A3681

Alfalfa Germination & Growth

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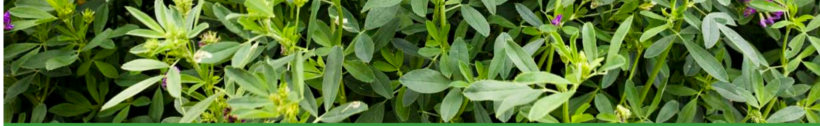


Contents

Knowing how alfalfa germinates will help producers create conditions necessary for good stand establishment. Knowing how seedlings develop will be useful in determining when to control diseases, insects, and weeds. Understanding patterns of growth—spring green-up and growth after cutting—will aid in identifying winter injury and disease problems, and in managing weeds. And being familiar with the mature stages of alfalfa growth will be helpful when making decisions about when to cut in order to ensure the maximum yield of forage of the quality required.

Basics of alfalfa growth

Alfalfa growth is driven by photosynthesis, a process that captures the sun's energy and converts it into chemical energy. Glucose sugar is the primary chemical energy product of photosynthesis. Glucose combines with other nutrient elements to provide all the components needed for alfalfa growth.

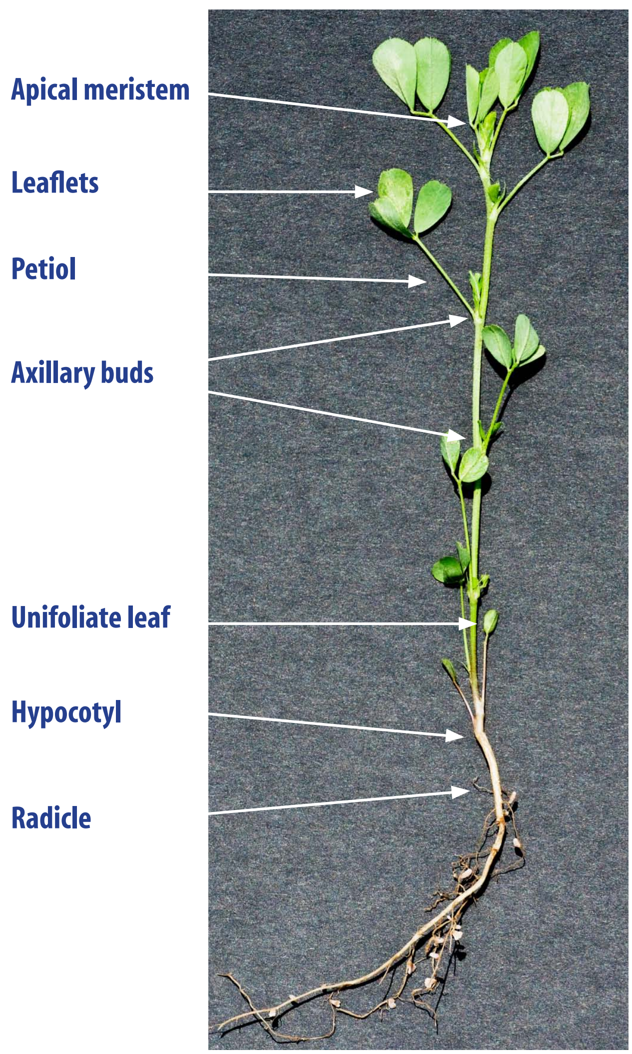
Alfalfa requires nitrogen, phosphorus, potassium, sulfur, calcium, magnesium, iron, boron, manganese, zinc, copper, molybdenum, and a few other micronutrients for growth. These nutrients, along with water, are absorbed by the root from the soil. Also, some trace minerals may be taken up through the leaves if they are applied foliarly. Part of the nitrogen needed for growth is obtained from bacterial nitrogen fixation in the root nodules if soil pH is sufficiently high (6.5 or more).

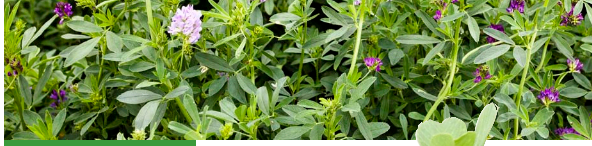
Living cells extract energy from glucose through a process called respiration. For alfalfa to have sustained growth, glucose production by photosynthesis must be greater than glucose use by respiration.

Alfalfa cells divide to produce new cells at the tips of stems and roots in tissue known as the apical meristem. Below the apical meristem of the stem, cells of the stems (but not the leaves) develop thicker walls which contain more lignin and are less digestible. Consequently, the oldest and least digestible part of the alfalfa stem is at the bottom, while the youngest and most digestible part is at the top.

At points where leaf petioles and stem branches attach to the stem are axillary buds (see figure 1). Axillary buds contain meristematic (growing) tissue which can develop into leaves, stem branches, or new stems. Axillary buds generally remain inactive until the apical meristem begins producing flower buds or is removed. Alfalfa cut high may regrow from axillary buds rather than from crown buds, which generally means yield will be reduced because of the excessive forage left in the field as a result of cutting the alfalfa higher.

Figure 1. The parts of an alfalfa plant.





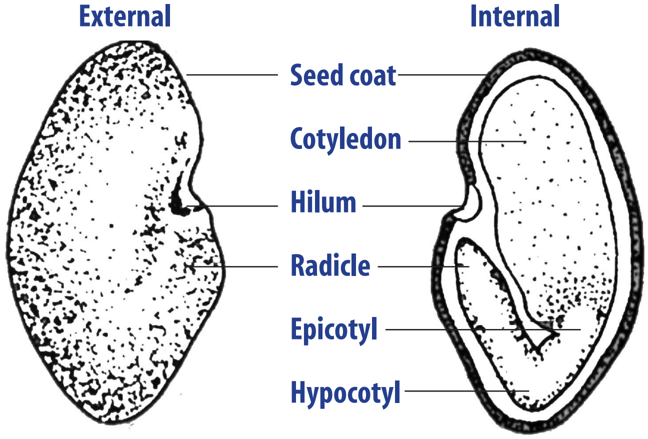
The seed

Alfalfa seeds are generally kidney shaped, small (2/32 by 1/32 by 1/32 inch, with about 225,000 seeds to a pound), and yellow-brown to olive green in color. The seed consists of two cotyledons (embryonic leaves), a radicle (embryonic root), a hypocotyl (the area of radicle just below the cotyledons), and an epicotyl (embryonic stem). All of these embryonic plant parts are surrounded by a protective seed coat (see figure 2). Carbohydrates, proteins, and fats stored in the cotyledons supply the energy needed during germination until the true leaves begin photosynthesis. The radicle becomes the primary root and is the initial anchoring and absorption structure during alfalfa emergence. The epicotyl is the growing point (where the meristematic tissue is located) of the future stem and is protected between the two cotyledons until the cotyledons are above ground and separate. The scar tissue on the seed coat, known as the hilum, is the previous point of attachment of the seed to the pod.

Sometimes an alfalfa seed may have a coat not permeable to water, and this is known as a "hard seed." A hard seed can lie dormant in the soil for several weeks or years before germinating. Hard seed percentage is noted on the seed tag and is included in the total germination calculation. Most hard seed germinates within 30 to 60 days of planting. Alfalfa hard seed cannot be depended upon to thicken a thin stand.

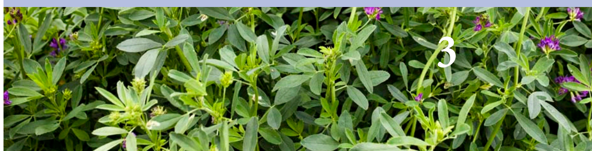
Several kinds of coatings—for example, fungicide, *Rhizobium* bacteria, nutrients, lime, or clay—may be applied to the seed as it is processed and prepared for marketing. In general, these seed coatings have no effect on seed quality but are placed on the seed to aid growth and development after planting.

Figure 2. **Alfalfa seed, external and internal views.**



Management tips

- **Store seed at cool temperatures and in low humidity.** Many precautions are taken by the alfalfa seed industry to ensure that the purchaser receives very high-quality, weed-free seed. Decline in seed quality on the farm can be slowed by storing seed in a cool, dry place.
- **Re-inoculate with Rhizobium bacteria if stored beyond expiration date.** Alfalfa is generally inoculated with *Rhizobium* (a bacteria responsible for nitrogen fixation) during seed processing. How long *Rhizobium* will live depends on environmental conditions during seed storage. Preinoculated seed stored beyond the *Rhizobium* expiration date (printed on the seed bag label) should be inoculated again with fresh *Rhizobium* before planting.



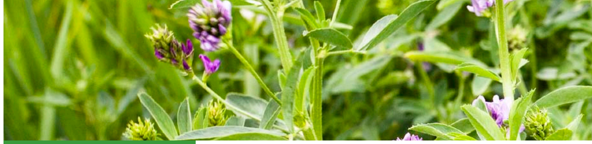
Germination & emergence

Alfalfa seeds begin to germinate after absorbing about 125 percent of their weight in water and swelling to break the seed coat (see figure 3). Alfalfa can germinate at temperatures greater than 37°F but optimum germination temperature is between 65 and 77°F. As soil warms, the rate of germination increases because of increased water movement into the seed and because of increases in the rate of other metabolic activities associated with germination.

Germination begins with the radicle (young root) emerging through the seed coat near the hilum (see figure 4) and anchoring itself in the soil as an unbranched tap root (see figure 5).

Figure 3. The seed on the right is swollen with water taken up from the soil. This condition marks the first step in seed germination. Under favorable conditions, water uptake begins within 24 to 48 hours after planting.

Figure 4. The first part of the seedling to emerge is the root radicle. The radicle anchors the seedling in the soil and always grows downward, regardless of the direction it is pointing when it first comes out of the seed.



GROWING ALFALFA

Supplying the right conditions will help to assure maximum germination. Prepare a firm, weed-free seedbed to minimize competition from weeds and to ensure good seed-to-soil contact. Avoid overworking the soil surface, as rainfall following seeding may crust the surface, preventing seedling emergence.

Management tips

- **Optimize seed-to-soil contact.** Poor seed-to-soil contact restricts water movement from the soil to the seed and causes poor or sporadic germination. In conventionally tilled seedbeds, the best seed-to-soil contact is achieved when the seedbed is free of clods and when press wheels or a cultipacker are used to press the soil onto the seed. Many no-till alfalfa plantings fail because they are done when the soil is too wet and the seed furrow does not close, resulting in poor seed-to-soil contact.
- **Plant no deeper than ½ inch.** Seeding alfalfa at depths greater than ½ inch makes it difficult or impossible for the hypocotyl to pull the cotyledons above ground, especially in heavy-textured soils. Alfalfa seedlings that do emerge from deeper than ½ inch usually are weaker because of greater energy expenditure during emergence. A firm seedbed is extremely helpful in regulating and maintaining seeding depth. If seed is drilled and no seeds are visible on the surface after planting, it is likely that the seed was planted too deep.

As the radicle tip grows deeper into the soil, the hypocotyl elongates and pulls the cotyledons and epicotyl (growing point) above the soil surface. As the cotyledons emerge above the soil surface, the seed coat falls off and cotyledons open to expose the epicotyl.

Management tips

- **Avoid planting outside recommended planting window.** Planting too early will reduce the germination rate and increase the likelihood of disease infecting the crop. Also, a few hours of air temperatures of 24°F or lower can kill an alfalfa seedling when the second trifoliolate leaf has just emerged.
- **Provide adequate levels of nutrients.** Adequate levels of nutrients are important for alfalfa shoot and root development. Nutrient levels are especially important during early seedling establishment to ensure a root system large enough to support maximum herbage growth for the life of the plant.
- **Minimize risk of soil crusting.** Soils that crust easily create an additional problem during alfalfa emergence. The germinated seed will die if the elongating hypocotyl cannot penetrate this crusted soil and pull the cotyledons above the soil surface. Excessive tillage can increase the potential for crusting. Rain, irrigation or light tillage may be required to soften or break the crusted layer.
- **Don't plant alfalfa into established alfalfa fields.** Established alfalfa plants release a compound into the soil that reduces germination and growth of new alfalfa seedlings, a phenomenon known as autotoxicity, or "self-toxicity." The extent of autotoxicity in a field depends on the amount of alfalfa residue in the soil, how long since the previous stand of alfalfa was killed, soil type, amount of rain or irrigation prior to the seeding of the new crop, soil temperature, and other factors. At high autotoxicity, alfalfa germination will be inhibited; at somewhat lower autotoxicity, seed will germinate but plants will be stunted and never yield well. To avoid alfalfa autotoxicity in medium to heavy soils, plow under or chemically kill an established alfalfa field, then grow a crop other than alfalfa for one season or, preferably, two seasons. This also will help reduce disease and insect populations that may have developed in the original alfalfa field.

Figure 5. **As the radicle grows, the portion nearest the seed enlarges and forms a hook. It pushes up through the soil surface, dragging the cotyledons and seed coat with it. Once the seedling emerges above ground and is exposed to light, it straightens out. At the same time, small root hairs are developing on the lower radicle. The root hairs absorb water and nutrients from the soil.**

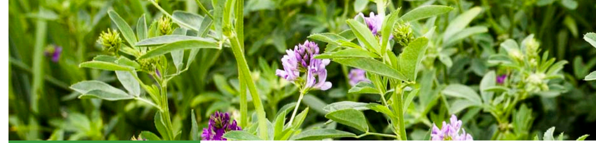
Seedling growth & establishment

The establishment phase is the period between seedling emergence and first harvest. Cotyledons turn green after opening but have limited photosynthetic activity, for the energy stored in the cotelydons is quickly used up and they soon shrivel, turn brown, and die. The epicotyl produces the first leaf, which is a single leaflet (unifoliolate). The meristematic region of the epicotyl continues to grow, adding trifoliate leaves (three-leaflet leaves) or multifoliolate leaves (more than three leaflets per leaf) on alternate sides of the developing stem (see figures 7, 8, and 9).

While the epicotyl continues to add stem, leaves, and flowers, the bud in the axil of the unifoliolate leaf begins to grow and form a secondary stem. Additional secondary stems develop from the axillary buds at the cotyledon nodes (the points where cotyledons attach to the stem). Temperatures of 68 to 85˚F during early seedling development are optimum for growth and development; however, as the seedling continues to develop, slightly cooler temperatures (60 to 75˚F) are ideal.

Figure 6. Cotyledons are usually the first visible portion of an alfalfa seedling as they emerge above the soil surface.

Figure 7. The first true leaf to develop on an alfalfa seedling has just one leaflet and is called the unifoliate leaf.



GROWING ALFALFA

Young seedlings are particularly vulnerable to diseases and herbicide damage. As the seedlings mature they become more resistant to seedling diseases and less susceptible to herbicide damage. Many herbicides have application restrictions until a specific growth stage is reached. It is important to be able recognize each growth stage so you can apply treatments at the correct time.

Management tips

- **Minimize risks of seedling diseases.** Soil moisture is necessary for nutrient absorption by the roots and for rapid seedling development, but excessive soil moisture can stop root growth. Wet soil conditions also can lead to fungal diseases such as *Pythium* (damping off), *Phytophthora* (root rot), *Aphanomyces* (damping off), and *Rhizoctonia* (stem and root canker). Seed-applied fungicides can reduce the incidence of these diseases, but planting in well-drained soils can do the same.
- **Ensure that there are adequate amounts of *Rhizobium* in the soil.** *Rhizobium* bacteria may not be present if alfalfa has not been grown recently in the field or if soil pH is low. Once pH is corrected, use preinoculated alfalfa seed or inoculate the seed with live *Rhizobium* prior to planting in order to provide adequate bacteria. In general, inoculation is an inexpensive way of ensuring that adequate *Rhizobium* bacteria are present.
- **Optimize nitrogen-fixing potential.** Low soil pH (below 6.5) limits nodulation and the availability of molybdenum, which is essential in the nitrogen fixation process. Apply lime if a soil test indicates low pH.

Management tips

- **Control weeds during the first 60 days to prevent stand loss.** Weeds in establishing stands may out-compete and shade young alfalfa plants, thinning the stand. All weeds should be controlled in new seedings, both spring and fall. Herbicides should generally be applied as early as alfalfa will tolerate the herbicide. If, for example, five leaflets are required before the herbicide should be used, this means five trifoliate leaflets (not counting the unifoliate leaf) must be visible, with each of the leaflets expanded so they are not touching each other (see figure 10).
- **When to harvest a new seeding.** New plantings should not be harvested until sufficient carbohydrates have been stored in the roots to support rapid regrowth. Depending on growing conditions, this generally occurs around 60 days after emergence. Delaying harvesting beyond 60 days generally does not improve regrowth and may dramatically reduce forage quality.

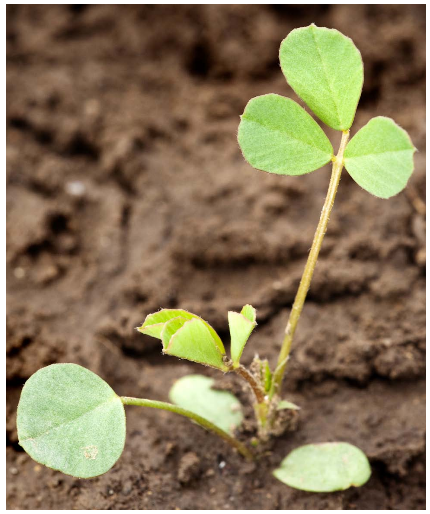


Figure 8. **The second leaf to appear has three leaflets. This is called a trifoliate leaf. Most subsequent leaves are trifoliate, although some varieties produce leaves with four or more leaflets per leaf, and these are called multifoliate leaves.**

Figure 9. **This plant is at the two-leaf stage. Note the two trifoliate leaves in addition to the unifoliate leaf. At this stage, the seedling can manufacture all of its energy through photosynthesis.**

Figure 10. **Counting only the fully expanded trifoliate leaves reveals that this plant is at the five-leaf stage. A leaf is considered fully expanded when the outer edges of all leaflets are no longer touching.**

The radicle tip continues to grow deeper into the soil. The hypocotyl and upper portion of the radicle begin contractile growth, a process in which these organs enlarge laterally and contract vertically.

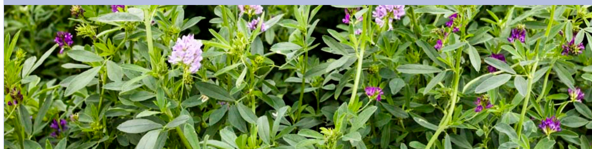
Figure 11. **Within four weeks after germination, if *Rhizobium* bacteria are present, round structures called nodules will form on alfalfa roots. The bacteria help the plant use nitrogen from the air in a process known as nitrogen fixation.**

The radicle begins to thicken and develop into the primary taproot (see figure 13). At the same time, smaller secondary roots begin to develop on the radicle as it grows deeper. The location and extent of secondary root formation is genetically regulated. Root growth during establishment is generally about 80 percent of herbage growth. That is, for every ounce of herbage growth, there is 0.8 ounce of root growth. However, under hot temperatures (greater than 90°F), root growth may drop to 40 percent of herbage growth.

Within four weeks after germination, root hairs on the radicle become infected with the nitrogen fixing bacteria *Rhizobium meliloti,* and begin to form the nodules (see figure 11) where atmospheric nitrogen fixation occurs. The rate of *Rhizobium* infection depends on the soil nitrogen content and the rate of seedling growth. Only *Rhizobium meliloti* bacteria will infect alfalfa root hairs. *Rhizobium* bacteria that infect other legumes (e.g. soybeans) are incapable of infecting alfalfa, and *Rhizobium meliloti* is incapable of infecting other legumes. Only about 5 percent of the alfalfa root hairs become infected, and only about 30 percent of these infections result in nodule formation, regardless of the quantity of *Rhizobium* present.

Management tips

- **Ensure that soil pH and fertility is optimum for nitrogen fixing.** Low soil pH (below 6.5) limits nodulation and the availability of molybdenum, which is essential in the nitrogen fixation process.
- **Factors reducing nitrogen fixation.** Waterlogged soils inhibit oxygen and nitrogen movement to the roots and nodules. Harvesting alfalfa herbage will cause nitrogen fixation to decline until herbage regrowth is adequate to supply the nodules with sugars (energy) from photosynthesis.



Crown formation and development

Contractile growth (that pulls the lowermost buds below ground to form a crown) begins as early as one week after emergence and is usually complete within 16 weeks. Contractile growth pulls the axillary buds below the soil and forms the crown (area between the soil surface and the cotyledonary nodes). Alfalfa varieties with greater fall dormancy tend to have more pronounced contractile growth than those with less dormancy: their nodes are pulled farther below the soil surface. Plants with deep crowns tend to be more persistent than plants with shallow crowns because they have increased soil protection from extremely cold air temperatures. Axillary buds that are pulled below the soil surface during contractile growth are referred to as crown buds.

Figure 12. Crown development has not yet begun on these young plants. The cotyledons, though brown, are still present. Note the distance between the nodes on the plants in this picture compared to the distance between nodes on the plant in figure 13.

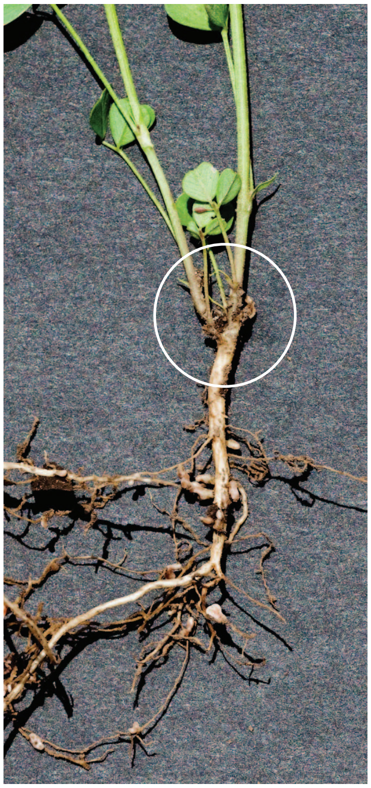


Figure 13. The lowermost buds have been pulled below ground to form the crown. Crown development on this plant is already sufficient for winter survival. The crown will continue to enlarge throughout the life of the plant.

Management tips

- **To allow enough time for crown development,** avoid seeding after the recommended late-summer planting dates. Plants that have not formed a crown will not survive the winter. Following contractile growth, alfalfa stems may be frosted but the plant can survive freezing air temperatures because the crown buds are protected below the soil surface. Planting later than recommended reduces the probability of having a successful yield, for the crop will face higher temperatures, more soil drying, and more weed problems. Summer-seeded alfalfa generally needs a minimum of six weeks of growth after emergence to survive winter without injury and to produce maximum yields the following year.

  Even brief exposures to air temperatures below 27˚ F will kill young alfalfa seedlings. Alfalfa plants survive cold temperatures by pulling the lowermost buds below ground to form a crown.

Vegetative stage

During early vegetative growth in the spring or after harvest, the alfalfa has insufficient leaf area to produce enough energy, purely through photosynthesis, to support growth. Energy for early regrowth comes from carbohydrates and other nutrients stored in the root and crown. Once vegetative growth has attained about 8 inches of height, leaf area and photosynthesis have increased enough to supply adequate energy for continued growth and to begin replenishing the root and crown reserves.

Alfalfa growth in the spring is predominantly from crown buds and depends on temperature (see figure 14).

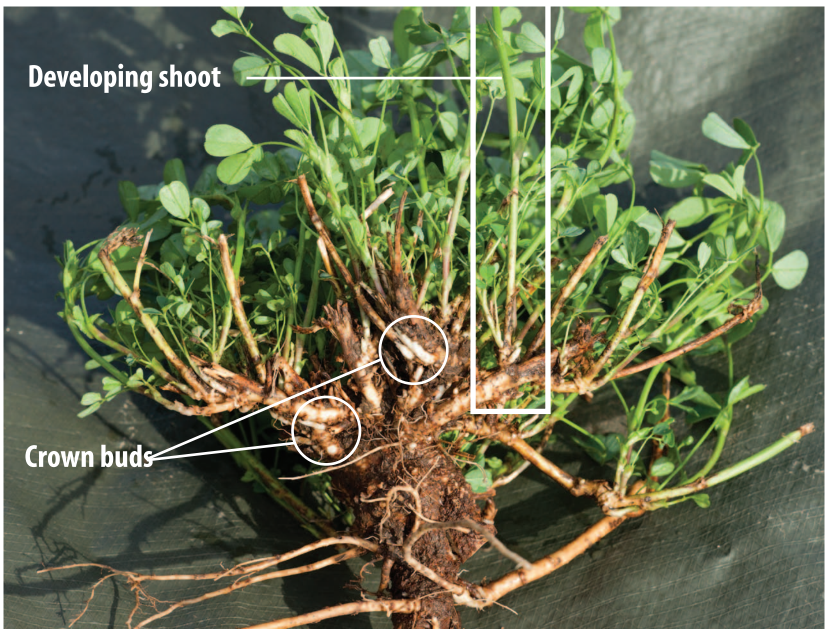
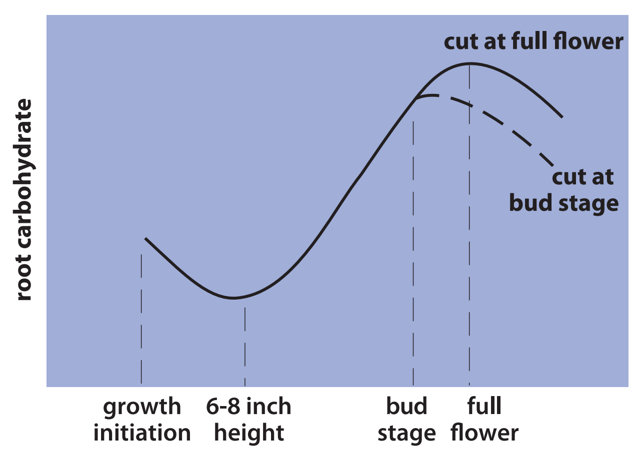


Figure 14. This well-developed crown shows healthy crown buds growing to produce the season's first cutting.

Spring green-up

Spring growth ideally comes from crown buds formed the previous year during late summer and fall. Green-up occurs when the buds located on the crown begin to grow in response to warm spring temperatures. In addition to weather, the timing of spring green-up depends on plant health, the genetic fall dormancy of the variety, and the amount of dormancy developed in the plants during the fall (determined by fall weather conditions). If plants are injured or slow to green up, consider planting more winter-hardy varieties.

Figure 15. Carbohydrate content of alfalfa roots.



Growth after cutting

Regrowth after harvest is primarily from crown buds (figure 14) but may also come from axillary buds if cutting is high. The number of stems that develop from either axillary or crown buds depends on the variety, the developmental stage at the time of harvest, the health of the crown, and the cutting height.

Environmental conditions play an important role in determining the rate and amount of vegetative growth. The maximum number of stems on a plant is set within 14 days after harvest and declines as the plant matures. Drought or flooding stress during the first 14 days after harvest can greatly reduce the number of stems a plant will produce in that regrowth period. Drought reduces stem growth more than leaf growth, causing shortened plants that are low-yielding but generally high in quality because of increased leaf-to-stem ratio.

Immediately after harvest, alfalfa regrowth is fastest when temperatures are 85 to 90˚F. However, as alfalfa growth continues, maximum growth rate occurs when temperatures are between 50 and 80˚F. Leaf-to-stem ratio declines as the plant matures within each regrowth period. Leaf-to-stem ratio is less for growth in spring than in midsummer. The warmer temperatures and longer days of summer cause more rapid plant development and greater cell wall lignification than occurs in the cooler temperatures and shorter days of spring.

Alfalfa yield is determined by the number of stems in a given land area and the weight of each stem. The maximum number of stems per plant and the weight of each stem are determined during the period of vegetative development. Consequently, it is important that pH, fertility, moisture, and pests be carefully controlled during this period.

Figure 16 and 17. Regrowth after cutting arises primarily from crown buds, and also from axillary buds if forage is cut high. Axillary buds occur wherever a leaf petiol attaches to the stem.

Management tips

- **The ideal cutting height is at least 2 inches** above the soil surface (3 to 4 inches if a grass is mixed with the alfalfa).
- **Maximize stem density.** Short cutting intervals (less than 35 days) will reduce the number of axillary buds. Moisture stress immediately after cutting will reduce the number of crown and axillary buds and therefore will reduce stem density and yield, even if rain occurs later in the growth cycle.

Winter hardening and winter survival

Shortening days and declining temperatures in the fall can cause some alfalfa varieties to change their vegetative growth pattern. Stem growth in the fall serves as the basis for assigning varieties a relative fall dormancy rating. A fall dormancy of 1 indicates the greatest fall dormancy and least height of fall growth, while a rating of 11 indicates the least fall dormancy and greatest height of fall growth. Usually, the more fall-dormant the variety, the slower it regrows after harvest but the better it survives adverse winter conditions.

Figure 18. The plant on the left has suffered winter injury while the plant on the right has not. Injured plants become less vigorous and are slow to recover.

During the fall, dormant varieties alter their chemical processes to prepare for winter survival. Some of the starch in the crown and root is converted into sugars that function as antifreeze and help keep the crown, crown buds, and root from freezing at temperatures well below 32˚F. Crown buds, which will be the source of growth the following spring, are formed during the fall.

Dormant alfalfa varieties can survive temperatures of about 5˚F after they have been prepared for winter survival by having had at least two weeks of temperatures alternating between near-freezing nights and 60˚F days. Plant tissue below the soil surface is insulated from cold air temperatures by soil and layers of snow. When there is no snow cover, extremely cold air temperatures can cause the soil temperature to drop below 5˚F. This will injure or possibly kill the alfalfa plant.

Figure 19. If crown buds have been killed, the plant must form new buds to replace them. The taller shoots are from buds that survived the winter, the lower layer of shoots are from spring-formed buds.

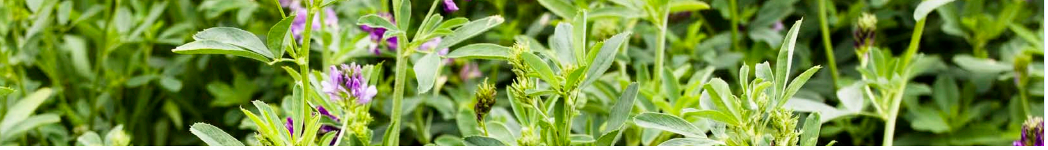
GROWING ALFALFA

When to cut

Management tips

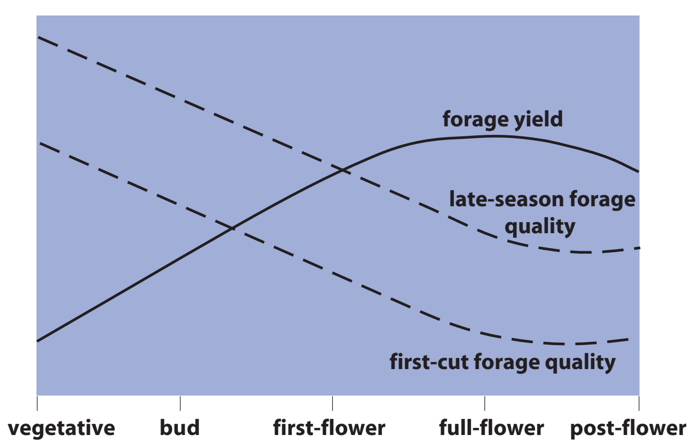
When to cut for hay or haylage. Forage yield, quality, and stand persistence are affected by the cutting schedule chosen. Forage yield increases until the plant reaches full flower, while forage quality decreases continually during growth. Cutting for high quality will reduce total season yield, so one must ensure that the high quality will produce a return to offset the yield loss. Early season growth may not flower normally and quality will decline if it doesn't. Therefore, using a forage quality stick (available from some state forage associations and some alfalfa seed marketing companies), or measuring forage height and plant stage (as described later), is crucial in determining when to do the first cutting in order to harvest alfalfa of the desired quality. The stage to cut alfalfa for optimum forage quality for dairy cattle ranges from the vegetative to early bud stage on first cutting and is generally at bud stage on later cuttings. Later stages may be harvested for animals with lower nutritional requirements.

- **Watch for pests.** Some insect pests feed on the alfalfa bud and flower. Excessive numbers of these insects in an alfalfa field can remove buds as they form, causing the casual observer to assume that the alfalfa has not begun to form buds. If initiation of alfalfa harvesting is based on plant development, then careful monitoring of insect populations and plant development is necessary.



- **Understand the risks of harvesting during the bud stage.** Alfalfa varieties developed in the past 10 years have greater disease resistance than older varieties. With adequate fertility and pest control, these newer varieties can survive aggressive harvest schedules better than older varieties. In addition, newer alfalfa varieties have been selected for rapid regrowth, which increases their yield potential. Faster regrowth is a result of decreased production of auxin (a plant hormone) during the flower bud stage, allowing earlier regrowth from crown buds. Harvesting during the flower bud stage provides relatively high forage quality, but continuously harvesting at this stage will result in low root carbohydrate reserves and stand decline. Alfalfa stands that are intended to remain in production for more than three years must be allowed to mature beyond the flower bud stage at least once during the season to replenish root reserves.
- **Forage yield, quality, and stand persistence are considerations when deciding when to cut.** Forage yield increases until the plant reaches full flower, while forage quality decreases continually during growth or regrowth (see figure 20). The optimum balance between yield and quality depends on the cutting and the forage quality desired. Early in the growing season, plants may not flower normally and quality may decline even though the plant is not flowering. This can be determined using a forage quality stick or by measuring plant height. Take later cuttings based on growth stage or time interval (35 to 45 days).
- **The stage to cut alfalfa for optimum yield and forage quality** for milking dairy cows ranges from the vegetative to early bud stage on the first cutting, to 10 percent flower on the second and third cuttings, to full flower on a late fall cutting. For animals with lower nutritional requirements, later stages may be harvested. The pictures on the following pages depict growth stages commonly referred to when discussing cutting management.

Figure 20. **Forage yield and quality at various stages of growth.**



Flowering process

Flower bud stage

The formation of a flower bud marks a major transition in alfalfa growth and development. Up to this point, the alfalfa plant has been using energy from photosynthesis to build a larger photosynthetic factory (more leaves) and to store energy in the crown and roots. When floral development begins, the plant shifts a large portion of its energy into flower production and, ultimately, seed production.

Alfalfa has an indeterminate growth pattern, meaning it continues to produce both leaves and stems along with reproductive (bud) structures. Because of this, it is possible to have a single alfalfa stem with newly emerged leaves, flower buds, flowers, and seedpods. Continued vegetative growth means the alfalfa crop will increase through the flower bud and early flower stage of development.

The onset of floral development is controlled primarily by temperature and photoperiod. In midsummer, flower buds may appear on alfalfa regrowth three weeks earlier than in the spring when temperatures are lower and the photoperiod shorter. Flower buds begin to appear at the 6th through 14^{th} node on the stem, depending on environmental and genetic factors. Flower bud formation usually begins at lower nodes in summer (6^{th} through 8^{th} nodes) than in spring. After the first flower bud appears, a new bud will appear about every three days until the stem is harvested or reaches maturity.

Early bud

Figure 21. The flowering process begins when small buds form in the top one or two leaf axils. These buds are detectable as small swellings in the axils of the leaves. Forage cut at this stage will be very high in quality. However, yield will be reduced. Cutting several times per season at this stage will decrease persistence.

Mid bud

Figure 22. At the mid bud stage, flower buds are larger and easier to detect. Some buds are beginning to lengthen. Additional buds are forming lower on the stem.

Late bud

Figure 23. At the late bud stage, flower buds are large and lengthening rapidly. Buds begin developing at three or more leaf axils lower on the stem.

The appearance of the first flower bud usually indicates that forage quality is beginning to rapidly decline (see figure 20). This decline is partly due to the loss of lower leaves when they are shaded by leaves higher on the stem, and partly due to continued thickening and lignification of cells in the stem. Some producers begin harvesting when buds first appear in order to avoid the rapid decline in quality thereafter. However, root carbohydrate reserves used to support early vegetative growth have not been fully replenished at the bud stage.

Flower stage

The length of time between when flower buds form and when flowers open depends on the environment, but is generally about five days. The flower stage is the interval between when the first flower opens and when a seedpod is formed. In the fall, when there are fewer than 12 hours of daylight, flower buds often wither and fall off without developing into flowers.

The alfalfa flower possesses both female (pistil) and male (stamen) structures. The flower petals (corolla) of alfalfa grown in the United States are usually some shade of purple because of *Medicago sativa* parentage (see figure 24). Yellow flowers show *falcata* parentage which indicates increased winter hardiness, though with less yield. However, alfalfa flower colors can vary from cream to yellow, to shades of blue-green, depending on the parentage of the plant (see figure 25).

Because alfalfa is largely self-incompatible and self-sterile, it is typically cross pollinated—pollen from one flower fertilizes the ovules of a flower on a different plant. For alfalfa to be pollinated the flower must be "tripped." That is, the stamen and pistil must be released from the keel petals (see figure 26). This "tripping" is usually caused by nectar- or pollen-collecting insects such as honeybees, alkali bees, and leaf-cutter bees. Alfalfa pollen is carried by insects, not wind. After tripping and pollination, pollen usually fertilizes the ovule within 24 to 32 hours. Each alfalfa flower has between 6 and 18 ovules in its ovary, each of which could become a seed. However, only 10 to 12 ovules usually develop.

Flowers generally do not progress to seed production in the fall.

Flower

Figure 24. **Alfalfa flowers grow in clusters attached to a stem (raceme). The most common flower color is purple. Purple flowering plants come from Mediterranean stock and have high yield and quick recovery. Plants with yellow flowers are from more winter-hardy stock. A small percentage of flowers may also be blue, cream, or white.**

Figure 25. **Most alfalfa has purple flowers but many other colors are possible.**

Figure 26. **Flower before tripping on right. Tripped flower on left.**

10 percent flower

Figure 27. At this stage, 10 percent of the stems have open flowers. Allowing one cutting per year to grow to this stage will improve stand persistence. Late-season harvests at this stage may still provide dairy-quality hay.

50 percent flower

Figure 28. Half of the stems have open flowers. Roots have the most carbohydrates stored at this stage. This is beyond the recommended harvest stage for quality hay.

100 percent flower

Figure 29. All stems now have open flowers. Shoots from crown buds for the next growth cycle may be visible at the base of the plant.

Seedpod stage

After the ovules have been fertilized, they begin to develop into seeds and stretch the ovary, which becomes the pod surrounding the seeds (see figure 30). The petals wither and fall off, exposing the green seedpod, which becomes brown with maturity. Alfalfa seed must develop for six to eight weeks in the pod before it will become viable seed.

Long days and low humidity favor flowering, pollination, and seed development. Too much or too little soil moisture will decrease seed yield. Minimum temperatures above 68˚ F favor seed production. Low temperatures during seed development tend to increase the percent of hard seed. In the United States, seed is produced primarily in California, Idaho, Nevada, Oregon, and Washington, states where humidity is low and rain scarce during the summer while seed is maturing and being harvested .

Figure 30. Alfalfa seedpods take many shapes, depending on the number of seeds they contain and the parentage of the plant, but most alfalfa varieties commonly found in the United States have seedpods that are spiral shaped.

Estimating preharvest alfalfa quality

Choose five representative 2-square-foot areas in the field. (Sample more times for fields larger than 30 acres.) In each area, determine the stage of the most mature stem (see below).Then measure the height of the tallest stem, NOT the highest leaf. Note that the tallest stem may not be the most mature stem. Use the chart to determine relative feed value of the standing alfalfa forage. This procedure does not account for changes in quality due to wilting, harvesting, and storage. These factors may lower relative feed value by 10 to 20 points.

late vegetative	stem is more than 12 inches tall, no visible buds or flowers
early bud	1 to 2 nodes have visible buds; no flowers or seed pods present
late bud	more than 2 nodes have visible buds; no open flowers or seed pods
early flower	1 node with at least one open flower
late flower	2 or more nodes have open flowers

	stage of most mature stem				
height of tallest stem (inches)	**late vegetative**	**early bud**	**late bud**	**early flower**	**late flower**
			relative feed value		
16	234	220	208	196	186
17	229	215	203	192	182
18	223	211	199	188	178
19	218	206	195	184	175
20	213	201	191	181	171
21	209	197	187	177	168
22	204	193	183	173	165
23	200	189	179	170	161
24	196	185	175	167	158
25	191	181	172	163	155
26	187	178	169	160	152
27	184	174	165	157	150
28	180	171	162	154	147
29	176	167	159	151	144
30	173	164	156	148	141
31	169	161	153	146	139
32	166	158	150	143	136
33	163	155	147	140	134
34	160	152	145	138	132
35	156	149	142	135	129
36	154	146	139	133	127
37	151	144	137	131	125
38	148	141	134	128	123
39	145	138	132	126	121
40	142	136	130	124	118

Dairy quality forage

Source: *Derived from equations developed by R.W. Hintz, V.N. Owens, and K.A. Albrecht at the University of Wisconsin-Madison, Department of Agronomy.*

SUMMARY

Management tips for optimum alfalfa growth and development

- Select alfalfa varieties with proven high-yield potential, disease resistance, and winter hardiness in your region.
- Get the soil tested, then fertilize and lime according to the soil test recommendation.
- Plant alfalfa in well-drained fields.
- Buy preinoculated seed, or inoculate your own seed.
- Plant less than ½ inch deep at an adequate rate for your area.
- Ensure good seed-to-soil contact by firming soil around seed with press wheels on drill or cultipacker.
- Control weeds, especially during first 60 days after seeding.
- Control insects.
- Apply needed nutrients annually, based on soil or tissue tests.
- Follow a harvest schedule which will provide forage of the required quality and will lead to the desired life expectancy of the alfalfa stand.

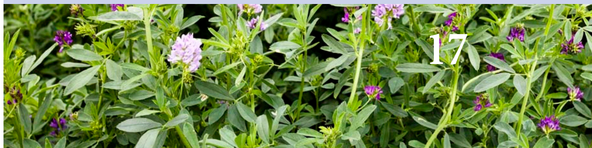
Additional information

The following publications are available from your county extension office.

Alfalfa Management Guide (NCR547)

Alfalfa Stand Assessment: Is This Stand Good Enough to Keep? (A3620)

Forage Variety Update for Wisconsin (A1525)



Glossary

Apical meristem—The meristem at the top of a shoot or tip of a root; here cells are produced that eventually become shoots, leaves, or buds.

Auxin—A plant hormone stimulating growth.

Axil—The upper angle between the petiole of a leaf and the stem from which it grows.

Axillary bud—The bud formed in the axil of a leaf.

Contractile growth—Growth in which the root cells contract vertically, pulling the cotyledonary nodes and their associated axillary buds below the soil surface to form the crown.

Cotyledons—Structures in seeds that contain concentrated amounts of proteins, oils, and carbohydrates to be used as energy sources during germination and emergence.

Crown—The area at the base of the stem with tightly packed nodes and internodes, which generate vegetative growth. The formation of the crown results from contractile growth pulling axillary buds on the first branches of a seedling below the soil surface. The crown is the area of meristematic activity.

Crown bud—The bud formed at the axillary site on the crown.

Epicotyl—The portion of the plant which is just above the cotyledons.

Fertilization—The union between the pollen grain and the ovule.

Hilum—Scar tissue on an alfalfa seed where the seed was attached to the pericarp (seedpod).

Hypocotyl—The portion of the plant which is just below the cotyledons.

Leaf—The plant organ borne by the stem, responsible for photosynthesis and gas exchange; comprised of the petiole, leaflets, and stipule.

Meristem—The area of dividing cells; undifferentiated tissue capable of differentiating into specialized tissue.

Node—The location on the stem where the leaf attaches.

Nodule—The site of nitrogen fixation, composed of a mass of root cells surrounding the *Rhizobium* bacteria.

Ovary—Located at the base of the pistil, it contains the ovules, and it will become the seedpod (pericarp) in legumes.

Ovule—A rudimentary seed before fertilization, containing the female egg cell.

Pedicel—A single branchlet which connects the flower bud, flower, or seedpod to the peduncle.

Pericarp—Wall of the ovary (seedpod) which encloses seeds.

Pistil—The female portion of a flower, consisting of the ovary, style, and stigma.

Pollination—Pollen coming in contact with the stigma.

Raceme—A type of flower where the floral structures are attached to the peduncle via a pedicel.

Regrowth—Vegetative bud and shoot elongation of new shoots either after the existing shoots are cut or after the shoots have begun to flower.

Rhizobium—Bacteria responsible for nitrogen fixation in legumes.

Stamen—The male portion of the flower, consisting of anther and filament.

Tripping—Release of the pistil and stamen from the fused keel petals, resulting in the rupture of the stigmata cuticle.

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