

# Irrigated Alfalfa Management

for Mediterranean and Desert Zones



## Weed Management in Alfalfa

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**W**eeds are serious economic pests of alfalfa. A variety of different weed species, including annuals and perennials, warm and cool season grasses and broad-leaf plants, and parasitic and poisonous plants, infest alfalfa hay grown throughout the arid alfalfa production regions of the West. Weeds in alfalfa directly compete for the same resources required for alfalfa growth and development: water, nutrients, light, and space. If weeds are left uncontrolled, they will reduce alfalfa yield and weaken or even destroy the stand, particularly if left unchecked during the seeding period (Table 8.1). Weeds have a large effect on forage quality. Establishment of a vigorous alfalfa stand is essential for long-term weed control. In older alfalfa fields, weeds are quick to fill in open spaces when stands decline. It is nearly impossible to control weeds in a thin or weak alfalfa stand.

Weeds affect alfalfa during two distinct periods: stand establishment and in established fields. Yield is sometimes reduced, but more often yield is the same or actually higher when weeds are not controlled. However, the feeding value of the hay is usually drastically reduced. For example, in one study, protein content was as low as 9 percent in hay that contained 80 percent weeds. When weeds were controlled with herbicides, the protein



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### Chapter 8

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content rose to over 20 percent. Thus, an effective weed control program can more than double the nutritive value of the hay.

Weeds affect quality because most weeds are less palatable and less nutritious than alfalfa. Although some weeds make high quality forage, they are too mature at the time alfalfa is harvested. The loss of feeding value from weed infestation can be due to physical, chemical, or toxic factors. Many weeds are much lower in protein and higher in fiber than alfalfa. Additionally, when certain weeds, such as foxtail or pigeongrass (*Setaria* spp.) or wild barley (*Hordeum* spp.), are present in hay, livestock may develop serious mouth and throat ulcerations. This is due to physical factors, such as prickly or spiny texture. Other weeds, including wild celery (*Apium leptophyllum* [Pers.] Muell.), Mexican tea (*Chenopodium ambrosioides* L.), creeping swinecress (*Coronopus didymus* [L.] Smith), and mustards (*Brassica* spp.), can contribute off flavors in milk. Weeds such as coast fiddleneck (*Amsinckia intermedia* [Fischer & C. Meyer] Ganders) and common groundsel (*Senecio vulgaris* L.) contain alkaloids that are toxic to livestock, especially horses. Weeds that contain higher moisture than alfalfa at baling can cause mold and off-color hay (tobacco hay) and lead to haystack and barn fires.

## Understand the Biology of Your Weeds

An understanding of the life cycle, germination, flowering, and seed formation of weeds and their method of propagation is necessary for effective weed management. Weeds are classified into three groups according to their life cycle: annual, biennial, and perennial, and can be broadleaf or grassy weeds. Table 8.2 lists common weeds present in alfalfa in California and their life cycles.

### Annual Weeds

These are plants that emerge from seed, grow vegetatively, flower, and produce seed all within a year. Annual weeds are classified into winter or summer, depending on their season of growth. Winter annuals germinate in the fall and winter with the cool temperatures and high rainfall. Summer annual weeds germinate as soil temperatures increase in the spring and early summer. Grasses are the most common summer annual weed problem in alfalfa. Yellow and green foxtail (*Setaria* spp.) and watergrass or barnyardgrass (*Echinochloa crus-galli* [L.] P. Beauv.) are usually the most problematic. They begin germinating in early February and continue through July. Plants are vegeta-

**TABLE 8.1**

Lack of effective weed control during stand establishment can dramatically reduce alfalfa yield, and result in poor stands, regardless of seeding rate

	Alfalfa Seeding Rates	Alfalfa 1 <sup>st</sup> Season Yield	Weed 1 <sup>st</sup> Season Yield	Alfalfa Stand End of Year 1
	Pounds per acre	Tons per acre	Tons per acre	Plants per ft <sup>2</sup>
Fiddleneck	15	0.5	12.7	0.9
	30	0.1	12.2	0.8
Common Groundsel	15	6.1	1.8	9.9
	30	6.3	1.7	11.6
Annual Bluegrass	15	6.9	1.5	10.7
	30	7.5	1.3	11.7
Hand Weeded	15	8.3	0.16	11.9
	30	8.1	0.13	11.8

Conversions: To obtain kg per ha, multiply pounds per acre by 1.12. To obtain megagrams per hectare, multiply tons per acre by 2.24. To obtain plants per meter<sup>2</sup>, multiply plants per ft<sup>2</sup> by 9.29 x 10<sup>-2</sup>.

tive through June when seedheads develop and appear above the alfalfa canopy. New seed heads are continually produced during each cutting cycle (typically on a 28- to 30-day interval).

### Biennial Weeds

These plants take up to 2 years to complete their life cycle. Vegetative growth occurs dur-

ing the first year, and seed production often does not occur until the second year. The few biennials that are problems in alfalfa are mostly broadleaves, including buckhorn plantain (*Plantago lanceolata* [L.]), blessed milk thistle (*Silybum marianum* [L.] Gaertn.), and Mexican tea.

### Perennial Weeds

Perennial weeds live 2 years or longer. Vegetative growth and reproductive parts develop during the first year and subsequent years of the life cycle. Reproduction occurs by seed or by vegetative structures, including rhizomes, stolons, and tubers. Problem perennial weeds include yellow and purple nutsedge (*Cyperus* spp.), Johnsongrass (*Sorghum halepense* [L.] Pers.), Bermudagrass (*Cynodon dactylon* [L.] Pers.), field bindweed (*Convolvulus arvensis* L.), curly dock (*Rumex crispus* L.), and dandelion (*Taraxacum officinale* Wigg.). Some perennials, such as dallisgrass (*Paspalum dilatatum* Poiret), only reproduce from seed. Johnsongrass reproduces by seed and rhizomes. Nutsedge, even though it develops seed, only reproduces by tubers. Bermudagrass reproduces by seed or stolons (aboveground roots).

**TABLE 8.2**

Weeds commonly found in alfalfa and their life cycles

ANNUALS	
annual bluegrass (w)	California burclover (w)
volunteer cereals (w)	roughseed buttercup (w)
common chickweed (w)	cheeseweed ( <i>malva</i> sp.) (w)
coast fiddleneck (w)	cocklebur (s)
common groundsel (w)	fillarees (w)
miner's lettuce (w)	henbit (w)
mustards (w)	prickly lettuce (w)
London rocket (w)	blessed milk thistle (w)
Italian ryegrass (w)	shepherd's purse (w)
wild celery (s)	bristly oxtongue (w)
annual sowthistle (w)	common purslane (w)
yellow starthistle (w)	toad rush (w)
barnyardgrass (s)	Persian speedwell (w)
dodder (s)	creeping swinecress (w)
foxtail, yellow and green (s)	common lambsquarters (s)
prostrate knotweed (s)	
nightshades (s)	
BIENNIALS	
buckhorn plantain (s)	Mexican tea (s)
PERENNIALS	
Bermudagrass (s)	dandelion (s)
Johnsongrass (s)	curly dock (s)
nutsedge (s)	dallisgrass (s)
field bindweed (s)	goosegrass (s)

s = spring and summer germination w = fall and winter germination.

## Weed Control During Stand Establishment

The importance of weed control during stand establishment cannot be overemphasized. Weed competition in new alfalfa plantings can cause irreversible damage to the productivity of the stand. Weed competition in seedling alfalfa impedes root development, lowers forage quality and alfalfa yield, and thins the alfalfa stand. Competitive effects of weeds during early growth can extend well into the first year, the second year, and often throughout the life of the stand. The presence of poisonous weeds such as common groundsel, coast fiddleneck, and poison hemlock (*Conium maculatum* L.) can make the hay completely unmarketable.

The first step toward an effective weed-control program in alfalfa is to use farming practices that promote a healthy, vigorous stand that will compete effectively with weeds. Weed

control during stand establishment involves integrating many factors, including cultural practices and use of herbicides.

### **Controlling Weeds through Crop Rotation**

It is advisable to rotate out of alfalfa for 2 or 3 years to reduce disease pressure and disrupt weed and insect life cycles. Occasionally alfalfa is replanted within 1 year. However, this practice

is not recommended and usually results in greater expense and shorter stand life, and it requires more inputs to manage pests.

Know the weed history of a field prior to planting. Fields infested with perennial weeds are not well suited for alfalfa. Use crop rotations with annual crops such as

wheat and corn that compete more aggressively with perennial weeds and allow the use of registered herbicides that control bindweed, nutsedge, and Johnsongrass effectively. An integrated approach that includes crop rotation is the key to management of perennial weeds. Nutsedge, an important perennial weed problem in alfalfa, can be managed by rotating with cotton, corn, or beans and with the use of herbicides and continuous cultivation. Control of yellow nutsedge through crop rotation was demonstrated in a study comparing four cropping systems in California. A 2-year rotation of alfalfa with applications of EPTC, 2 years of barley double-cropped with corn and using a thiocarbamate herbicide, and 2 years of barley followed by fallow with glyphosate applications all reduced the viable nutsedge tubers by 96 to 98 percent when compared to continuously grown cotton. Field bindweed is more easily controlled in fields of small grains with the use of 2,4-D herbicide or glyphosate after crop harvest.

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### **Seedbed Preparation**

Proper land leveling and laser finishing promote the uniform distribution of irrigation water and improve drainage, and is also an important first step for effective weed management. If fields are not properly leveled, water collects in low spots, drowning out the alfalfa, leading to weed infestations. Non-uniform water distribution adversely affects alfalfa growth, reducing its ability to compete with weeds. A well-prepared seedbed promotes uniform germination and rapid growth of alfalfa seedlings. Good seedbed preparation often involves ripping or chiseling and the use of finishing discs, harrows, and ring rollers to produce a firm, trash-free seedbed.

### **Fertilization**

Healthy alfalfa is an excellent competitor with weeds. Proper soil fertility is important to maximize the competitiveness of alfalfa. Soil analysis is advised to determine the nutritional status of the soil before applying preplant fertilizer. Fertility requirements can be met with commercial fertilizers or manures. If manures are used, they should be composted to kill existing weed seeds. Fertilizers containing high amounts of nitrogen promote weeds and are not recommended in pure stands of alfalfa (see Chapter 6, "Alfalfa Fertilization Strategies").

### **Pre-irrigation**

Weed problems are reduced by pre-irrigating to promote weed germination before planting. After emergence, weed seedlings are controlled through cultivation. This does not completely eliminate all weeds, but it reduces the viable seed population and makes other control measures more effective. Pre-irrigation also enhances final seedbed preparation, promotes uniform planting depth, and aids in the incorporation of pre-plant herbicides by minimizing the large clods in the soil.

## Variety Selection

Selecting a well-adapted alfalfa variety is important to minimize weed infestations (see Chapter 5, “Choosing an Alfalfa Variety”). Fall dormancy influences the ability of alfalfa to compete with weeds. Dormant varieties often grow too slowly in the San Joaquin Valley and Low Desert, giving weeds a competitive advantage. Selecting varieties with the appropriate insect, nematode, and disease resistance will prevent many problems and increase the chances of a vigorous and persistent stand. Plant certified seed that is free of noxious weed seed. Use alfalfa seed inoculated with nitrogen-fixing *Rhizobium* bacteria when seeding a field without a recent history of alfalfa.

## Planting Dates

One of the most important cultural practices for controlling weeds is to plant at an optimum time for the alfalfa seedling growth, and when weed populations and growing conditions do not favor the weeds. The range of soil temperature suitable for alfalfa planting and germination is from 65° to 85°F (18° to 29°C), which is typically in the early fall (Sept.–Oct.) in California’s deserts and Central Valley. Time of planting can have a large effect on weed problems. Alfalfa planted too late in the fall will germinate and grow very slowly. Winter annual weeds germinate in late fall and winter and are better adapted to cold temperatures than is alfalfa, and they will grow more rapidly and compete vigorously with the alfalfa (Fig. 8.1). In contrast, summer planting in very hot conditions can also slow alfalfa establishment and result in infestations of summer weeds and grasses that flourish under these conditions. Refer to Chapter 4, “Alfalfa Stand

Establishment,” for optimal planting dates for different regions.

## Seeding Depth and Rate

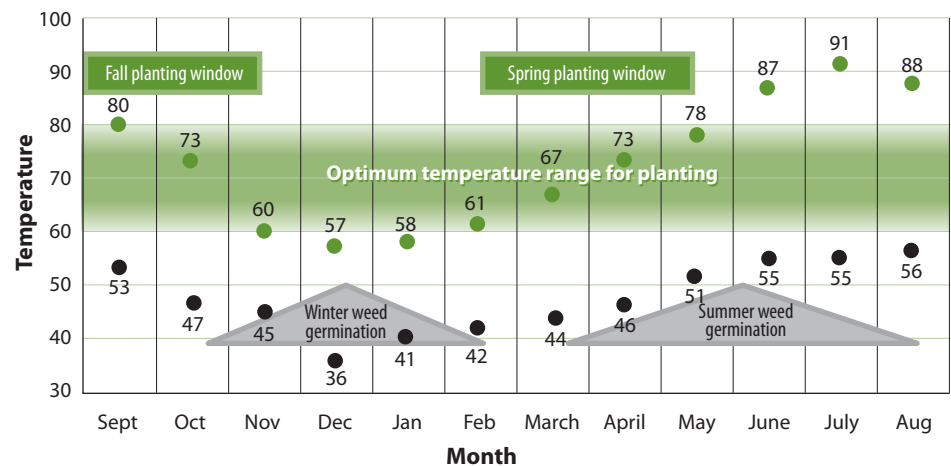
Alfalfa seeding depth and rate are critical for successful establishment. Seeding rates vary, depending on seedbed conditions and planting method. A seeding rate of 15–20 pounds (17–22 kg/ha) drilled, or 20–25 pounds per acre (22–28 kg/ha) broadcast planted, will usually result in a competitive alfalfa stand. Seeding alfalfa at higher rates than these will further improve the ability of the alfalfa to compete with weeds, but the additional seed cost is usually not justified.

## Companion Crops or Nurse Crops

Companion crops (also referred to as “nurse crops”) consist of a second species planted along with the alfalfa during the establishment phase. Small grains (e.g., oat, wheat, and barley) are commonly used as companion crops, oat being the most common. The purpose is to prevent soil erosion and suppress weeds while the alfalfa is becoming established. Most companion crops germinate and grow faster than alfalfa and provide additional competition against rapidly growing weeds. Companion crops can reduce weed populations and, in

**FIGURE 8.1**

Monthly high and low average temperatures used as a planting guide for weed germination for the San Joaquin and Sacramento Valleys of California. Alfalfa Planting Guide.



some cases, eliminate the need for herbicides during the establishment period.

By replacing most weeds with a desired plant species, first-harvest forage quality and yield may be improved. However, companion crops have several drawbacks. If seeded at too high a rate, companion crops can negatively impact the seedling alfalfa in the same manner as weeds and can lower alfalfa vigor and stand density. Forage quality of alfalfa is reduced by most companion crops compared with stands of pure alfalfa.

### Irrigation

Irrigation practices significantly impact weed infestation levels. Overwatering, especially when it results in standing water being present for several hours, creates anaerobic condi-

*Excessive soil moisture at harvest and frequent watering promote the growth of shallow-rooted summer annual weeds.*

tions and provides an environment conducive to diseases or scald. Alfalfa mortality may result, allowing weed encroachment. Water-loving weeds, such as nutsedge, curly dock, watergrass and foxtail, invade the field where standing water has killed the alfalfa. Harvesting too soon after irrigation when soils are moist may cause permanent ruts and soil compaction,

which leads to standing water and ultimately to weed growth. Excessive soil moisture at harvest and frequent watering promote the growth of shallow-rooted summer annual weeds, particularly grasses, over the deeper-rooted alfalfa.

### Cutting Management

Early mowing or clipping can inhibit weed growth and be an effective way to rescue a new alfalfa planting that is heavily infested. Mowing tall weeds that shade the small seedling alfalfa improves sunlight penetration into the canopy, allowing alfalfa to grow and

compete more successfully during the next regrowth. Annual grassy weeds, if cut too early, will recover after mowing and contaminate subsequent cuttings. Mowing immature alfalfa is not a preferred practice because it slows alfalfa development and depletes carbohydrate root reserves. However, early harvest to remove weeds may be a practical way to rescue a heavily weed-infested, newly seeded alfalfa field. It may be the best (or only) option if the weeds have grown beyond the optimum treatment timing for herbicides.

Cutting intervals have a profound impact on the weed infestation level in established stands. Short cutting intervals (such as 20–25 days) do not allow the alfalfa plants enough time to build up sufficient stored carbohydrates in their roots to initiate vigorous growth after cutting. This gives weeds a competitive advantage. Extending the time interval between harvests can reduce weed problems in established stands but lowers the nutritional quality of the alfalfa.

### **Herbicide Controls During Establishment**

Chemical weed control is used on probably 80 percent of the alfalfa acreage in California for seedling weed control. Herbicides are considered an integral component of a total weed-management system, and when coupled with cultural practices, weeds can be efficiently and effectively controlled. Herbicides used in the establishment phase can be grouped into categories, based on their application timing relative to newly planted alfalfa (see “UC IPM Pest Management Guidelines: Alfalfa” [[www.ipm.ucdavis.edu](http://www.ipm.ucdavis.edu)]) for more details on herbicide use and selectivity.

Pre-plant herbicides are applied and mixed into the soil before planting and control weeds at germination or through root uptake. Post-plant, pre-emergence herbicides are applied after planting the crop but before the weeds or the crop have emerged. Post-emergence herbicides are applied after weed and/or crop emergence.

## Pre-plant Herbicides

Pre-plant herbicides are applied to soil and thoroughly incorporated before planting alfalfa. EPTC (Eptam) and benefin (Balan) are two pre-plant herbicides used primarily for stand establishment. They are selective, soil-active herbicides that control a wide range of leaf and grassy weeds before they emerge. Pre-plant-incorporated herbicides perform best when thoroughly mixed into soil in a seedbed free of large clods.

Benefin and EPTC effectively control small-seeded broadleaf plants and grasses. Benefin generally controls weeds for 3 months and EPTC for 6 weeks. Benefin is effective for spring plantings because it controls many summer annual weeds, such as pigweed (*Amaranthus* spp.), common lambsquarters (*Chenopodium album* L.), and barnyardgrass. It is less effective for fall plantings because it does not adequately control many of the winter annual weeds that infest fall plantings, such as mustard species and common groundsel.

EPTC belongs to the thiocarbamate chemical family, which is very volatile and therefore requires immediate incorporation into the soil. EPTC controls many of the same grasses and broadleaf weeds as benefin, and it also suppresses the perennial problem weed nutsedge. EPTC is effective for pre-emergence control of volunteer cereals. EPTC and benefin can be combined at reduced rates of each to expand the spectrum of weeds controlled. EPTC injury symptoms of alfalfa include cupping and crinkling of leaves (Color Plate 8.6 at the end of this chapter).

## Post-plant, Pre-emergence Herbicides

Herbicides classified for this use are applied after the alfalfa is planted but before it emerges. Although this is not a common practice in the West, there are circumstances when soil conditions and timing favor this decision. EPTC can also be used at this timing and applied after planting. No-till or minimum-till systems often rely on post-plant, pre-emergence applications of herbicides as an effective weed-management tool. Glyphosate and paraquat kill existing

vegetation after planting but before alfalfa emerges.

## Post-emergence Herbicides

Post-emergence herbicides are applied to the crop after weeds and alfalfa emerge. These herbicides are more commonly used than pre-emergence herbicides because they are generally more effective and provide more flexibility. A major advantage of post-emergence herbicides is that herbicide selection is made after weed emergence, after the weeds have been properly identified. Thus, the most effective herbicide can be selected.

Proper timing depends on the post-emergence herbicide and its safety. For example, post-emergence *selective* herbicides that cause minimal injury (e.g., clethodim) can be applied at a smaller alfalfa growth stage than *nonselective* herbicides (e.g., paraquat) (Table 8.3). Some herbicides are applied when one trifoliolate leaf is visible, and others require that three or more trifoliolate leaves are fully developed. It is critical to identify the appropriate alfalfa growth stage for the herbicide chosen.

**TABLE 8.3**

Rate and timing for herbicides registered for use on newly planted alfalfa

Herbicide	Stage of Alfalfa Growth Before Treatment	Rate lbs. a.i./A
Gramoxone	3 trifoliolate leaves	0.126
Inteon	6 trifoliolate leaves	0.25
	9 trifoliolate leaves	0.25–0.46
Buctril	2–4 trifoliolate leaves	0.25–0.375
Velpar	6-inch root growth/ multiple stems	0.25–0.375
Poast	2–4 trifoliolate leaves	0.1–0.46
Prism	2–4 trifoliolate leaves	0.095–0.176
2,4-DB	1–4 trifoliolate leaves	0.375–0.46
Pursuit	2–4 trifoliolate leaves	0.047–0.094
Raptor	2–4 trifoliolate leaves	0.03–0.046
Glyphosate: (Roundup Ready Alfalfa)	flexible	22–44 oz

Conversion: To convert pounds/acre to kg/ha, multiply by 1.12.

As a rule, making an application at the earliest stage when weeds are small will provide the most consistent and effective weed control. More weed control failures in seedling alfalfa occur from treating the crop too late than from any other factor. Less-selective herbicides are generally applied at a more advanced growth stage, when alfalfa can withstand a higher amount of leaf burn. When applied at a later timing, usually beyond the three- or four-leaf stage (Fig. 8.2), the alfalfa will usually grow out of the injury symptoms, lowering yields only for the first cutting, if at all. Nonselective herbicides are specifically used when weeds are large or not controlled by other herbicides. The safety of nonselective herbicides to alfalfa seedlings is marginal and requires special attention when selecting the rate in relation to seedling size.

**Bromoxynil** (Buctril). This is a selective contact herbicide for broadleaf weed control. It is applied when the alfalfa plants have two or

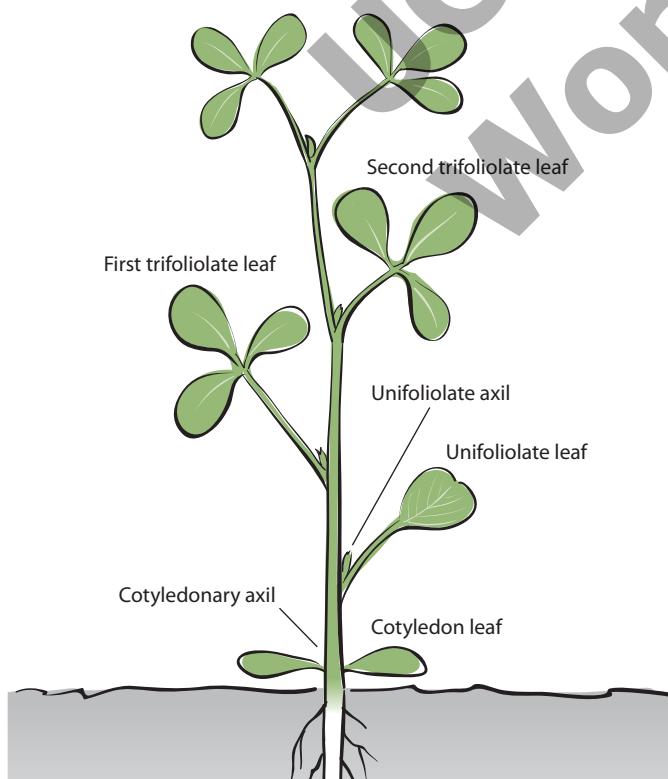
more trifoliolate leaves. It is especially effective on coast fiddleneck, mustards, common groundsel, and annual sowthistle (*Sonchus oleraceus* L.). With a diverse weed spectrum, including numerous grass and broadleaf weeds, Buctril is often tank-mixed with other herbicides to provide broad-spectrum control with a single application. Avoid spraying when temperatures are expected to exceed 80°F (27°C) for 3 days after application. The best results are achieved when weeds are small, from 1 to 3 inches (2.5 to 7.6 cm) tall. Since it is a contact herbicide, thorough spray coverage is very important; this is accomplished using higher spray volumes of 20–30 gallons per acre (185–280 liters per ha). Bromoxynil injury symptoms of alfalfa include leaf burning and necrotic tissue (Color Plate 8.7).

**2,4-DB** (Butyrac, Butoxone). This is a broad-leaf-selective herbicide that translocates from the leaves to the rest of the plant. It is used for broadleaf weeds such as prickly lettuce (*Lactuca serriola* L.), annual sowthistle, and mustards and is also effective on perennial curly dock. It is applied when alfalfa reaches the two-trifoliolate leaf stage. The effectiveness of 2,4-DB is enhanced in warm temperatures. Erratic control occurs when conditions are cold and foggy. To broaden the spectrum of control, 2,4-DB is often tank-mixed with other herbicides. Injury symptoms to alfalfa from 2,4-DB can include slight twisting and narrow, cupped leaves (Color Plate 8.8).

**Sethoxydim/clethodim** (Poast/Prism). These are selective grass herbicides that control both annuals and perennials. They have no toxic effect on alfalfa or broadleaf weeds, including sedges. These herbicides work best on immature grasses up to the tillering stage (before heading) that are vigorously growing and not drought stressed. Poast or Prism can be used between alfalfa cuttings to control summer grasses, including yellow and green foxtail, barnyardgrass, and perennials: Bermudagrass, Johnsongrass, and goosegrass (*Eleusine indica* [L.] Gaertn.). Well-established perennial grasses usually require multiple or sequential applications. Both herbicides can be tank-mixed with many broadleaf herbicides.

**FIGURE 8.2**

The number of trifoliolate leaves indicate whether plants are old enough for herbicide treatments.





**Paraquat** (Gramoxone Inteon). This is a non-selective contact herbicide that controls a wide range of broadleaf and grassy weeds. Paraquat is injurious to alfalfa seedlings when applied before the three-trifoliolate leaf stage or when an excessive rate is used. The rate is based on the size of the alfalfa plants, rather than weed size, to maintain crop safety. Higher rates can be applied to larger alfalfa plants. Paraquat is not tank-mixed with other post-emergence herbicides because it controls a broad spectrum of grasses and broadleaf weeds, and its mode of action can inhibit the effectiveness of systemic herbicides. Paraquat is commonly used when weeds become too large for other herbicides. It is not the first herbicide of choice but is often considered a rescue treatment to reduce the volume of weed canopy overtopping young alfalfa seedlings. Paraquat injury symptoms of alfalfa include burning and necrotic leaves (Color Plate 8.9).

**Imazethapyr** (Pursuit). This is a selective systemic herbicide that controls most broadleaf weeds and some grasses. Apply Pursuit to small weeds that are not moisture stressed after alfalfa has developed two trifoliolate leaves. Pursuit is very effective at controlling winter annuals such as mustards, shepherd's purse (*Capsella bursa-pastoris* L.), creeping swinecress, chickweed (*Cerastium* spp.), and many more. It is in the ALS (acetolactate synthesis) inhibitor herbicide family, and continual use beyond stand establishment or 2 years should be avoided to minimize the potential for herbicide resistance. There are restrictions on when other crops can be planted after applications of Pursuit (called plant-back intervals). Plant-back intervals range from 6 to 40 months, which reduces long-term use of this herbicide in older established stands. Imazethapyr injury symptoms of alfalfa include yellow, stunted growth.

**Imazamox** (Raptor). This is a selective, translocated herbicide that controls broadleaf and grass weeds. The weed spectrum controlled is similar to those controlled by Pursuit, except that it is far more effective on grasses, especially winter annual grasses. Raptor is applied to alfalfa with two or more trifoliolate leaves. It is in the same chemical family (ALS inhibitor)

as Pursuit; therefore, it is not recommended to alternate Raptor and Pursuit applications. Combining Raptor with other broadleaf herbicides can broaden the spectrum of weeds controlled, especially for weeds not adequately controlled with Raptor, such as prickly lettuce, annual sowthistle, redmaids (*Calandrinia ciliata*), and coast fiddleneck. Performance is best when weeds are small, 1–3 inches (2.5–7.6 cm) in height and growing vigorously. The addition of a nitrogen fertilizer with a surfactant (as per label recommendations) greatly enhances control of marginally sensitive weeds. Crop rotation guidelines are half of those for Pursuit, and the pre-harvest interval is 20 days, which allows for applications between cuttings. Imazamox injury symptoms of alfalfa include yellow, stunted growth.

## Weed Control in Established Alfalfa Stands

In most alfalfa growing regions, weeds can plague alfalfa production during the fall and winter dormant period, as well as during the summer growing season. Weed problems in established alfalfa stands can be divided into winter annuals, summer annuals, perennial weeds, and parasitic weeds, each of which may require a different control strategy.

### Control of Winter Annuals in Established Alfalfa

Winter annual weeds consist of broadleaf and grassy weeds that germinate and grow vigorously during the late fall and winter and compete with the established alfalfa crop when the crop is dormant. The most common annual weeds in established alfalfa during this period in California's Mediterranean and desert zones are numerous and depend largely on the field history and crop rotation. For a comprehensive list of weeds that infest alfalfa fields, refer to Table 8.2.

## Cultural Methods

Certain cultural practices during winter months, such as light cultivation, grazing, and flaming, can reduce winter weed populations.

**Cultivation.** Dormant established alfalfa can be lightly cultivated with a spring-tooth harrow during winter if soil moisture is low enough to prevent compaction. Small weed seedlings will be uprooted, but injury to alfalfa crowns may also occur. Crown injury can delay the first cutting, reduce yields, and predispose the alfalfa to crown disease. Normally, cultivation is only partially effective; some weeds re-root, weeds may emerge after cultivation, and perennials are not controlled. Timing and skill are critical as cultivation must take place after weed emergence but before the alfalfa has much growth. Techniques should minimize injury to the alfalfa.

**Grazing.** “Sheeping” or grazing-off alfalfa and weed growth during late fall and winter can reduce weed growth significantly if soil conditions allow. Some weeds are quite palatable and nutritious to grazing animals, and grazing can reduce winter weed competition (Color Plate 8.10). Grazing can be coupled with chemical methods, thereby improving chemical weed control. Spray coverage is increased by exposing

*Grazing can be coupled with chemical methods, thereby improving chemical weed control.*

the soil and young weeds so that herbicides can then be uniformly applied after grazing. Soil compaction and damage to crowns is a major risk of grazing for weed control. A large number of animals should graze the field rapidly because prolonged intensive grazing can deplete root reserves, reduce vigor, and lead to

a thin, weedy stand (see Chapter 18, “Alfalfa Grazing Management”). Risk of nitrate poisoning to grazing livestock should be considered with some types of weeds (especially lambs-quarters, pigweed, and grasses). Some weeds, such as common groundsel, can be poisonous to livestock.

**Flaming.** Flame throwers can be used as effective weed control measures. This generally has a similar effect as “burn back” herbicides such as Gramoxone (paraquat), killing weeds, but also killing some of the alfalfa foliage. Flaming large areas can be expensive, but flaming is often appropriate for smaller weed-infested areas, and has been used for control of dodder.

## Herbicide Controls for Winter Annuals

Herbicides are normally required for complete winter annual weed control in alfalfa. Diuron (Karmex and Direx), hexazinone (Velpar), norflurazon (Solicam), pronamide (Kerb), paraquat (Gramoxone Extra), imazethapyr (Pursuit), imazamox (Raptor) and metribuzin (Sencor in selected regions) are registered for winter annual weed control in established alfalfa. Apply soil-active, pre-emergence (pre-emergence for the weed) herbicides in fall, winter, or spring before new alfalfa growth begins and before weeds germinate. Pre-emergence herbicides must be incorporated by winter rainfall or sprinkler irrigation (consult the label). Certain soil-active herbicides can cause yellowing of foliage and delay the first cutting when used on alfalfa that has already resumed growth. Many of the soil-active herbicides have a 1- to 2-year plant-back restriction, limiting their use in the last years of the alfalfa stand's life. Consider the weeds present, soil texture and organic matter content, rainfall patterns, and the remaining stand life before selecting the appropriate herbicide. These soil-residual herbicides are often tank-mixed to broaden the weed-control spectrum (see the UC IPM Pest Management Guidelines: Alfalfa [[www.ipm.ucdavis.edu](http://www.ipm.ucdavis.edu)] for more details on herbicide use and selectivity).

**Diuron** (Karmex and Direx) controls many broadleaf weeds and some grasses but usually does not adequately control common groundsel, speedwell (*Veronica officinalis* L.), and wild oat (*Avena fatua*). Apply before alfalfa growth begins and before weeds are well established, generally no later than January. Only stands 1 year or older can be treated, and because diuron persists in the soil, it cannot be used on fields in their last year of production. Treated

fields may be replanted to any crop after 1 year from the last application if the rate does not exceed 2 pounds per acre (2.24 kg/ha). Diuron injury symptoms of alfalfa include leaf yellowing and interveinal chlorosis (Color Plate 8.11).

**Hexazinone** (Velpar) controls a range of broad-leaf weeds and some grass weeds, including common groundsel, chickweed, miner's lettuce (*Claytonia perfoliata* Willd. spp. *perfoliata*), and annual bluegrass (*Poa annua* L.). It also suppresses some biennials and perennials, such as dandelion, buckhorn plantain, and speedwell. Many crops cannot be planted for 18 months following treatment without yield damage. Hexazinone injury symptoms of alfalfa include leaf yellowing and interveinal chlorosis.

**Norflurazon** (Solicam) controls many broad-leaf and grassy weeds and suppresses nutsedge, a difficult perennial weed that escapes most herbicides. Applications can be made to both dormant and actively growing alfalfa, but if used during the growing season, norflurazon cannot be applied within 28 days of harvest. Norflurazon will not control emerged weeds. If emerged weeds are present at the time of application, norflurazon must be tank-mixed with an herbicide with foliar activity, such as paraquat. Twenty-four months is the rotational interval after the last application of norflurazon. Norflurazon alfalfa injury includes bleached (white) leaves.

**Paraquat** (Gramoxone Inteon) is used as a "burn-down" herbicide and is the herbicide of choice when weed populations have germinated and are 2–4 inches (5–10 cm) tall. Apply Gramoxone alone or in combination with soil-active herbicides diuron, hexazinone, or norflurazon for extended residual control. Rates depend on weed size. Leaf burn will occur if alfalfa regrowth has resumed. Alfalfa cannot be harvested or grazed within 60 days of application. Gramoxone does not adequately control larger weeds or perennials. It is especially important that weeds are thoroughly covered with the spray solution since gramoxone does not translocate through the plant. Gramoxone is often used during the last year of an alfalfa stand.

**Imazethapyr** (Pursuit) can be applied post-emergence to established alfalfa but because of its soil activity should not be used during the last year of production because of plant-back restrictions, which range from 4 to 40 months, depending on cropping type. Sugarbeets are especially sensitive to residual Pursuit and cannot be planted for 40 months after application. Pursuit is rarely used on established alfalfa because herbicide activity is slow in winter months and is less effective on large weeds and grasses than other herbicides used in dormant alfalfa. Therefore, Pursuit has limited potential as a soil pre-emergence herbicide. It may be useful for late applications where other herbicides are restricted and would cause excessive injury.

**Imazamox** (Raptor) is in the same chemical family as Pursuit (an ALS inhibitor) but has a shorter soil life. Raptor has the advantage that harvest can take place immediately after application. This makes it a useful product for use during the growing season since it can be applied between cuttings to control a variety of broadleaf weeds and some grassy weeds.

## Control of Summer Annuals in Established Alfalfa

Summer annual weed problems include, but are not limited to, grasses such as yellow and green foxtail (*Setaria* spp.), crabgrass (*Digitaria* spp.), barnyardgrass or watergrass, and south-western cupgrass (*Eriochloa gracilis* [Fourn.] A. S. Hitchc.). These weeds germinate in early to late spring and can severely contaminate alfalfa fields, especially those that have poor stands or exhibit poor growth due to soil compaction, poor fertility, or frequent cuttings.

### Cultural Methods

To reduce the spread of these weeds, keep the alfalfa growing vigorously through proper irrigation management and soil fertility, and with cutting schedules that allow sufficient time between harvests to maintain crop vigor. As detailed in Chapter 13, "Harvest Strategies

for Alfalfa”, a “staggered” cutting schedule (alternating long and short intervals) enables plants to recover from defoliation to more vigorously compete with weeds. A dense, vigorous alfalfa stand reduces the amount of light reaching the soil surface, preventing weeds from germinating and becoming established. Residual soil-applied herbicides applied during winter for control of winter annual broadleaf weeds can sometimes increase summer grass problems. For example, Karmex and Velpar are effective for most winter annuals, but they only control foxtail for a short time. With the winter annuals eliminated, the later germinating grasses flourish, having little competition, and fill in the empty spaces. It is important to anticipate and address the problem of grass invasions during the summer.

### Herbicide Controls for Summer Annuals

**Trifluralin** (Treflan/TR-10). Summer grasses in established alfalfa are most commonly controlled with trifluralin granules (Treflan TR-10). Apply in winter or early spring before grasses germinate. January to mid-February is the best time to apply trifluralin in the San Joaquin Valley because the summer annual foxtails germinate as early as mid-February. At least 0.5 inches (1.3 cm) of rainfall or sprinkler irrigation is needed within 3 days after application to incorporate the herbicide. Trifluralin injury symptoms (stunted growth) are generally observed in established alfalfa.

**Pendimethalin** (Prowl). This herbicide controls a similar weed spectrum to trifluralin TR 10. Prowl differs from TR-10 in that, as a liquid formulation, it can be applied by itself or tank mixed with other post or pre-emergent herbicides in the same application. It is especially effective for control of most summer grasses including setaria species, yellow and green foxtail; and some broadleaf weeds provided it is applied before they germinate and emerge. When Prowl is applied in late winter or in the spring after first cutting, effective weed control can be achieved for several months into the summer. The actual length of control depends on the rate used. It can also be used in newly

planted seedling stands after the alfalfa crop has emerged as a pre-emergent tool for later germinating weeds. Prowl has relatively low volatility loss on the soil surface, however, it still must be moved into the soil by rainfall or an irrigation within 7–10 days after an application for best results.

**EPTC** (Eptam) liquid applied in irrigation water or applied as a broadcast granular just ahead of irrigation can also control summer grasses. This herbicide must be uniformly metered into the water during irrigation. Best results are obtained when fields are properly leveled, allowing irrigation water to be uniformly applied. As with trifluralin, EPTC must be applied before grasses emerge in mid-February. One application controls grasses for 30 to 45 days, so repeated applications are necessary for season-long control. EPTC injury symptoms of alfalfa can include cupping and crinkling leaves and shortened internodes.

**Sethoxydim** (Poast) or **Clethodim** (Prism, select) are also used as post-emergence treatments in fields where summer grasses have already emerged or escaped an earlier trifluralin application. Apply the herbicide after the first or second cutting before grasses become too large and well tillered. The best timing is after bale removal and within 2 to 4 days after the field has been irrigated as these herbicides do not perform well on moisture-stressed weeds. Injury symptoms have not been observed in alfalfa.

### Dodder

The parasitic weed dodder (*Cuscuta* spp.) is one of the most serious weed problems in alfalfa and presents unique challenges to the producer. Dodder is a rootless, yellow-orange, threadlike parasitic weed that penetrates into alfalfa stems and forms a dense tangled mat, sometimes several feet in diameter (Color Plate 8.12). Dodder can reduce yield of newly planted and established alfalfa stands and shorten stand life. Dodder seeds survive in soil for many years; therefore it is difficult to manage solely through fallowing or crop rotations. Because dodder is especially difficult to control

after it attaches to alfalfa, prevention and pre-emergence control are the best strategies. A dense, vigorously growing stand of alfalfa slows dodder development, as it requires sunlight to thrive, but a dense stand alone is not sufficient. Prevention of seed production is critical for long-term dodder management.

**Trifluralin** (Treflan TR-10) granular herbicide application before dodder germination is the most effective program to manage dodder in conventional cultivars. Dodder typically germinates in late February in the San Joaquin Valley. Two pounds of trifluralin active ingredient (20 pounds of 10% trifluralin granular per acre) (22 kg/ha) controls dodder for 3 months; an additional 20-pound application after the first cutting is needed for large populations and extended control. Once dodder has attached and imbedded its haustoria (sucker-like tissues) into the alfalfa stem, control becomes more difficult.

**Pendimethalin** (Prowl) liquid herbicide is an effective herbicide for dodder control in alfalfa. Herbicide timing is very important and similar to Trifluralin TR-10. Application must be made before dodder germinates and attaches to the alfalfa plant. In the Central Valley, dodder germination begins in February and is continuous throughout the warm periods. Research has shown that split applications of herbicide made 60 days apart provide longer and more effective control than one single high rate. As is the case for all pre-emergent herbicides, a timely rain or irrigation is needed for incorporation for the best results.

Attached dodder is controlled by flaming with a propane-fueled burner (may be restricted in certain air pollution control districts) and flail mowing. For effective control by flaming, the alfalfa stems and foliage must be burned below the point of dodder attachment. Repeat treatments may be necessary after each cutting because dodder continues to germinate from seed through most of the growing season.

Flail mowed alfalfa is cut near the ground surface to remove attached dodder. Alfalfa

regrowth can be slow after flail mowing, especially if cut too short. This may extend the number of days between cuttings required to achieve a normal yield, but flail mowing is generally less injurious to yield and stand life than is flaming.

The use of glyphosate in Roundup Ready alfalfa is effective when applied at the early attachment period, before the dodder colonies become too large. Multiple applications may be needed throughout the season.

Few post-emergence herbicides are available for dodder control. However, Pursuit has been successful in controlling dodder at germination and early attachment to alfalfa. As is the case with many post-emergence herbicides, coverage of the entire weed is essential. The best success has been in seedling alfalfa when both alfalfa and dodder plants are thoroughly covered with the herbicide solution. Pursuit will not translocate through the alfalfa plant to dodder or by soil uptake since dodder is rootless.

## Control of Perennials in Established Alfalfa

Several perennial weeds, such as dandelion, nutsedge, Bermudagrass, Johnsongrass, and short-lived perennials such as curly dock and buckhorn plantain, commonly infest alfalfa. Once established, perennials are difficult to remove in established alfalfa, so site selection and prevention are key components of perennial weed-control strategy. Control options for established perennial weeds are limited to a few herbicides that only provide marginal control at best and only when an alfalfa stand is healthy.

Yellow and purple nutsedge can cause serious problems in alfalfa. When other weeds are controlled with residual and/or selective grass

*Perennials are difficult to remove in established alfalfa, so site selection and prevention are key components of perennial weed-control strategy.*

herbicides, nutsedge populations can increase due to the lack of competition. Excessive irrigations also cause nutsedge to flourish.

**EPTC** (Eptam) or **norflurazon** (Solicam) beginning in February, before or just as plants emerge, can suppress nutsedge. With both herbicides, it is important to make the initial application before nutsedge emergence and sequential applications for season-long suppression.

Johnsongrass growth from rhizomes and Bermudagrass growth from stolons are not controlled with any of the residual herbicides used in established alfalfa. **Sethoxydim** (Poast) and **clethodim** (Prism) will provide acceptable control if applied when the grass is 12–18 inches (30–46 cm) tall, but usually two to three treatments are necessary.

Timely applications of **2,4-DB** (Butoxone, Butyrac) can suppress some broadleaf perennials, such as curly dock and field bindweed. Curly dock, also referred to as sour dock, can be a problem in established alfalfa, especially in low areas of the field or at ends of the field that tend to collect water and stay moist for extended periods. Control is achieved with a fall application of 2,4-DB made before a freeze or drought conditions stress the plant. However, once curly dock becomes well established, soil-residual herbicides have no effect.

## Roundup Ready Alfalfa System

**Glyphosate (Roundup), using Roundup Ready (RR) Alfalfa varieties.** Commercial alfalfa varieties genetically engineered for resistance to glyphosate herbicide were released in 2005. This technology, combining herbicides with a variety genetically engineered to be tolerant of the herbicide, enables Roundup to be applied post-emergence both during stand establishment and in established stands. This technology provides the advantages of wide-spectrum weed control and very low risk of crop injury. It enables considerable flexibility in timing of application compared with many other seedling weed-control strategies.

Most broad-spectrum herbicides injure the alfalfa crop to some degree. Crop injury has been demonstrated to be dramatically reduced or eliminated with RR Alfalfa. Furthermore, there are few effective weed-control programs for some of the most difficult-to-control perennial weeds in alfalfa (Bermudagrass, nutsedge, Johnsongrass, and dandelion) that could be improved with the RR strategy. Adequate control of these tough perennials could add years to stand life.

A disadvantage of this strategy is the lack of residual control, since glyphosate kills only emerged weeds. Therefore, it is important to spray Roundup after most of the weeds have emerged or when there is enough crop canopy to outcompete late-emerging weeds. On the other hand, do not delay application so long that weeds become large and are difficult to control. Generally, the best time to treat seedling alfalfa is when the alfalfa is between the three- and six-trifoliolate leaf stages. There is usually bare soil with earlier applications, allowing subsequent weed emergence. With later applications, weeds may be too large for adequate control and with heavy weed infestations, alfalfa stand density or vigor may be affected before the herbicide is applied. Sometimes it may be necessary to make two applications of glyphosate during alfalfa stand establishment.

Preventing the development of glyphosate resistance in weeds is a major concern with the overuse of Roundup in alfalfa. Continuous use of glyphosate in an RR Alfalfa system can lead to weed species shifts or weeds developing resistance to glyphosate. We recommend diverse systems which incorporate cultural methods as well as rotations or tank mixes of herbicides to prevent weed resistance or weed shifts (Figure 8.3). Additionally, growers should be assured that their buyers of the hay or animal product are not sensitive to the presence of a genetically engineered (GE) crop. The RR technology is reviewed in detail in Van Dynze et al. 2004 “Roundup Ready Alfalfa: An Emerging Technology.”

**FIGURE 8.3**

Example weed management strategies for glyphosate-resistant alfalfa with continuous glyphosate applications compared with an herbicide strategy that includes herbicide rotations during a 4-year alfalfa stand. A combination of soil residual herbicides and different modes of action is recommended to prevent weed shifts and herbicide resistance. Note: these are examples only—appropriate strategies should be modified for different regions and weed pressures.

Year	Objective	Season	Continuous Glyphosate Strategy	Rotational Herbicide Strategy
Seedling	Control weeds that compete during stand establishment	Fall	Glyphosate	Glyphosate
1	Control late-emerging weeds during establishment	Winter (late)	Glyphosate	Glyphosate*
	Summer annual weed control may not be needed first year	Spring		
		Summer		
2	Control winter annual weeds and/or pre-emergence control of summer weeds	Winter	Glyphosate	Soil residual herbicide or tank mix* of soil residual herbicide with Glyphosate**
	Summer annual weed control/Dodder	Spring		
		Summer	Glyphosate	
3	Control winter annual weeds and/or pre-emergence control of summer weeds	Winter	Glyphosate	Soil residual herbicide or tank mix* of soil residual with Glyphosate**
	Control summer annual grassy weeds/Dodder	Spring	Glyphosate	
		Summer (mid)	Glyphosate	
4	Control winter annual weeds	Winter	Glyphosate	Glyphosate
	Control summer annual grassy weeds/Dodder	Spring	Glyphosate	
		Summer (mid)	Glyphosate	Glyphosate
	(Stand take-out)	Fall (late)	Tillage and/or 2,4-D + dicamba as necessary	Tillage and/or 2,4-D + dicamba as necessary
(4 years)	<b>Total Number of Glyphosate Applications</b>		<b>10</b>	<b>4–6</b>

\* Tank mixing with another herbicide is advised if significant populations of glyphosate tolerant weeds such as burning nettle are present.

\*\*Soil residual herbicide (depending on location and weed spectrum, use hexazinone, diuron, or metribuzin) for pre-emergence control of winter annual weeds. An application of a dinitroaniline herbicide (pendimethalin or trifluralin) applied at this time will control summer annual grassy weeds.



## Summary

An integrated approach to weed management assures an effective and cost-efficient system over the life of the alfalfa stand. A key aspect of an integrated weed control program is careful attention to the stand establishment period. Using sound production practices that promote longer alfalfa life and higher yields generally provides weed-free fields and better performance from herbicides. Relying only on a chemical approach for weed management will generally fail over time if recommended cultural practices aren't used in a total management system.

A successful weed-management program integrates a total cultural system that includes the following practices:

- monitoring and controlling problem weeds, especially perennials prior to planting
- land leveling to enhance efficient irrigation applications and tailwater drainage
- seedbed preparation and planting time that promote fast germination and emergence
- selecting pest-resistant varieties best suited for your area and market
- maintaining nutritional balance and soil chemistry that promote vigorous alfalfa growth
- cutting alfalfa on longer cycles to keep alfalfa vigorous and competitive with weeds
- timely controlling of insects to maintain a healthier stand with more foliage to shade weeds
- managing irrigation to prevent damage to the plant from excess water and disease
- choosing the right herbicide and applying when weeds are small



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## Color Plates

### PLATE 8.1

Weedy alfalfa field.

### PLATE 8.2

Perennial weeds, yellow nutsedge.

### PLATE 8.3

Poisonous weeds, coast fiddleneck.



8.2



8.3



8.4



8.5



### PLATE 8.4

Clean alfalfa field.

### PLATE 8.5

Companion planting of oats.

**PLATE 8.6**

EPTC injury symptoms include cupping and crinkling of leaves.



**PLATE 8.7**

Bromoxynil injury symptoms include burning and necrotic leaf tissue.

**PLATE 8.8**

2,4-DB symptoms can include slight twisting and narrow cupped leaves.



**PLATE 8.9**

Paraquat injury symptoms include burning and necrotic leaves.

**PLATE 8.10**

Sheep grazing alfalfa assists in controlling winter weeds.



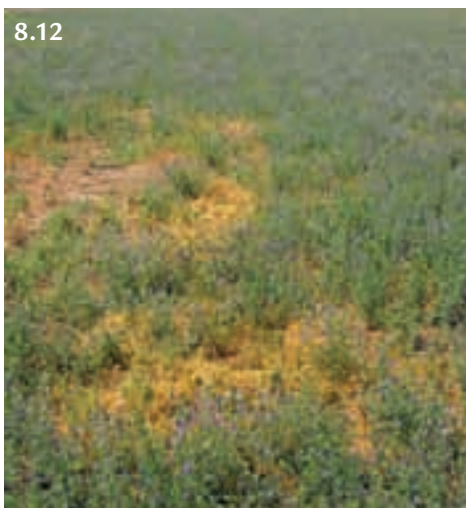
**PLATE 8.11**

Hexazinone and Diuron injury symptoms include leaf yellowing and interveinal chlorosis.



**PLATE 8.12**

Dodder in alfalfa.





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