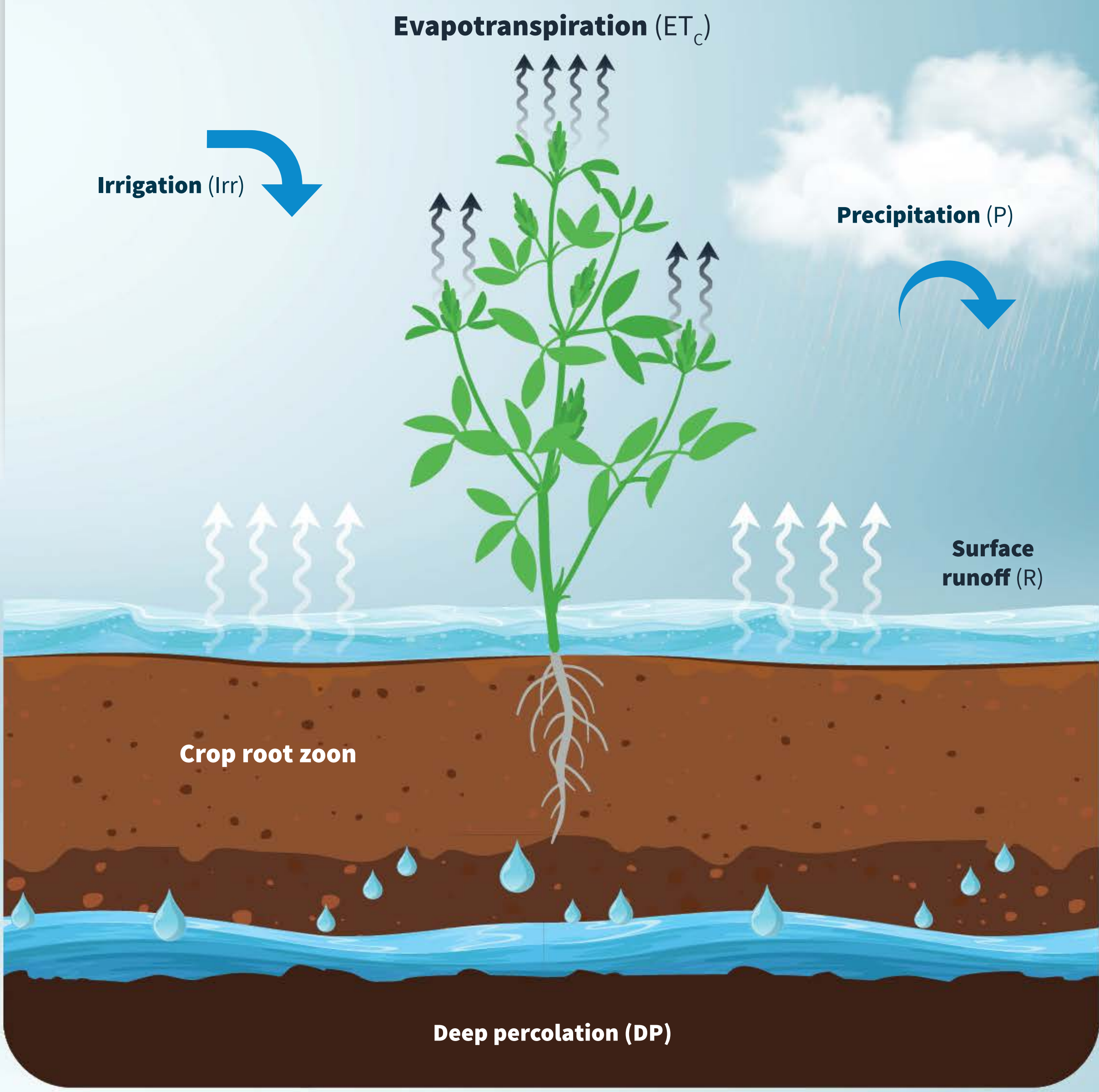
$$ET_c = K_c \times ET_0$$

Growers can calculate $ET_c$ daily and apply irrigation accordingly, while also factoring in irrigation intervals. For example, if the crop coefficient ($K_c$) is 1.10, daily $ET_0$ is 8mm, and the irrigation interval is every 3 days, the grower should apply water as follows:

$ET_c$ = 1.10 ($K_c$) × 8mm (daily $ET_0$) × 3 (irrigation interval) = 26.4mm = (26.4 $m^3$ /du) or × 10 (du/ha) = 264 $m^3$/ha.

In order to leach salts down from the root zone, it is generally recommended to add 10%-15% more water to the $ET_c$ calculation. To calculate annual water supply, growers should also factor in annual local precipitation, since many regions have rainfall during the irrigation season.

## Soil water balance components



# Physically measuring soil water content

In areas with significant rainfall, measuring soil water content using sensors or probes in the root zone is critical for assessing the amount of useful rainwater received and for precise irrigation scheduling. When soil water content drops below a certain threshold, irrigation is used to replenish it.

One relatively cheap and easy-to-use option is tensiometers, which measure how tightly soil water is held. These devices come in both mechanical and electronic versions. Since tensiometers tend to lose soil contact when the soil is too dry, it is best to install 1-2 tensiometers at active root zone depths where water uptake occurs, and another tensiometer below that level to detect wasted water being leached down.

Other, more sophisticated and expensive tools allow for more precise scheduling. For example, TDR (time-domain reflectometry) probes use electromagnetic waves to record soil water content, and should be spread out at varying depths according to the alfalfa's shoot and root sizes, covering the root zone and below.

TDR probes are typically placed in pairs, at 1/3 and 2/3 of the crop's root zone depth, at two or more locations in the field, preferably in the representative soil type, and away from high points, depressions, and slopes.

Some fields contain both heavy and light-textured soils, each with a different water holding capacity.

In these fields, it is best to monitor each soil type and manage its irrigation separately. Field mapping technologies (e.g., electromagnetic (EM) conductivity mapping) can be used to identify the different soils and create the separate management zones.

## The soil as your water reservoir

The soil serves as your water reservoir, with upper and lower thresholds on the amount of water it can store. Understanding these thresholds is critical for alfalfa irrigation scheduling. Depending on soil type and texture, oversupplying the reservoir can result in runoff or percolation below the active root zone; while undersupplying it can lead to plant stress, where the plants strain to extract water from the soil – and thus to reduction in alfalfa yield and quality.

**Proper irrigation management lets you keep your soil water reservoir at optimum levels, avoiding both plant stress and runoff. A properly-designed SDI system from Metzer will help you to apply water accurately, effectively, and profitably.**

# Soil Characteristics & Water Holding Capacity

Your soil type and its physical aspects, such as soil texture, have a direct bearing on its water holding capacity, the water available to your crop, and your irrigation scheduling. Here are the main indicators to consider:

## Saturation

In saturation, all soil pores are filled with water, and water readily percolates or drains out from the root zone through gravity. Saturation occurs when the rate of water supply exceeds the soil's infiltration rate – normally right after heavy rains or when irrigating using flood and sprinkler systems. Saturation decreases the soil oxygen available to alfalfa roots, and can result in plant disease. An SDI system will enable you to control your soil's water content and avoid saturation.

## Field Capacity (FC)

This is the amount of water that remains in the soil once excess water from saturation has been drained out. To reach FC in sandy soils, allow the soil to drain for approximately 24 hours after saturation. For heavier soils with more silt and clay, allow 2-3 days. At field capacity, gravity pulls all the water out of the large pores in the soil, replacing it with air, but leaves water in the smaller ones. This is ideal for the alfalfa roots, since it allows for both easy water uptake and proper ventilation.

## Permanent Wilting Point (PWP)

When plants take up all the available water from the soil, the soil dries up and can no longer sustain them. At PWP, the crop's water absorption power cannot overcome the soil's water holding power. The plants cannot extract the tightly-held water in the film around soil particles or in small pores. In this condition, plants will wilt even if the soil feels moist. Unlike saturation and field capacity, PWP depends not on the soil but on the crop, with some crops wilting faster than others.

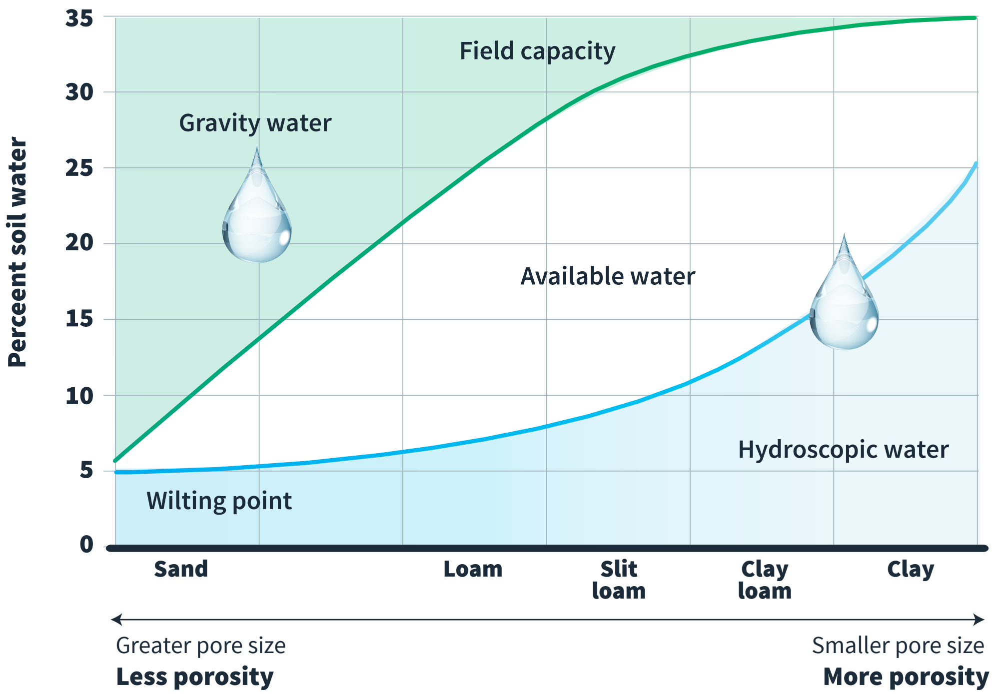
## Available Water Capacity (AWC)

AWC is the maximum amount of plant-extractable water that the soil can store. In other words, it is the amount of available water between field capacity and the permanent wilting point.

A crop's total available root zone water is calculated by multiplying the rooting depth by the available water holding capacity per soil depth unit.

AWC differs by soil type. Coarse-textured soils such as sand and sandy loam typically have larger pores, unlike fine-textured soils such as clay or clay loam, which contain small mineral particles and very small pores. A large number of small pores means better water holding capacity.

## The soil as your water reservoir




## Maximum allowable depletion or deficit (MAD)

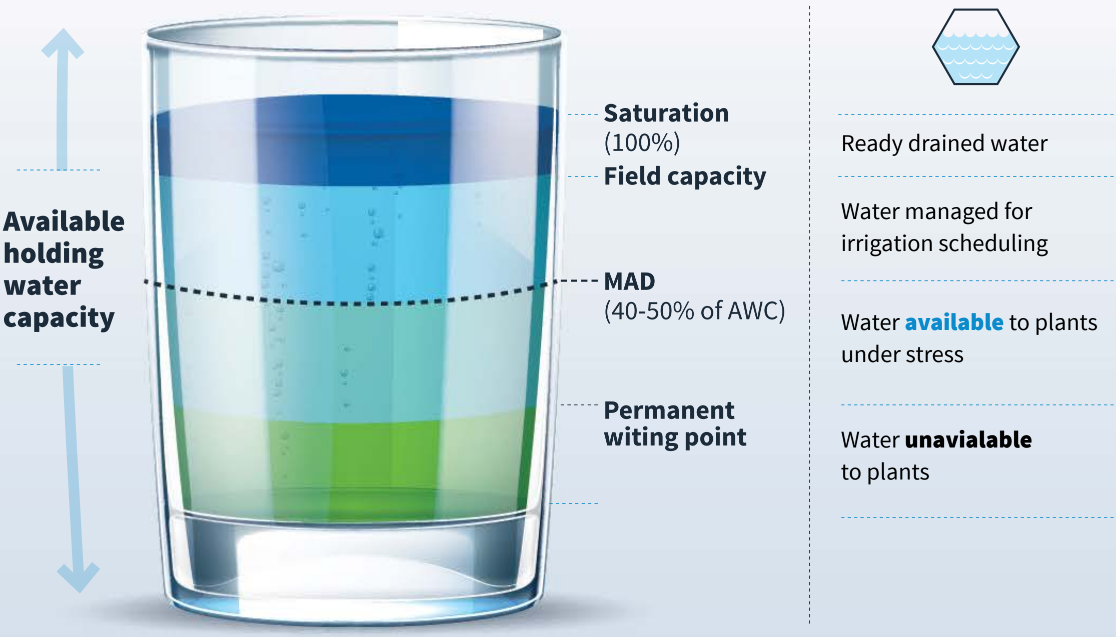
Since soils aren't uniform, crop water extraction isn't uniform throughout the field. While in theory all of the AWC is available to the plant, in practice AWC is a gross estimate, and the plant reaches water stress long before using this water up. Thus, it is bad practice to schedule irrigation to the wilting point, which should be strongly avoided. To provide a safety margin, irrigation scheduling should be designed around "easily available water".

The maximum allowable depletion/deficit (MAD) is the point at/before which irrigation must be triggered, which for alfalfa means irrigating when no more than 50% of the available water has been depleted. Apply the amount of water needed to fill the soil reservoir to field capacity.

MAD is usually expressed as a percentage of total available water in the root zone. To convert it into in/mm of water per specific crop and soil type, multiply this percentage by the total available water in the root zone. For example, 30% MAD for soil holding 4in (101.6mm) of water would be 0.3 x 4in (101.6mm) = 1.2in (30.4mm).

If there is potential for rain, make sure to factor that amount of water into the calculation.

# Soil water reservoir components



# Superior Irrigation with SDI

Alfalfa reacts exceptionally well to subsurface drip irrigation (SDI) – in terms of both production and financial return.

**To strike the ideal water balance for your alfalfa crop, there is no better solution than subsurface drip irrigation (SDI) – and no better partner than Metzer.**

## Flexibility and precision

SDI grants you total control over the root zone environment of your alfalfa crop.

## Significant water savings

A major advantage for thirsty crops such as alfalfa. SDI consumes only as much water as the crop requires to reach optimal quality, and completely eliminates surface runoff. For many growers, this means using less water than with other irrigation methods.

## Faster regrowth

SDI allows to irrigate during and immediately after harvest, which results in rapid regrowth, more cuts, and higher yields. Some growers report 1-3 additional harvests a year.

## Better fertilizer management

Applying fertilizer directly to the root zone results in a healthier crop that can remain productive for longer and yield higher-quality hay.

## Less labor-intensive

Requires up to 50% less labor than other irrigation methods.

## Better stand management

Since SDI keeps the soil surface dry, soil compaction and weeds are greatly minimized, leading to healthier root systems and longer-living stands.

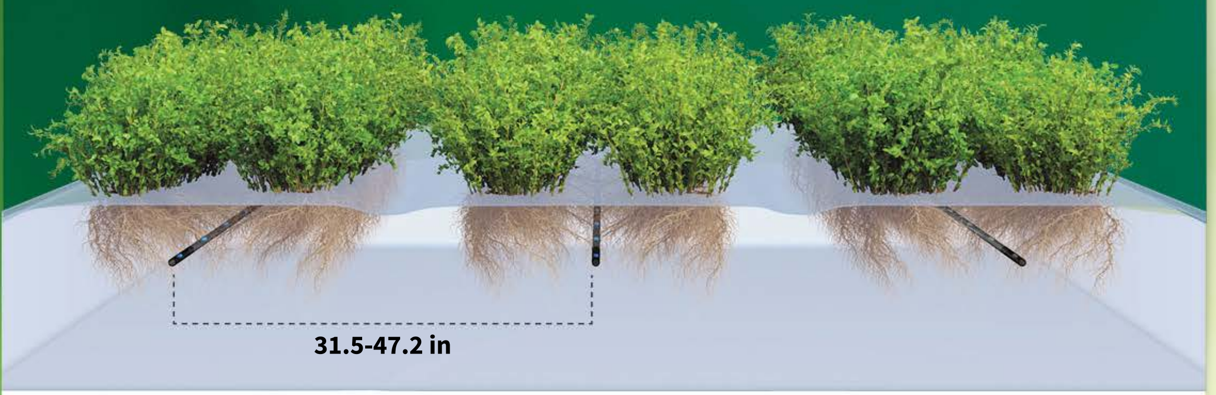
## Minimizes diseases

With SDI, the drier conditions of the crop itself mean fewer diseases, which in turn requires less herbicide application.

# SDI Layout

The exact layout of your SDI system depends on soil type, water availability, water quality, pump capacity, the crop's water requirements, and if relevant, crop rotation. The four key elements of SDI layout for alfalfa are dripline row spacing, placement depth, dripper spacing, and dripper flow rate.

**Using your input, your local Metzer dealer will provide you with a drip system that is precisely tailored to your alfalfa operation.**




## Dripline spacing

**In SDI for alfalfa,** the general working range for dripline spacing is 31.5-47.2in (80-120cm) between dripline rows. To achieve even irrigation and uniform stands, the current best practice specifies a spacing of 40in (101.6cm).
When widening this spacing to cut costs, one often sees bands of better and worse-performing stands. Note that wider dripline spacing also requires closer dripper spacing and possibly higher dripper flow rates, which may exceed the infiltration rate of heavier soils. At present, anything beyond 60in (152.4cm) is unrecommended.

**Soil type** determines both the optimal and the maximum allowable dripline spacing. Lateral water distribution through soil capillary action is affected by clay, silt, and fine sand, which together determine soil texture. Soils with over 10% of clay, silt, or fine sand have a width-to-depth-water distribution ratio of 1.5 or more, and are thus ideal for 40in (101.6cm) dripline spacing. In soils with less than 10% clay and medium-to-coarse sand, it may be necessary to lay the driplines closer together.

**Crop rotation** also affects dripline spacing. SDI systems can last up to about 20 years, so it is important to establish a rotation plan before installation, factoring in the possible need for sprinkler or flood irrigation for the rotated crops. In principle, since your alfalfa SDI system is designed to water the entire soil volume, any other crop with a relatively deep root system (e.g., tomato, cotton, corn) can be cultivated using the same system.

## Dripline depth

Having SDI lines in place allows to irrigate immediately following (or even during) harvest – an important factor in the rapid re-growth and potentially higher yields of alfalfa.
SDI driplines are placed at a depth of 12-18in (30.5-45.7cm) in order to provide adequate water and nutrient supply to the alfalfa's deep roots. They keep the soil surface dry, thus allowing for machinery operation even during irrigation, and reach below the active region of most rodents which may damage the dripline.
While driplines for alfalfa can be placed at any depth, there is little reason for anything shallower than 12in (30.5cm), a depth above which moisture would reach the soil surface, impede mechanical surface operations, and encourage weed growth.

In areas with severe rodent pressure, a dripline depth of 15in to as much as 24in will help to reduce damage by operating below most rodent activity. A depth of 12in or more enables to till at a minimum depth of 5.9in (15cm), which also helps to deal with rodents and their burrows.
Recent data has shown that SDI causes less soil compaction. Alfalfa's strong root system reduces soil compaction and the need for deep follow-up cultivation.
Follow-up soil preparation for rotation crops shouldn't have to be deeper than 10in. However, if the SDI system is installed using GPS, rotation crops can be easily planted at an ideal distance from the dripline, with deep cultivations taking up the space between the driplines.

## Dripper spacing and flow rate

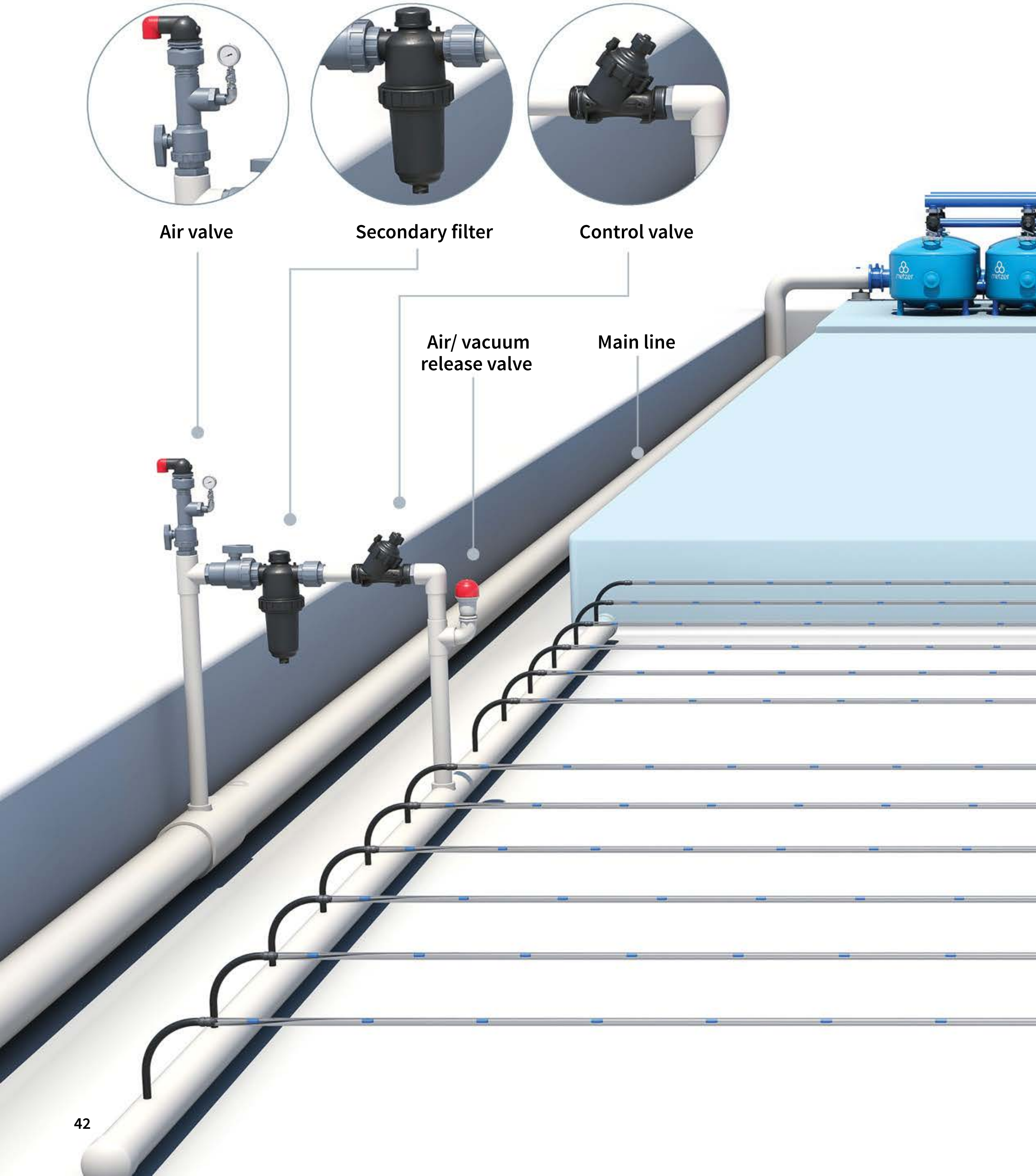
Together with row spacing, dripper spacing and flow rate dictate the water application rate. They depend on row spacing, as well as on water requirements, water availability, and crop management practices. A typical system can use 0.22 GPH (0.85 L/h) emitters spaced 24in (60cm) apart, for an application rate of 0.055in/h (~1.4mm/h) or 1.44in (36.6mm) over 24 hours.

Dripper spacing and flow rate should allow to supply adequate water to satisfy your crop's peak water use (ETc), normally expressed in/mm per day. The precise ETc depends on climate, and can be obtained from your local meteorological or agricultural service. For low-quality water or soil, a leaching factor should be added to the equation to ensure that the required additional water is available.

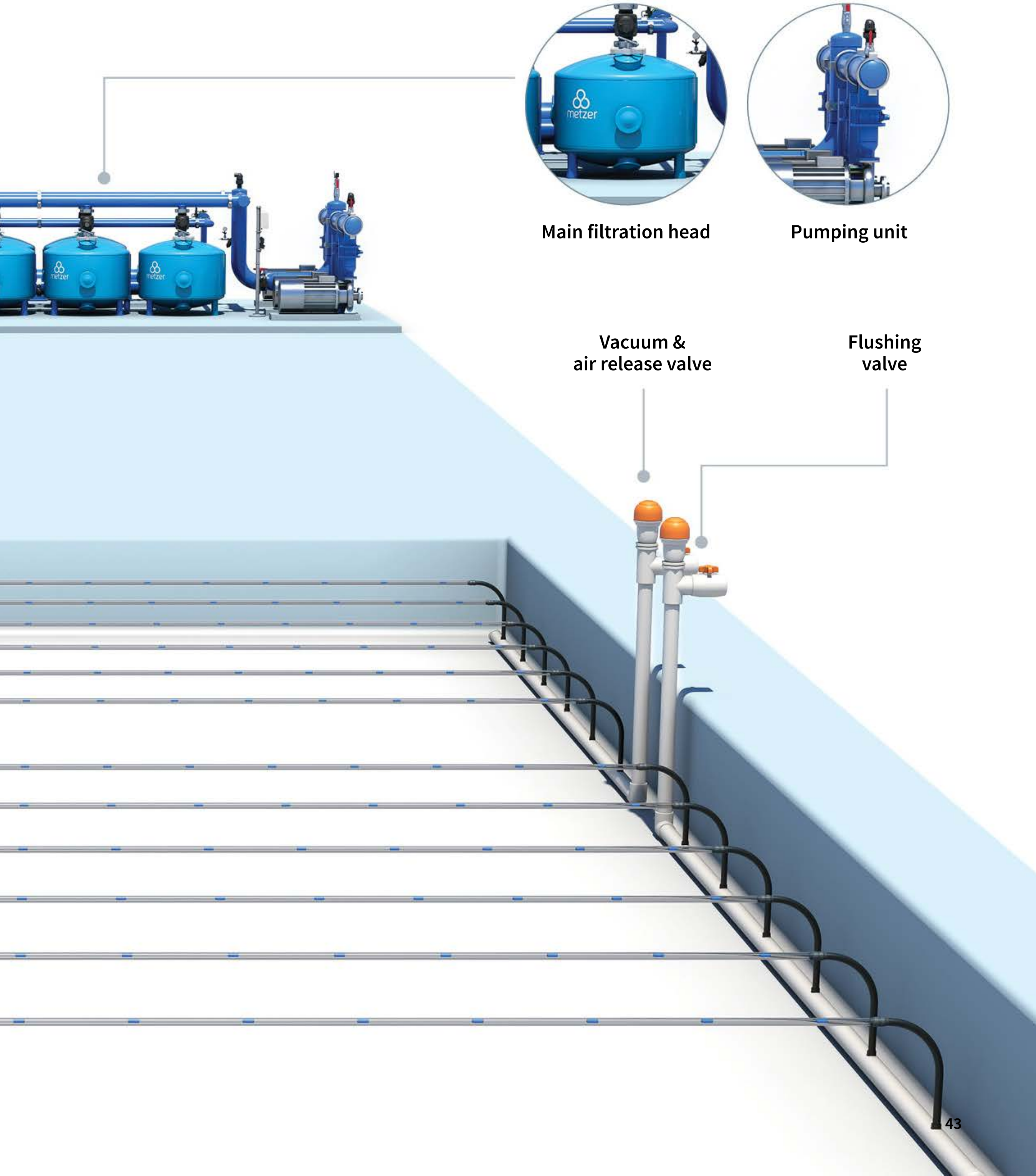
**Dripper spacing and flow rate for alfalfa depend on a wide range of agronomic factors. Consult with Metzer's experts to determine the ideal settings for your SDI system.**

# Subsurface Drip Irrigation (SDI)

## System installation



To enable efficient lateral flushing, the lateral ends are normally connected to a common collector line, which allows to flush them all through a single valve.



# SDI Installation Step by Step

A carefully planned and executed installation will ensure more alfalfa cuts, higher yields, and all the benefits of an SDI system. Driplines are buried using a ripper, which has depth-controllable wheels.

**The process is as follows:**

01 Place the dripline on the ripper

02 Feed the line through the welded pipe

03 Adjust the installation depth as per agronomic needs

04 Make sure to mark the lateral spacing on the ground

05 Start at the one end of the plot, hold one end of the dripline, and make allowance for 1-2 extra meters

06 Install the dripline underground from one end to the other. Again, make allowance for extra space according to the distance between drippers

07 Ensure that the spacing between driplines is consistent

**Installing the submain line and discharge line:**

08 Dig the trench for these lines. Ensure that the ends of the driplines are bent to prevent soil particles from entering

09 Place the driplines in the trench

10 Install the head connectors in both the submain and discharge lines

11 Connect the driplines to the head connectors

12 **Install the anti-vacuum valves**
To ensure the best results from your SDI system, consult with an expert before and after installation.

## Preliminary System Activation

Before the irrigation season starts, it is important to activate your SDI system (whether new or existing) by cleaning, flushing, and inspecting it. The following simple steps will help to ensure optimal performance:

### Flush the well before activation with a filter

At activation, a new well or one that has sat still during off-season may discharge sand particles that could overwhelm the filtration system, repeatedly triggering an unproductive backflush cycle. If the well discharges sand particles on a regular basis, it may be necessary to install a sand separator before the regular filtration system.

### Thoroughly flush the driplines & mains before normal irrigation

New SDI installations may contain dirt and PVC bits that should be flushed out. During irrigation season, systems need be flushed regularly, since filters often do not filter 100% of particles and silt – and debris may also get into the lines during breaks and repairs.

### Check for leaks in dripline laterals

Laterals are occasionally damaged during installation. System start-up is a good time to check for leaks, before crop growth makes inspection and repair difficult.

## Irrigation During Soil Preparation & Germination

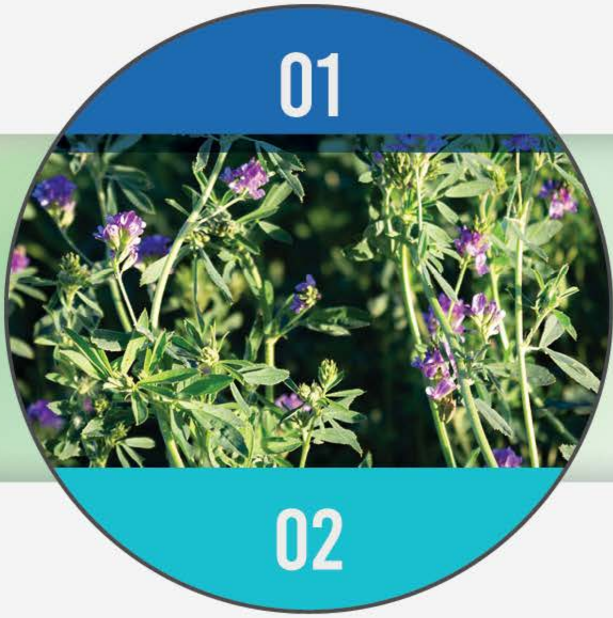
Germinating alfalfa with SDI is unrecommended, except for the most experienced of growers. Although alfalfa establishment is sometimes possible with the SDI system, it is best to use sprinkler or flood irrigation for soil preparation, germination, and emergence. The reason is that in most new installations the capillary soil pores are disturbed during dripline installation, causing the water not to rise to the surface even after long irrigation. A similar problem occurs with lighter soils.

# Testing System Pressure and Flow Rate

On initial startup, it is recommended that you evaluate the uniformity of your SDI system by measuring and adjusting its pressure and the flow rate.

## PRESSURE

Drip systems are typically designed to operate at a pressure of 1.0-2.5 bar. Measure the pressure at multiple points in your system – including at least 3 points along the header end and 3 points at the far end of the field. Additional measurements along the laterals will provide a fuller picture of system uniformity, but are usually not necessary if the header and end pressures are within one psi of each other.




## FLOW RATE

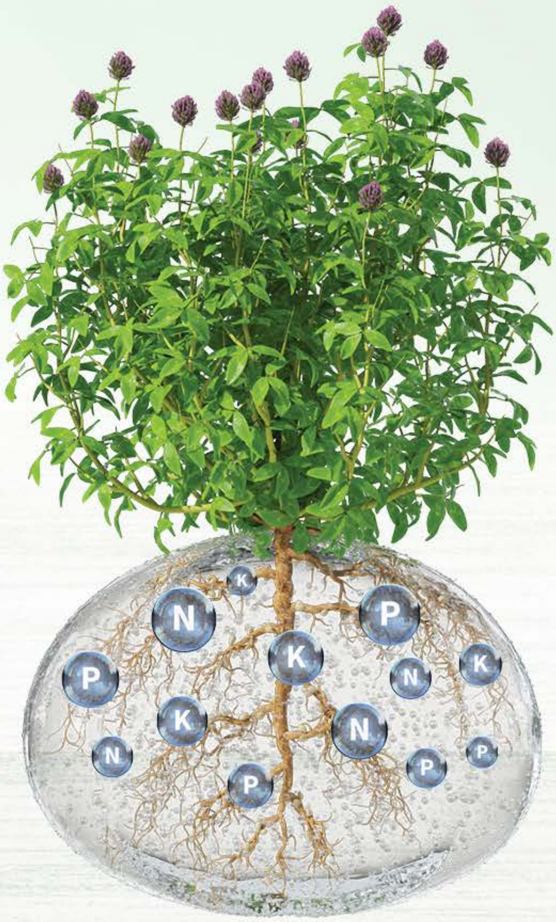
A key component of any modern drip system is a flow meter, which provides a quick indication of the system's performance and is used to determine precise water application rates.
Older systems without flow meters should have one installed. SDI system design should include an estimated system flow rate, and the actual rate measured should fall within 7% of that designed rate.

# Fertilization With SDI

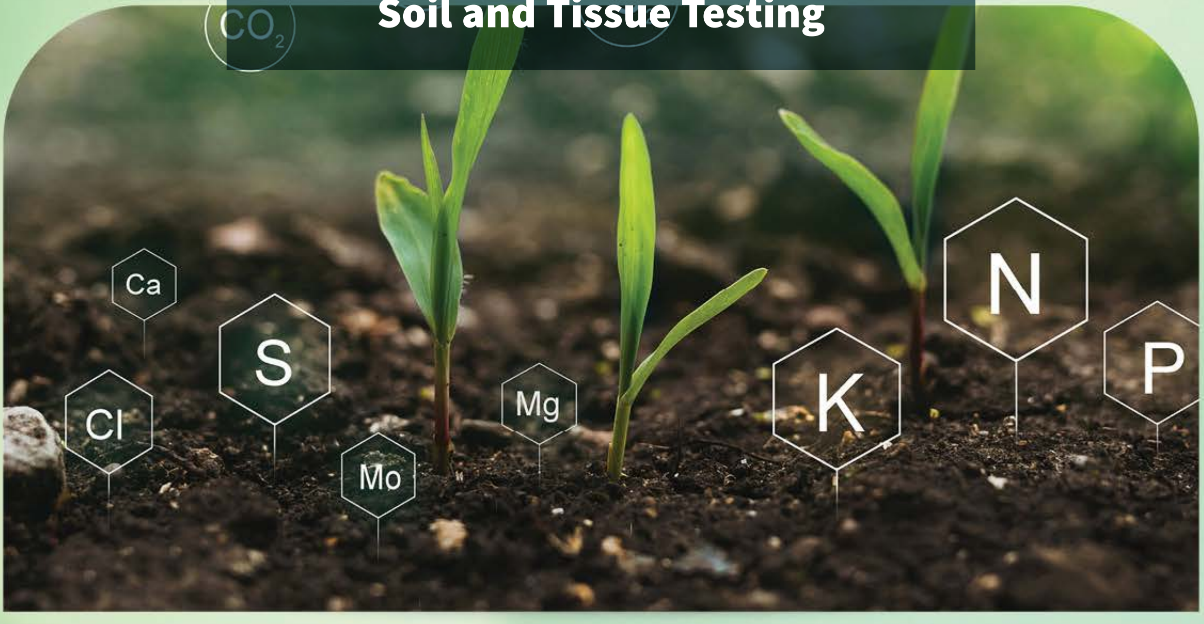
As with irrigation, alfalfa fertilization benefits immensely from the use of subsurface drip irrigation. SDI fertilizer application enables to apply nutrients directly to the active root zone, at far more accurate times and amounts, while maintaining a near-optimal level of soil nutrients. As a result, your alfalfa will grow more vigorously and last longer, while reducing waste and using less fertilizer per pound of yield.

**SDI is the most efficient way of delivering fertilizer to a permanent crop such as alfalfa. Metzer's SDI solutions allow you to reach stronger, healthier yields through a lower fertilizer investment.**

For every 1 ton of production, a well-managed alfalfa stand with leaf analysis showing high nutrient values will require 60 lb/acre (67.2 kg/ha) of nitrogen; 12 lb/acre (13.4 kg/Ha) of phosphorus in the form of $P_2O_5$; and 48 lb/acre (53.7 kg/Ha) of potassium in the form of $K_20$. Amounts may vary by crop variety, plantation age, expected yield, and more.
Before applying mineral fertilizers through drip fertigation, growers should factor the existing nutrients in the water source into their seasonal and annual fertilization program.



# Soil and Tissue Testing




Soil testing and plant tissue testing are used to detect nutrient deficiencies. Since the two tests differ in their diagnostic accuracy re: alfalfa, it is highly recommended to perform both in order to fully evaluate problems towards producing a commercial yield.

## Soil testing

Soil tests are useful for assessing nutrient availability for plant uptake. They must be performed before planting. The lab results, and their interpretation by a qualified agronomist, will affect the recommended amounts of soil to be applied for amending the existing soil.
Soil sampling from a drip-irrigated field is slightly different than from a sprinkler or flood-irrigated field.
The drip system creates localized wetted areas in the soil profile. Since the nutrients injected via drip are only found in those areas, it is important to sample there in order to accurately assess soil fertility.
The goal is to test near the dripline but not to hit it. This can be tricky. A good idea is to develop some kind of marking system. If soil tests are taken in established stands, sampling may be repeated every 2-3 years.

### Interpretation of soil test results for alfalfa production

| | | Soil Value (ppm)[a] | | | |
|---|---|---|---|---|---|
| **Nutrient** | Extract[b] | Deficient | Marginal | Adequate | High |
| **Phosphorus** | Bicarbonate | <5 | 5-10 | 10-20 | >20 |
| **Potassium** | Ammonium acetate | <40 | 40-80 | 80-125 | >125 |
| **Boron** | Saturated paste | 0.1[c] | 0.1-0.2 | 0.2-0.4 | >0.4[d] |

a. An economic yield response to fertilizer application is very likely for values below the deficient level.
b. Soil test values are based on the cited extract; values for other extracts are different.
c. Soil testing is not a suitable method to diagnose a deficiency. Use a plant tissue test.
d. Possible toxicity to sensitive crops, such as cereals.

Source: Meyer, R. D.; Marcum, D. B.; Orloff, S. B.; Schimierer, J. L. 2007. “Alfalfa fertilization strategies”. IN C. G. Summers and D.H. Puntam, eds., Irrigated alfalfa management for Mediterranean and Desert zones. Chapter 6. Oakland: University of California Agriculture and Natural Resources Publication 8292. See: htttp://alfalfa.ucdavis.edu/IrrigatedAlfalfa.

# Tissue testing

While some growers rely on soil testing alone to evaluate the effectiveness of their fertilizing regime, plant tissue testing is far more precise in determining the nutrient status and requirements of alfalfa, especially regarding sulfur, boron, and molybdenum.
The best time to sample tissues is when the crop is at 10% bloom or when regrowth is at a length of ¼-½in (0.6-1.3cm). Samples can be collected at any cutting, but first cutting is preferable, as it is the best time to detect sulfur deficiency.

Tissue testing can determine the most limiting nutrient affecting plant growth, thus allowing to correct the most severe deficiency first. After this correction, take new samples to determine whether other nutrients are also deficient.
Note that low concentrations of a nutrient in plant tissue do not always indicate a deficiency in the soil. For example, a root problem such as nematodes can affect nutrient uptake and manifest as deficiency.
It is recommended to consult an agronomist or a guide who specializes in soil and tissue analysis, both before and during growing season.

## Interpretation of test results for alfalfa tissue samples taken at 10% bloom

| | | | **Plant Tissue Valuea** | | | |
|---|---|---|---|---|---|---|
| **Nutrient** | Plant Part | Unit | Deficient[b] | Marginal | Adequate | High |
| **Phosphorus** ($PO_4$-P) | Middle third, stems | ppm | 300-500 | 500-800 | 800-1,500 | 1,500< |
| **Potassium** | Middle third, stems | % | 0.45-0.65 | 0.65-0.80 | 0.80-1.5 | 1.5[c]< |
| **Sulfur** ($SO_4$-S) | Middle third, leaves | ppm | 0-400 | 400-800 | 800-1,000 | 1,000[d]< |
| **Boron** | Top third | ppm | <15 | 15-20 | 20-40 | 200[e]< |
| **Molybdenum** | Top third | ppm | <0.3 | 0.3-1.0 | 1-5 | 5-10[f] |

a. Phosphorus concentration should be higher if alfalfa is cut at bud stage, 1,200 ppm at mid-bud, and even higher, 1,600 ppm, if alfalfa cut very early bud stage. Other nutrient concentrations should be approximately 10% higher than when sampled at the 10% bloom growth.
b. An economic yield response to fertilizer applications is very likely for values below the deficient level, somewhat likely for values in the marginal level and unlikely for values over the adequate level.
c. Alfalfa having greater than 3% potassium may cause animal health problems, particularly if the magnesium concentration is not greater than 0.25%.
d. Alfalfa having greater than 3,000 ppm $SO_4$-S may intensify molybdenosis in ruminants.
e. A concentration over 200 ppm may cause reduced growth and vigor.
f. A concentration over 10 ppm may cause molybdenosis in ruminants. Copper concentrations should be twice as high as molybdenum concentrations.

Source: Meyer, R. D.; Marcum, D. B.; Orloff, S. B.; Schimierer, J. L. 2007. “Alfalfa fertilization strategies”. IN C. G. Summers and D.H. Puntam, eds., Irrigated alfalfa management for Mediterranean and Desert zones. Chapter 6. Oakland: University of California Agriculture and Natural Resources Publication 8292. See: htttp://alfalfa.ucdavis.edu/IrrigatedAlfalfa.

# Correcting Nutrient Deficiencies

In applying fertilizer to correct nutrient deficiencies, you should carefully factor in the amount of nutrients removed by alfalfa, the field's yield potential, current soil and tissue test levels, and historic responses to fertilization events.

| | | Alfalfa crop yield[a] | | | |
|---|---|---|---|---|---|
| | | 6 ton/acre | 8 ton/acre | 10 ton/acre | 12 ton/acre |
| Nutrient | Symbol | Nutrient removal, lb/acre | | | |
| **Nitrogen** | **N** | 360 | 480 | 600 | 720 |
| **Phosphorous** | **P ($P_2O_5$)** | 31 (71) | 42 (95) | 52 (120) | 62 (143) |
| **Potassium** | **K ($K_2O$)** | 240 (288) | 320 (384) | 400 (480) | 480 (576) |
| **Calcium** | **Ca** | 192 | 256 | 320 | 384 |
| **Magnesium** | **Mg** | 40 | 53 | 66 | 79 |
| **Sulfur** | **S** | 24 | 32 | 40 | 48 |
| **Iron** | **Fe** | 2.3 | 3.0 | 3.8 | 4.6 |
| **Manganese** | **Mn** | 1.5 | 2.0 | 2.5 | 3.0 |
| **Chlorine** | **Cl** | 1.5 | 2.0 | 2.5 | 3.0 |
| **Boron** | **B** | 0.4 | 0.5 | 0.6 | 0.7 |
| **Zinc** | **Zn** | 0.3 | 0.4 | 0.5 | 0.6 |
| **Copper** | **Cu** | 0.12 | 0.16 | 0.20 | 0.24 |
| **Molybdenum** | **Mo** | 0.024 | 0.032 | 0.04 | 0.048 |

a.Nutrient quantities are given on a 100% dry matter basis, (ton/acre×2.24=Mg/ha, and lb/acre×1.12=kg/ha

Source: Meyer, R. D.; Marcum, D. B.; Orloff, S. B.; Schimierer, J. L. 2007. "Alfalfa fertilization strategies". IN C. G. Summers and D.H. Puntam, eds., Irrigated alfalfa management for Mediterranean and Desert zones. Chapter 6. Oakland: University of California Agriculture and Natural Resources Publication 8292. See: htttp://alfalfa.ucdavis.edu/IrrigatedAlfalfa.

# N

## Deficiency symptoms

Include stunted plants and yellowish leaves. Nitrogen deficiency symptoms manifest shortly after planting, when seedlings reach 4-8in in height. The most common cause of nitrogen deficiency is poor inoculation and nodule formation. Deficient plants are scattered among taller, dark-green plants.
**Excessive soil nitrogen** levels can reduce N fixation by rhizobia in the root nodules.

## Application

Alfalfa obtains N from the atmosphere through a symbiotic relationship with rhizobia bacteria in the root nodules. Thus, N fertilization of alfalfa is seldom beneficial or profitable.

## Starter nitrogen

N fertilizer applications at planting are generally unrecommended, as they are rarely cost-effective, can encourage weed growth, and may delay nodulation. After planting, N-fixing nodules may require several weeks to develop, and N fixation before the first cut is generally low. During this period, the seedlings benefit from soil and fertilizer N. Typically, however, residual soil N is sufficient to supply the required N before significant N fixation occurs. Under very cold conditions, in N-depleted or stressed soils, small applications of starter N may aid in seedling establishment. In addition, N applied in a band together with P can increase P uptake.
A starter N application of 20-40 lbs/acre (22.4-44.8 kg/Ha) may be beneficial when the residual nitrate concentration is below 3-4ppm $NO_3$-N (15ppm $NO_3$). Applying larger amounts of N, however, may inhibit the bacterial colonization of the root system and thus reduce N fixation.
Generally, N applications after stand establishment are only effective when nodulation and N fixation are limited. Situations in which N fixation may be insufficient include low soil Ph (<6.3), waterlogged or compacted soils, cold conditions, extremely shallow root zones, and molybdenum and/or cobalt deficiency. Fields without a history of alfalfa cultivation may also exhibit insufficient nodule formation. In all of these cases, adjusting the liming soil factor and re-inoculating the field with water-run inoculum applications to re-establish nodules may be more efficient than N fertilization.

# P

## Deficiency symptoms

Include stunted plants with small leaves. The leaves may turn a dark blue-green. In addition, leaflets may fold together, and their undersides and stems may turn red or purplish. Adequate P availability has a beneficial effect on the number of rhizobia nodules, resulting in larger nodule size and better N fixation. In acidic or alkaline soils, P availability is greatly reduced. In these conditions, soil P availability is improved better by adjusting soil pH than by applying large amounts of P fertilizer.

## Starter phosphorus

To establish a successful alfalfa stand, it is necessary to start with proper phosphorus levels. Small amounts of P and N are commonly applied at planting. Adequate P is essential for promoting strong roots, while N can enhance P uptake. The application rate should be based on soil P and N test values. As a rule, apply $P_2O_5$ at 60 lbs/acre (67.3 kg/ha) when soil P availability is low, and 30 lbs/acre (33.6 kg/ha) when soil testing is adequate. For the roots to have easy access to the starter fertilizer, it is best to place it 2in below the seed. The specific P fertilizer is chosen according to availability, application preferences, and cost per unit. As a pre-plant fertilizer, any good-quality phosphorus source can be used. Phosphorous for application through a drip system should be soluble, with minimum reaction with cations such as Ca and Mg.

## Phosphoric acid ($H_3PO_4$)

Is effective for high soil or water pH, but expensive. When using it, be aware of high Ca and Mg levels in the water, as these may react, potentially resulting in chemical precipitation and clogging the drip irrigation system – which could damage water supply. Mineral precipitation occurs when metal ions such as $Al^{3+}$ and $Fe^{3+}$ (dominant in acidic soils) and $Ca^{2+}$ (dominant in calcareous soils) react with phosphate ions in the soil solution to form Al-, Fe-, or Ca phosphates. This process is slow, but the change is permanent. The dissolution of these metal phosphates can release phosphorus into soil solutions, but the rate of release is very low.

Application rate: Generally, the preplant P application rate should be based on soil test results, while the P status of established alfalfa stands is best assessed via plant tissue testing. Approximately 12 lbs/acre (13.5 kg/Ha]) of $P_2O_5$ are removed with each ton of alfalfa hay. Thus, a yield of 10 tons/acre removes approximately 120 lbs/acre (135 kg/ha) of $P_2O_5$ each year. When soil or tissue P values indicate adequate P availability, applying the amount of P removed at harvest will ensure that the soil's P status holds steady over the long term. For high soil or leaf P values, the application rate can be reduced, while for low values it should be increased (according to the soil P test). When plant tissue or soil testing indicates P deficiency, 15 to 22.5 lbs/acre (16.8-25.2 kg/ha) of $P_2O_5$ per ton of alfalfa harvested may be required. To maintain the P status of alkaline soils, more P needs to be applied than is removed by crop uptake, as P can be immobilized in the form of calcium phosphate ($Ca_3(PO_4)_2$).

## Application timing

In fall planted alfalfa, preplant P applications have been found to produce a higher yield during the first year after planting than P applications the following spring. In established stands, while P can be applied at any time of year, winter applications are preferable, as it may take 60-90 days until the alfalfa visibly responds. A single application of $P_2O_5$ should not exceed 100-150lb/acre (112-168kg/Ha). If higher application rates are needed, it is best to use half of the fertilizer in late fall and winter, and the other half after the second or third cutting. It is possible to maintain soil P for alfalfa with either small applications throughout the year or large one-time applications for a multiyear crop rotation.

# K

## Deficiency symptoms

Normally include circular, pinhead-sized spots along the leaflet margins, especially near the tips. Spots are more common on upper leaves, while the tips and margins of more mature leaves turn yellow and the tissue dies.
Excess symptoms normally result from very high soil K availability, which may cause excessive uptake. This is of little concern for alfalfa production. The excess K may cause milk fever in dairy cows fed with high-K diets during the dry period before calving, as it may reduce calcium absorption and mobilization.
Preplant K is best utilized in the top 2-4in of the soil profile. In established stands, K can be applied on the soil surface. KCl is the most economic K fertilizer. If sulfur is also deficient, potassium sulfate ($K_2SO_4$) can be used as well.

## Application rate:

The preplant K application rate should be based on soil test results, while the K status of established alfalfa stands is best assessed via plant tissue testing. Approximately 48 lbs-$K_2O$/acre (53.8 kg/ha) are removed with each ton of alfalfa hay. Thus, a yield of 10 tons/acre will remove about 480 lbs/acre (538 kg/ha) of $K_2O$ each year. When soil or tissue K values suggest adequate K availability, applying the amount of K removed at harvest will ensure that the soil's K status holds steady over the long term. For high soil or leaf K values, the application rate can be reduced, while for low values it should be increased (according to soil K test). When plant tissue or soil tests indicate K deficiency, up to 50 lbs/acre (56 kg/ha) of $K_2O$ per ton of alfalfa harvested may be required.

## Application timing:

Potassium can be applied anytime during the year, but winter applications are preferable. When K requirements are high, applications should be split: for $K_2O$ applications over 200-300 lbs/acre (224-336 kg/ha), half of the fertilizer can be applied in late fall and winter, with the other half applied after the second or third cutting.

# Fe

**Iron.**
Iron deficiency in alfalfa is very rarely observed visually, and the best way to determine it is through tissue testing. Deficiency is associated with high pH or poorly-drained soils with high levels of lime. The visual symptoms of iron deficiency are white or canary-yellow colored plants.

B Mo

## Boron and Molybdenum.

Alfalfa is boron-tolerant. When your rotation includes boron-sensitive crops such as cereals, boron should be applied in low doses through drip irrigation. Otherwise, boron is typically applied as a granular product, either by air or through the small seed box in a grain drill. Some forms can be applied in liquid form together with herbicides. Make sure the boron and herbicide are compatible before mixing them.

Molybdenum deficiency is uncommon in alfalfa. Symptoms are similar to those of nitrogen and sulfur deficiency, with stunted, light-green or yellow plants. Tissue testing should be used to determine whether boron or molybdenum deficiency is present. Both boron and molybdenum are available in soluble form, which can be applied through the drip system or as a foliar spray.

Ca Mg

## Calcium and Magnesium .

In general, alfalfa doesn't tend to have calcium or magnesium deficiencies. Prior to planting, it is important to adjust the soil levels of these nutrients. Gypsum and magnesium sulphate are good sources.

Alkaline water and soil typically contain more calcium and magnesium than potassium. Thus, paying attention to K levels is necessary even if soil analysis indicates adequate potassium.

S

## Sulfur.

Deficiency symptoms include stunting and light-green or yellow leaf color. These symptoms can also indicate nitrogen or molybdenum deficiency. The only way to know which deficiency is involved is through tissue testing (soil testing will not provide reliable results). It is important to have adequate levels of available sulfate-sulfur in the soil at planting.

There are two types of sulfur fertilizer: long-term slowly-available elemental sulfur, and short-term rapidly available sulfate. The most economic practice is to apply 200-300 lbs/acre (224-336 kg/ha) of elemental sulfur before planting. Elemental sulfur is gradually transformed into the sulfate form, which can last in the soil for 3-5 years or longer. To ensure a long, slow release, the sulfur's particle size should range from 10 percent 100-mesh to 60 percent 6-mesh. The finer 100-mesh particles will convert into sulfate faster than the larger particles. After the crop is established, tissue testing must be done to check for sulfur deficiency, in which case sulfur can be applied through the drip system.

# Metzer's
# **flagship products**

## for Alfalfa irrigation

## Metzer SDI
### Exclusive technology for ideal results

Metzer's patented **RootGuard Band** solves one of the most persistent problems of SDI application: root intrusion into the drippers.
Backed with a multi-year guarantee, RootGuard Band prevents root intrusion for the entire lifespan of the drip line, with no need for chemical injections – thus minimizing cost for the grower and environmental impact. Ask your Metzer representative for details.

**Metzer's Assif RootGuard** is PC dripper developed specifically for SDI.
Featuring an Anti-Siphon mechanism, this dripper maintains full uniformity in uneven terrain and long laterals, preventing dirt suction into the dripper.
Combined with RootGuard Band, Assif RootGuard grants you peace of mind against root intrusion for years, assuring accurate operation and quick ROI on your drip system.

# Metzer CleanLine

The only solution that provides dual protection

## 01

With Metzer's CleanLine solution, pipes and drip lines are protected from clingy biofilm formation when using water with high organic content such as treated wastewater. This prevents clogging, and provides longer lifetime for any irrigation system, while at the same time achieving optimum yields.

## 02

Metzer CleanLine consists of two protective layers. The first includes an active ingredient that prevents bacteria from settling on the pipe wall, without affecting water quality. The second is a slippery coating that physically prevents buildup.

## 03

This revolutionary product is environmentally friendly, and decreases the use of harmful pipe-cleaning chemicals such as chlorine and hydrogen peroxide.
**Metzer CleanLine is also financially beneficial, cutting costs on maintenance, additives, pumping energy, and system wear-and-tear.**

**CleanLine Double Protection**

Regular PE Pipe

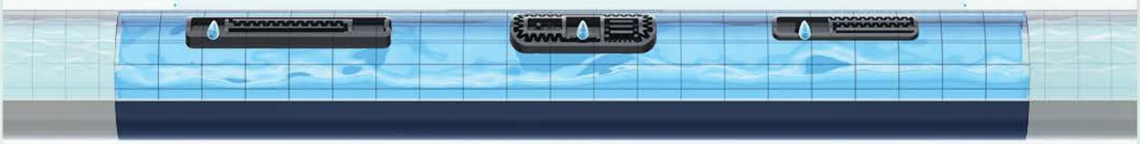
# Metzer Products for Alfalfa

## Thin wall drip
### for single/dual season use

Drip laterals with a wall thickness of 6-8mil (0.15-0.2mm). Used for one or two irrigation seasons, and then replaced. This method allows for low initial investment, and is primarily used for small-to-midsized areas with flat topography and short-term-lease lands.

**Flat integral drippers**
Injection-molded drippers with
low CV and high uniformity.
Excellent clog-resistance for reliable use.

**Lin** | **Mini Lin** | **Micro Lin**

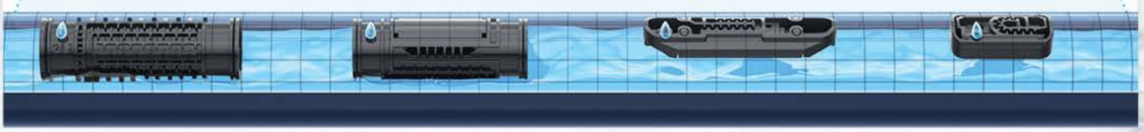


## Heavy duty drip
### for multi-seasonal use

Drip lines with 0.9mm wall thickness. Used aboveground for multiple years. The line is laid out at the start of the season and re-coiled when the season's over.
Using Pressure Compensated (PC) drippers allows for long laterals and irrigation on sloped terrain, while maintaining full uniformity.
Suitable for medium-to-large farms, this method requires higher initial investment and operational involvement, but offers higher returns over long years of operation.

High uniformity with excellent
clogging resistance, ensuring
reliable use for many years.

**Idit** Non-PC cylindrical Dripper | **Adi** PC Cylindrical Dripper | **Vered** Flat PC Dripper | **Assif** Flat PC Dripper



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