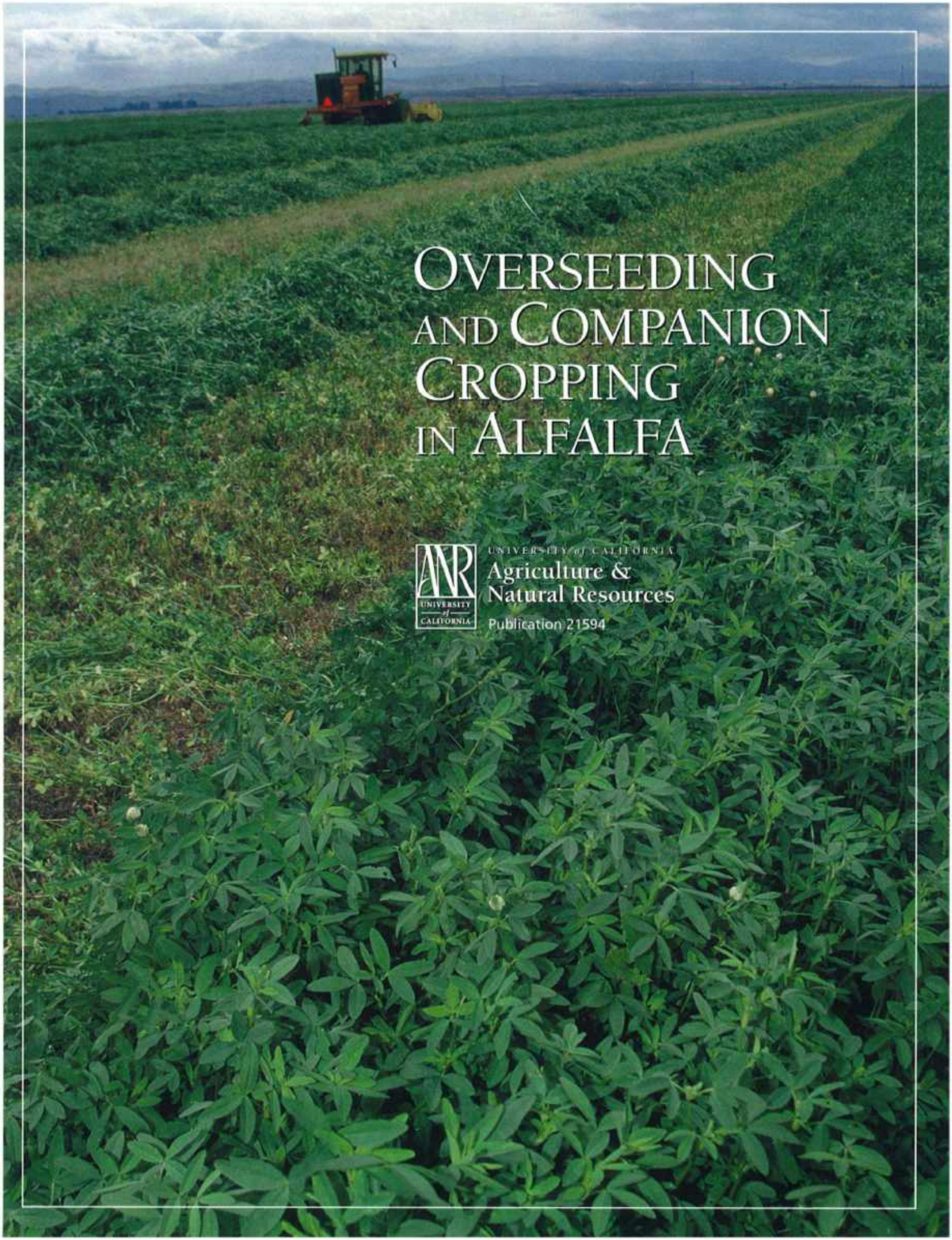

Overseeding and Companion Cropping in Alfalfa

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OVERSEEDING AND COMPANION CROPPING IN ALFALFA

W. Mick Canevari
University of California Cooperative Extension Farm Advisor
San Joaquin County

Daniel H. Putnam
Extension Forage Agronomist, Department of Agronomy and Range Science, University of California, Davis

W. Thomas Lanini
Extension Weed Ecologist, Department of Vegetable Crops
University of California, Davis

Rachael F. Long
University of California Cooperative Extension Farm Advisor
Yolo County

Steve B. Orloff
University of California Cooperative Extension Farm Advisor
Siskiyou County

Barbara A. Reed
University of California Cooperative Extension Farm Advisor
Glenn County

Ronald V. Vargas
University of California Cooperative Extension County Director/Farm Advisor, Madera County

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INTRODUCTION

ALFALFA IS CONSIDERED THE "QUEEN OF FORAGES" BECAUSE IT IS HIGH YIELDING, HIGH IN FORAGE QUALITY, A PERSISTENT PERENNIAL, AND RESISTANT TO MANY PESTS AND DISEASES. It is the primary forage for dairy cows in California and nationwide. Typically, growers with pure stands of vigorous, weed-free alfalfa would not wish to mix it with other crops. However, there are circumstances that may make the practice of mixing other crops with alfalfa desirable.

Older alfalfa stands decline rapidly due to various causes. As a result, yields are lowered and the crop becomes more susceptible to weeds. At some point, a decision must be made to either plow under the alfalfa, continue to harvest poor yields, or consider overseeding to enhance the yield and quality of the stand.

During seedling development, alfalfa is vulnerable to weed competition. Maximum production of pure alfalfa is often not achieved until the second year of growth. Companion cropping, the mixing of crops at planting, has been used in attempts to minimize weed problems, control soil erosion, and improve yields in the seedling year.

It is during these two vulnerable periods, stand establishment and stand depletion, that it may be desirable to consider mixing other crops with alfalfa. It is estimated that in California, greater than 30 percent of the 1 million acres of alfalfa in the state are either older stands below optimal production or newly established fields—acreage to be considered for mixed cropping.

Overseeding can significantly increase forage yields (see fig. 1). There may also be significant pest-management advantages of mixed cropping. Disadvantages of overseeding include inability to cure large volumes of high-moisture forage in the spring, and the lower forage quality of mixed alfalfa forage, which usually lowers the market value compared with alfalfa alone. The overseeding or companion cropping practices described in this publication can mitigate weed and insect pest problems, reduce pesticide use, and increase forage yield.

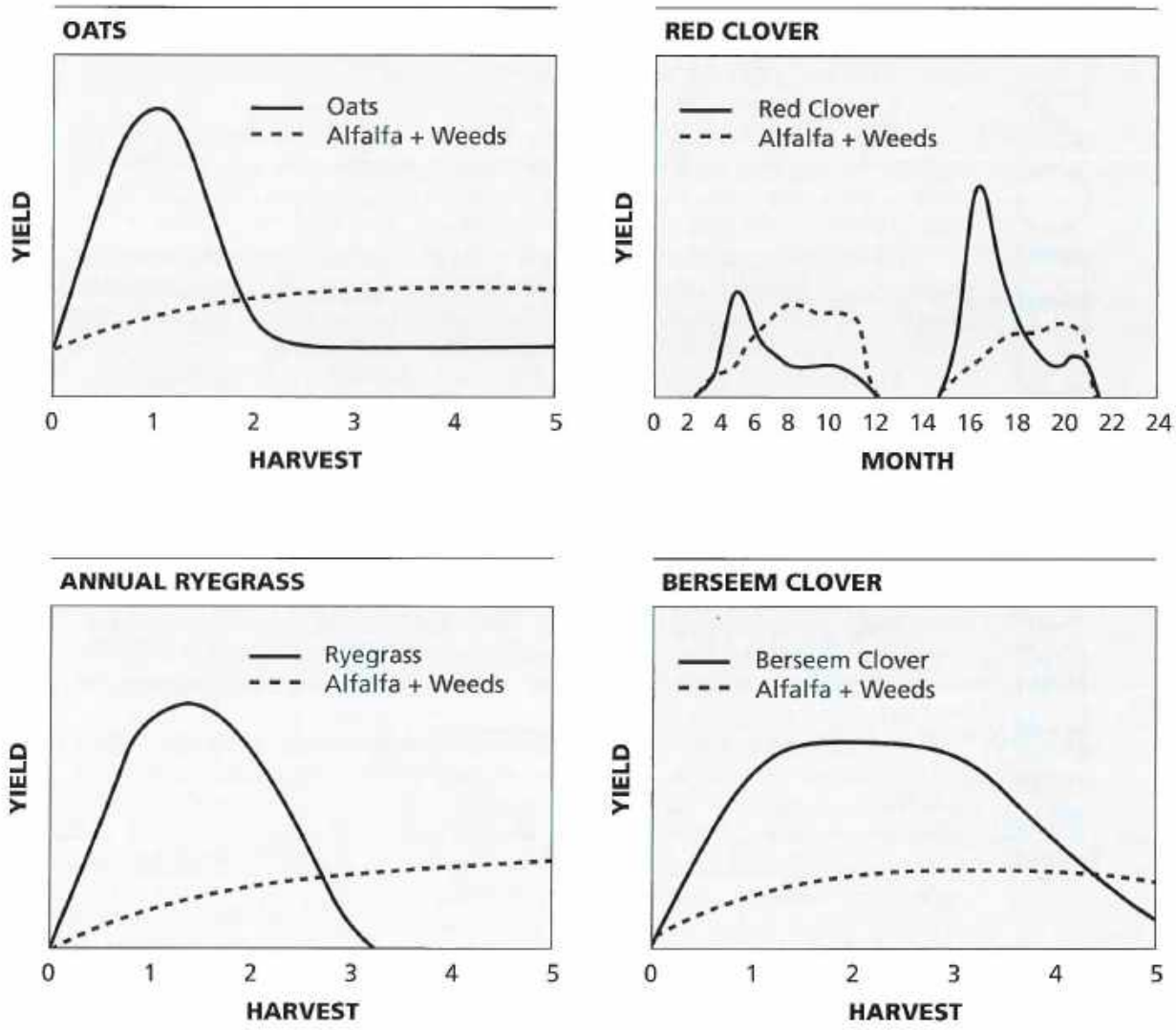
The publication emphasizes the alfalfa production areas of the San Joaquin Valley, the Sacramento Valley, and the Intermountain Region of California. The information provided is based on research and practical experience of University of California specialists, farm advisors, and growers. Although the recommendations or practices apply primarily to the Central Valley and Intermountain Region of California, they may also apply to other areas.

This publication is divided into two main sections. Overseeding is the planting of other forage species or alfalfa into existing alfalfa stands. Companion cropping (or nurse cropping) is the planting of a second species along with alfalfa during stand establishment. A companion crop is present only during the alfalfa establishment period, whereas an overseeded crop may exist for multiple cuttings or years.

Overseeding is the planting of other forage species or alfalfa into existing alfalfa stands. Companion cropping (or nurse cropping) is the planting of a second species along with alfalfa during stand establishment.

FIGURE 1

Yield patterns for selected legumes and grasses overseeded into alfalfa in the Central Valley of California. These are general yield trends; actual yields depend on the weather, cutting schedules, and management practices.



OVERSEEDING IN ALFALFA

WHY CONSIDER OVERSEEDING?

OVER TIME, ALFALFA STANDS DECLINE DUE TO NATURAL THINNING, DISEASE, WINTER INJURY, MACHINERY TRAFFIC, FREQUENT CUTTING, HEAT STRESS, AND RODENTS. Stand viability is evaluated by measuring the number of plants or stems per unit area. When alfalfa populations fall below 3 to 5 plants per square foot (32–54 per sq. m), yield begins declining (see plate 1). Table 1 shows the suggested plant density for alfalfa in the seedling and subsequent production years. Stem density is usually more important than plant density, since the number of stems per unit area also affects competition with weeds. Stem densities above about 55 stems per square foot (about 600 per sq. m) have been found to be adequate to maintain yields (table 2).

Overseeding another forage species into a depleted alfalfa stand can extend stand life and improve the yield.

As stands decline, weed control becomes increasingly difficult, because weeds invade areas left open due to dying alfalfa. Eventually, the yield and forage quality decline and a decision must be made whether to keep or remove the alfalfa. When faced with a declining alfalfa stand, growers may remove the stand and rotate to another crop; continue to harvest a depleted stand; or attempt to extend the stand life and increase production by overseeding another species or overseeding alfalfa.

Sometimes, removing the stand and rotating to another crop is not desirable because rotation crops may not be as profitable. Overseeding another forage species into a depleted alfalfa stand can extend stand life and improve the yield and marketability of the hay (see plate 2). However, the overseeded species and the harvest schedule must match market needs and be compatible with

TABLE 1.
MINIMUM STAND DENSITY REQUIRED TO MAINTAIN OPTIMAL ALFALFA YIELDS

Production year	Stand density (plants/ft²)
Seedling stand	>25 (range 25–80)
End of year 1	15–25
End of year 2	10–15
Year 3 or 4	6–10 (consider overseeding)
Following years	<3–5 (replace stand or overseed)

alfalfa for use as greenchop, silage, or hay. Potential overseeded forage species include annual and perennial grasses and legumes.

STAND ESTABLISHMENT METHODS FOR OVERSEEDED CROPS

Seedbed preparation is very important for successful establishment of any overseeded crop in alfalfa. Usually, a minimum amount of tillage is required. The objective of seedbed preparation is to break up the soil surface in the top 1 to 3 inches (2.5 to 7.5 cm), with enough tillage to kill weeds, but do minimal damage to alfalfa crowns (see plate 3). Normally one pass with a spring-tooth harrow (see plate 4), a light discing, or a power-driven (PTO) cultivator (see plate 5) is all that is necessary. If weed pressure is high or if the ground is hard, two passes may be required. Prior to tillage, excessive weed growth can also be removed by mowing or with herbicides. After seedbed preparation, planting can take place by broadcasting or drill seeding (see plate 6) or using a no till seeder. The field may need to be rolled behind the planter to firm the seedbed, break clods, optimize soil-seed contact, and enhance germination (see plate 7).

Overseeding can also be done using a conventional grain drill without seedbed preparation, provided the soil is sufficiently soft to allow penetration by the drill and to cover the seed.

Irrigation is often useful to promote early germination, which can lead to a uniform plant population and a vigorous seedling stand before cold winter weather. Seeding rates and timings depend on location, circumstances, and the species being planted (see table 3 and subsequent sections for details).

SELECTING THE RIGHT SPECIES FOR OVERSEEDING

The species selected for overseeding can affect yield (see fig. 1), forage quality, and the suitability of the forage for the end market (see sidebar below). Factors to consider are the desired time to keep in production (annuals or perennials, or number of harvests or years), climatic conditions, and the end-market user.

Overseeding grasses into alfalfa usually creates a mixture of hay that has a lower nutritional value than alfalfa hay alone. This hay is generally not suitable for lactating dairy cows but is acceptable for dry cows and appropriate for horses or other livestock. Grass-alfalfa mixtures generally provide sufficient energy and protein for most pleasure horses. Also, grass-alfalfa mixtures, especially mixtures with cereals, produce higher yields than legume-alfalfa mixtures.

Overseeding legumes into declining alfalfa stands creates a different forage product than overseeding grasses. Most clovers are comparable to alfalfa in nutritional value and therefore may be better suited for lactating dairy animals. Tests have shown the crude protein and fiber content of clover to be similar to dairy-quality alfalfa when cut at an appropriate stage. Clovers are not affected by the Egyptian alfalfa weevil and can withstand poorly drained, saturated soil conditions that are detrimental to alfalfa.

OVERSEEDING ANNUAL GRASSES

Cool-season annual grasses make the greatest contributions to yield early in the growing season and decline by midsummer. For this reason, using an annual grass is an appropriate choice if the alfalfa is to be removed after one or two cuttings. Annual cool-season grass species used for overseeding include cereals such as wheat, barley, oat, and triticale; and annual ryegrass.

TABLE 2.
STEM DENSITY RECOMMENDATIONS FOR EVALUATING ALFALFA STANDS

Stem density (stems/ft²)	Action
>55	Stem density not limiting to yield
40–55	Some yield reduction
<40	Consider replacing stand

Source: Undersander et al. 1994.

Factors to consider when selecting the most appropriate species and cultivar for overseeding in alfalfa

Yield and quality. Use variety trial results or local experience to determine the yield and quality characteristics of the different species. Fine-stemmed, leafy varieties are generally preferred as forage.

Disease management. Select species and cultivars that are known to withstand diseases.

Harvest compatibility. The first harvest of berseem clover or ryegrass may need to be greenchopped due to poor weather and haymaking conditions. Choose species that are compatible with harvest equipment.

Market. Consider forage quality, appearance, and the requirements of a specific market (i.e. dairy, horse, or beef).

Cereals

Wheat (*Triticum aestivum*), barley (*Hordeum vulgare*), oat (*Avena sativa*), and triticale (x *Triticosecale*) grow best under cool temperatures and contribute additional forage to the first harvest. Oat is the most common cereal crop used for overseeding (see plate 8). Hooded (or beardless) barley, hooded wheat, and triticale are also occasionally seeded into alfalfa and make excellent-quality forages if harvested at the right time.

Seeding date and rate. In the Central Valley of California, cereals grow best when planted from October to January (table 3). In the short-season Intermountain Region, planting should occur in late February to April.

Recommended cereal seeding rates range from 40 to 60 pounds per acre (45 to 67 kg/ha), depending on the date of planting and the existing alfalfa population. Higher rates are needed for later planting dates because tillering is less and height is reduced. When the alfalfa population is below 3 plants per square foot (32 per sq. m), higher seeding rates are recommended.

Yield, soil fertility, forage quality, and harvest considerations. The stage of maturity at harvest has a large effect on yield, quality, and the potential for regrowth of alfalfa-cereal mixtures (see table 4). An early harvest of alfalfa-cereal mixtures (before boot stage) provides higher-quality forage and allows for regrowth and a second harvest. Higher yields for alfalfa-cereal mixtures are in the dough stage, but mixtures harvested

TABLE 3.
SEEDING DATES AND RATES FOR CROPS OVERSEEDED INTO ALFALFA

	Seeding date by location		Seeding rate	
Crop	Sacramento–San Joaquin Valleys	Intermountain Region (Northern California)	lb/acre	kg/ha
ANNUAL GRASSES				
Cereals (oat, barley, wheat, triticale)	Oct–Jan	Feb–Apr	40–60	45–67
Tetraploid annual ryegrass	Oct–Dec	Feb–Apr	4–8	5–9
Sudangrass	May–Jun	not practiced	40–60	45–67
PERENNIAL GRASSES				
Orchardgrass	Oct–Dec	Aug–Sep or Mar–Apr	4–8	4.5–9
Tall fescue	Oct–Dec	Aug–Sep or Mar–Apr	4–8	4.5–9
Perennial ryegrass	Oct–Dec	Aug–Sep or Mar–Apr	4–8	4.5–9
Kemal festulolium	Oct–Dec	Aug–Sep or Mar–Apr	4–8	4.5–9
Bromegrass	Oct–Dec	Aug–Sep or Mar–Apr	20–30	22–33
Timothy	not practiced	Aug–Sep or Mar–Apr	4–6	4.5–6.7
ANNUAL LEGUME				
Berseem clover	Oct–Dec	not practiced	6–12	6.7–13.4
PERENNIAL LEGUME				
Red clover	Oct–Dec	not practiced	8–12	9–13.4

at this stage have a lower forage quality. Harvesting beyond the soft dough stage causes greater competition for the alfalfa and does not increase cereal yield. Alfalfa-cereal mixture yield is typically between 1 and 3 tons per acre (2.2 to 6.7 metric t/ha) greater than alfalfa alone. The first harvest is composed of 60 to 95 percent oat with a small amount of alfalfa, and later harvests contain a greater percentage of alfalfa. Curing time for alfalfa-cereal mixtures is generally longer than that for pure alfalfa.

Cereals overseeded into existing alfalfa should be fertilized according to the cereal requirements. Nitrogen fixed by the alfalfa crop is usually not sufficient for a full cereal forage yield. Apply 40 to 60 pounds per acre (45 to 67 kg/ha) of nitrogen to most soils when cereals are 4 to 6 inches (10 to 15 cm) tall and in late vegetative stage. Fertilizer applications should be made in advance of rainfall or irrigation for proper utilization. Dry fertilizers of urea, ammonium sulfate, or ammonium nitrate are common sources of nitrogen used for this purpose. Avoid applying excessive nitrogen fertilizers, since this may lead to excess nitrates in the forage.

Varieties. Cereals differ in yield and forage quality. Some varieties are also susceptible to leaf diseases that can affect forage yield. Therefore, you should select varieties that are well adapted to your area (consult your local UCCE farm advisor for the best-suited varieties). Varieties of oat differ in their susceptibilities to crown rust, stem rust, leaf blight and powdery mildew (table 5). These fungal diseases affect foliage and lower yields. Oat varieties also differ in their susceptibility to barley yellow dwarf virus and viruses spread by aphids. Viruses can stunt plants and reduce yields, particularly in early plantings when aphid flights occur.

TABLE 4.
STAGES OF MATURITY OF GRASSES AND LEGUMES

Stage	Description
GRASSES	
Vegetative	Leafy growth; few stems; no reproductive growth
Late vegetative	Stem elongating; seed head felt beneath the sheath
Boot	Seed heads begin to emerge
Early bloom	At least 25% of plants have seed heads emerged
Midbloom	Pollen beginning to shed; 75% of plants have seed heads emerged
Full bloom	100% of plants have seed heads emerged; peak pollen shed
Milk	All seed heads emerged; seed forming; seed soft, milky, and immature
Dough	Seed becoming harder, has dough-like consistency
Mature	Seed dry, hard, and ready for harvest
LEGUMES	
Vegetative	Leaf and stem growth; no buds, flowers, or seed pods
Early bud	Buds beginning to swell and become visible at a few nodes
Late bud	Several nodes with buds; buds more swollen
Early flower	About 25% of buds open; flower color visible
Midflower	50–75% of flowers visible
Late flower	More than 75% of flowers visible
Early seed	Green seed pods visible on a few flowers
Late seed	Many green pods visible; some seed pods turning brown
Mature	Seed pods brown to black and dry; ready to harvest as moisture content permits

Annual Ryegrass

Annual ryegrass (*Lolium multiflorum*), or Italian ryegrass (see plate 9), is a cool-season grass that has gained popularity in recent years because of its high yield potential and ability to withstand wet, saturated soils. Alfalfa-ryegrass mixtures have gained popularity for the horse and dairy industries. Like cereal grains, ryegrass is also planted in the fall.

Cultivars of ryegrass have not been widely tested in California. There are two basic groups: diploids and tetraploids. The distinction between the two groups is based on the number of chromosomes in each plant cell (there are twice as many in the tetraploids). Tetraploid ryegrass varieties often have larger leaves and fewer but larger tillers, and they produce a more open canopy (less ground cover). These may be better suited for production in alfalfa mixtures than diploid annual ryegrass. Tetraploids have been shown in some trials to have higher digestibility and grazing preference compared with diploids.

Seeding date and rate. Planting dates for ryegrass are similar to winter cereals. Planting begins in the fall from October through December in the Central Valley (Sacramento and San Joaquin Valleys). Seeding rates range from 4 to 8 pounds per acre (4.5 to 9 kg/ha). Lower rates are used when a higher alfalfa to grass ratio is desired. Higher rates may be necessary if seedbed conditions are poor or if the alfalfa population is extremely low. Under ideal seedbed conditions, few differences are found between using 4 or 8 pounds per acre (4.5 to 9 kg/ha) of seed.

TABLE 5. *
CHARACTERISTICS OF OAT CULTIVARS GROWN IN CALIFORNIA

Cultivar	Maturity	Height	Stem fineness	Straw strength	Planting date (region)*	Resistance to pests†				
						BYD	StR	CrR	BRKN	SBN
Ajay	late	short	—	good	spring (5)	—	—	—	—	—
Bates 89	late	tall	fine	fair	fall (1,2,3,4)	MR	R	MR	—	—
California red	late	tall	fine	poor	fall (1,2,3,4)	S	S	MS	S	S
Cayuse	late	tall	coarse	fair	fall (1,2,3,4) spring (5)	MS	R	MS	R	R
Curt	early	very short	fine	poor	fall (1,2,3,4)	S	MR	S	R	R
Kanota	early	tall	fine	poor	fall (1,2,3,4)	S	S	S	R	R
Monida	medium	tall	—	good	spring (5)	—	—	—	—	—
Montezuma	early	medium	fine	poor	fall (1,2,3,4)	S	S	S	S	S
Ogle	medium-late	tall	coarse	excellent	spring (5) fall (1,2,3,4)	MR	R	R	—	—
Pert	late	short	coarse	excellent	fall (1,2,3,4)	MR	R	MS	—	—
Sierra	medium-early	tall	coarse	fair	fall (1,2,3,4)	S	S	S	S	S
Swan	medium-early	tall	medium	good	fall (1,2,3,4)	MR	S	S	S	—

Note: Please refer to the UC IPM website (http://www.ipm.ucdavis.edu) or the Agronomy Research and Information Center website (http://agronomy.ucdavis.edu/agronomy/prgrpt.htm) for updated listings.

***REGIONS**

1: Sacramento Valley and Delta
2: San Joaquin Valley
3: Coastal
4: Southern Desert Valley
5: Intermountain

† ABBREVIATIONS

BYD: barley yellow dwarf virus
StR: stem rust
CrR: crown rust
BRKN: barley root knot nematode
SBN: stem and bulb nematode
R: resistant
MR: moderately resistant
MS: moderately susceptible
S: susceptible
—: no information

Yield, soil fertility, and harvest considerations. Annual ryegrass provides excellent winter growth under a wide range of soils and weather conditions. In research trials, it has shown a superior ability to withstand cereal leaf diseases and produces excellent yields under wet conditions.

Ryegrass overseeded into alfalfa can significantly increase yield in the first, second, and even third cutting of the season, provided soil moisture is adequate. The vigorous winter growth of ryegrass may necessitate an earlier harvest compared with overseeded oat or wheat. Ryegrass usually cures faster than cereals. Early harvests in March or April are commonly green-chopped or ensiled; later harvests can be baled for hay when weather conditions are favorable. Annual ryegrass growth diminishes as temperatures increase and does not persist beyond three spring cuttings. To maximize yield in a ryegrass-alfalfa mixture, it may be necessary to add 40 to 60 pounds per acre (45 to 67 kg/ha) of supplemental nitrogen. Soils with sufficient levels of phosphorus and potassium for alfalfa are also adequate for the grass component of the mixture.

Annual ryegrass is an excellent candidate for overseeding alfalfa when dairy manures are applied. Growth is typically enhanced with manure applications, and ryegrass can sustain saturated conditions better than many other species. However, it is highly competitive with alfalfa under these situations and may dominate the mixture.

Sudangrass

Sudangrass (*Sorghum bicolor*) and sorghum-sudangrass crosses are currently the only warm-season grasses occasionally overseeded into alfalfa in late spring or summer. These grasses thrive under high temperatures and do poorly under cool conditions. Sudangrass has been seeded into alfalfa stands late in the spring when alfalfa has been severely damaged from winter flooding and it is too late to plant other (cool-season) species.

Seeding date and rate. Soil temperatures should be above 60°F (15.6°C) at 1½ inches (4 cm) deep before planting sudangrass. Under these conditions, seed germinate in less than 1 week. Usually, these soil temperatures do not occur before late March or April in the Southern San Joaquin and Imperial Valleys, or before and April or early May in the Sacramento Valley. Sudangrass can be planted after the first, second, or even third cutting of alfalfa, depending on the location.

Sudangrass can produce multiple tillers and coarse stems if low seeding rates are used with long harvest intervals. Therefore, a seeding rate of 40 to 60 pounds per acre (45 to 67 kg/ha) is suggested to minimize stem size and reduce the number of tillers.

Yield, soil fertility, and harvest considerations. Research and field experience on sudangrass-alfalfa mixtures is limited. Harvest scheduling should be a function of market and end use. Experience suggests that harvesting sudangrass-alfalfa mixtures on a 30- to 40-day schedule produces good-quality horse hay during the summer months. The crop should be about 24 to 30 inches (60 to 75 cm) tall at harvest for these markets. Harvest at a later maturity (about 48 inches [1.2 m] tall) produces higher yields but the forage quality is more appropriate for ensiling purposes. When harvesting, leave at least 6 inches (15 cm) of stubble to ensure regrowth and stand persistence.

It is important for growers to test sudangrass forage (especially young sudangrass) to monitor nitrate and prussic acid levels. Take caution to avoid moisture stress or frost injury, or excessive nitrogen fertilizer applications, which increase the risk of nitrate and prussic acid accumulation in sudangrass. General nitrate and prussic acid levels of concern are provided in table 6. Feeding hay with moderate levels of nitrates can be done, but the whole ration, type and condition of animal, water source, and other factors must be considered.

Overseeded sudangrass should be fertilized according to recommendations for sudangrass, since little alfalfa is likely to remain because of sudangrass's vigorous summer growth and competitive nature. Nitrogen application rates of over 70 pounds per acre (78 kg/ha) per cutting have not increased forage yields in Imperial Valley studies, and typically the first growth period may be supplied with nitrogen from the alfalfa. Therefore, nitrogen application rates of 40 to 70 pounds per acre (45 to 78 kg/ha) per harvest period is recommended, with higher applications needed as the crop utilizes soil nitrogen later in the season (the crop should

TABLE 6.
GUIDELINES FOR PRUSSIC ACID (HCN) AND NITRATE NITROGEN (NO^3-N) CONCENTRATIONS FOR SUDANGRASS FORAGE (100% DRY MATTER BASIS)

Forage condition	HCN (ppm)	NO^3-N (ppm)
Generally safe, usually no concern	<500	<1,000
Moderate concern, rations should be monitored	500–750	1,000–4,000
High concern, potentially toxic when fed	>750	>4,000

PLATE 1. Alfalfa plant population below acceptable range.

PLATE 2. Large windrows of alfalfa-oat hay mixture.

PLATE 3. This field was broadcast-seeded then lightly tilled with a spring-tooth harrow to cover seed.

PLATE 4. Spring-tooth cultivator preparing a seedbed in an older alfalfa stand.

PLATE 5. PTO cultivator preparing a seedbed in tough soil conditions.

PLATE 6. Overseeding berseem clover using a brillion seeder.

PLATE 7. Rollers are used to firm the seedbed and incorporate seed.

PLATE 8. The alfalfa-oat mixture is well suited for the horse market.

PLATE 9. Overseeding annual ryegrass substantially increases early-season yield.

PLATE 10. The orchardgrass-alfalfa mixture is popular in high-elevation climates.

PLATE 11. Kemal festulolium (tall fescue–ryegrass cross) is well adapted for warmer climates.

PLATE 12. Tall fescue fills in rapidly in summer.

PLATE 13. Timothy-alfalfa hay is highly regarded in the horse market.

PLATE 14. Berseem clover leaf (*left*) closely resembles alfalfa, but alfalfa's middle leaf has an extended petiole.

PLATE 15. Berseem clover can increase yields but takes longer to cure.

PLATE 16. Berseem clover seeded with annual ryegrass is a high-yielding annual hay crop.

PLATE 17. Overseeded red clover fills gaps in old alfalfa stands after the first year.

PLATE 18. Small alfalfa seedlings can be shaded by larger alfalfa plants when reseeded into existing stands.

PLATE 19. Reseeded alfalfa germinating in a seedling stand damaged by winter rains.

PLATE 20. New alfalfa germinating near older plants initially appear to be successful but may stunt and die by season's end.

PLATE 21. Oats as a companion crop in seedling alfalfa offer protection from wind and soil erosion.

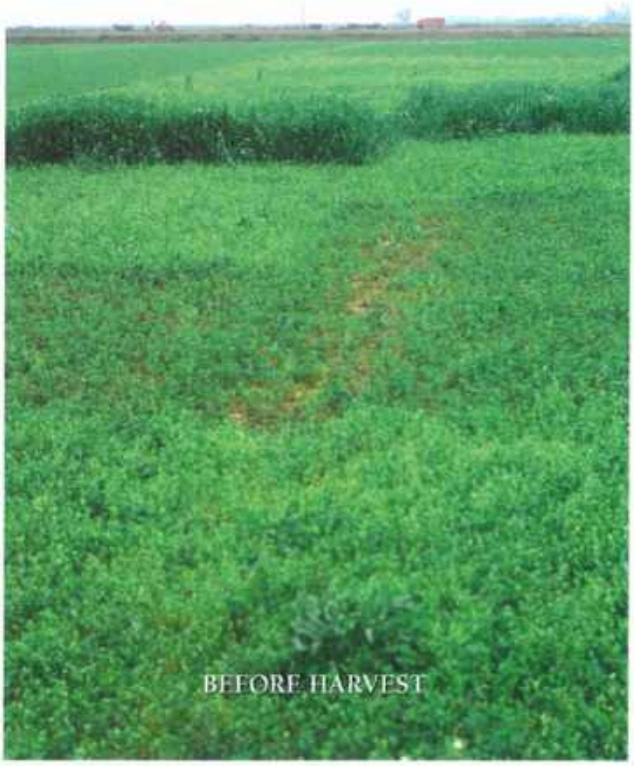


PLATE 22. Background plots show companion oats planted at too high a density, competing with seedling alfalfa.

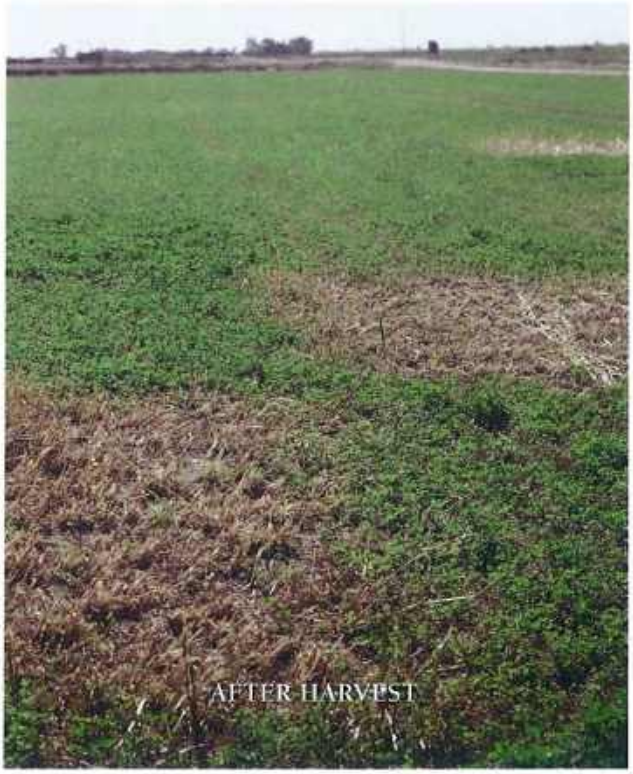


PLATE 23. The same plots as in plate 22, after harvest; bare spots show alfalfa stand loss due to oat companion crop competition.

PLATE 24. Berseem clover mixed in alfalfa can be distinguished by leaf type and a lighter green color.

PLATE 25. Early harvest of berseem clover–alfalfa are dominated by berseem clover.

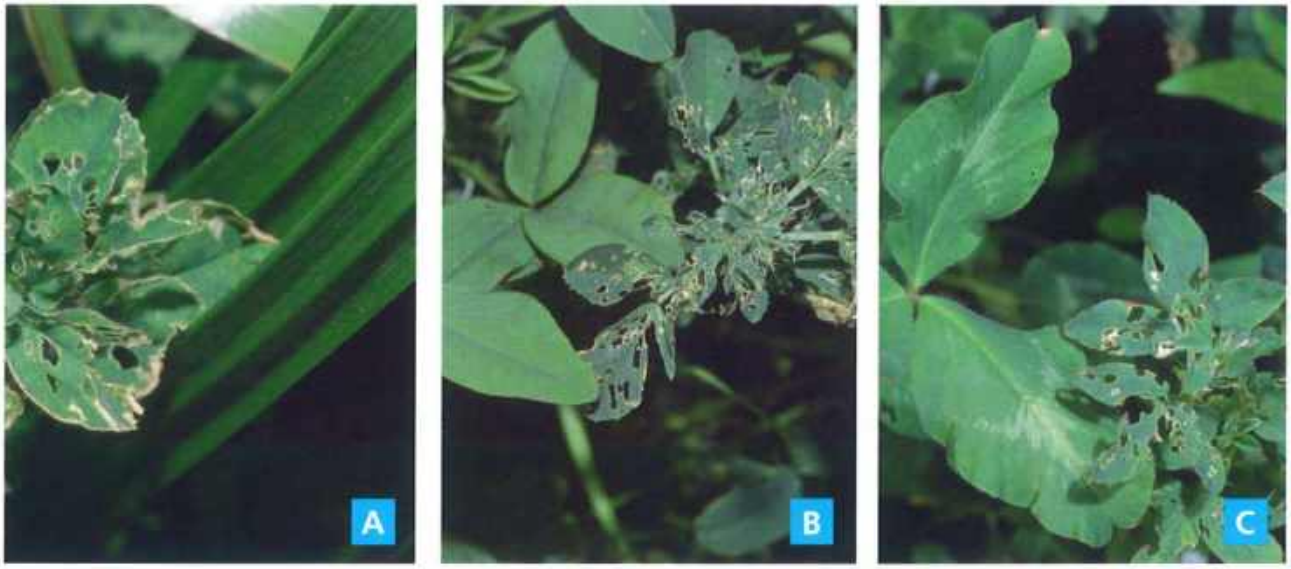


PLATE 26. Alfalfa weevil severely damages alfalfa but does not feed on ryegrass (**A**), berseem clover (**B**), or red clover (**C**).

PLATE 27. Overseeding clover (**A**) or grasses (**B**) can reduce weed invasion.

PLATE 28. Red clover harvested before flowering provides a high-quality forage.

PLATE 29. Oat-alfalfa hay baled properly makes an attractive product.

PLATE 30. Clover hay produces a brownish color, which may limit marketing.

PLATE 31. More bales are produced at the first harvest of alfalfa-oat mixture (*left*) than are produced with pure alfalfa.

be monitored to avoid excess nitrate accumulation). Two to three harvests are possible in the Central Valley. About 7 to 10 days of curing are required before baling. Since export markets demand a pure sudangrass product, sudangrass-alfalfa mixtures may not be appropriate for these markets.

OVERSEEDING PERENNIAL GRASSES

Perennial grasses are desirable for overseeding into alfalfa when the goal is to extend the alfalfa stand for more than a single year, up to 3 years or longer. However, the relative proportion of grass to alfalfa usually increases as the stand ages. Overseeding perennial grasses is practiced in the Central Valley to take advantage of the demand for mixed hay for the horse market.

Compared with annuals, perennial grasses are slow to establish, and one season is usually required before a full yield potential is reached. However, once established, they survive for several years and predominate in weak areas of the stand. Perennial grasses provide significant competition with and suppression of undesirable summer weeds.

Choosing Perennial Grasses for Overseeding

Several perennial grass species have been evaluated for overseeding into alfalfa in California. They include tall fescue, perennial ryegrass, orchardgrass, kemal festulolium (tall fescue-ryegrass cross), timothy, and bromegrass. These are all classified as cool-season grasses and produce best in spring and fall. The expected yield, quality, marketability, and expected stand life should be taken into consideration when deciding which perennial grass to interseed. No single perennial grass is best suited for all conditions and locations.

Orchardgrass (*Dactylis glomerata*) (see plate 10) is well suited for overseeding in the Intermountain Region of Northern California. It is high yielding, palatable, and compatible with alfalfa. It is highly valued by the horse market. However, orchardgrass is not heat tolerant and has not performed well in the hotter regions of the Central Valley.

Perennial ryegrass (*Lolium perenne*) and kemal festulolium (a ryegrass-fescue cross) (see plate 11) produce well in the Central Valley of California and contribute mostly to first-cut yield. However, it is so competitive with alfalfa in the spring that the alfalfa yield of summer cuttings is often reduced. For this reason, it has also been blended with other species to increase summer productivity. Perennial ryegrass has not persisted as well in the Intermountain Region due to winter injury .

Tall fescue (*Festucum arundinacea*) (see plate 12) is easy to establish and has been the highest-yielding perennial grass in several tests in different areas of California. However, the market acceptance of tall fescue-alfalfa hay is not as great as it is for other alfalfa-grass hays. In addition, tall fescue is so aggressive that, over time, it chokes out the alfalfa. If an alfalfa-grass mixture is desired for only 1 or 2 years, tall fescue may be a good choice because of its rapid establishment and high yield potential.

Bromegrass (*Bromus inermis*) has generally been found to be much less competitive with alfalfa than other grasses and can be used in as an overseeding crop. However, bromegrass can be difficult to establish and yields are usually lower than for other perennial grasses.

Timothy (*Phleum pratense*) hay (see plate 13) is highly valued by the horse market and has high market acceptability for exports. Because timothy is adapted to environments where cool summer weather and moist soil conditions prevail, it is grown only in portions of the Intermountain Region. Timothy is not heat tolerant and is not suited for the Central Valley. Stand establishment of timothy can be extremely slow and difficult in overseeding situations. Even under favorable growing conditions, timothy does not yield as well as many other perennial grasses when overseeded into alfalfa.

Seeding date and rate. Seeding rates for perennial grasses depend on the condition of the seedbed and the size of the seed (table 3). Lower rates can be used with an ideal seedbed in which a fine, smooth and level surface is prepared. Ryegrass, kemal festulolium, tall fescue, and orchardgrass are intermediate in seed size and can be seeded at 4 to 8 pounds per acre (4.5 to 9 kg/ha). Bromegrasses have a large seed and are therefore generally seeded at 20 to 30 pounds per acre (22 to 33 kg/ha). In contrast, timothy is a smaller seed and is sown at 4 to 6 pounds per acre (4.5 to 6.7 kg/ha).

For the Central Valley, fall planting from September-October into November may be appropriate. During this period, cool temperatures are conducive for germination and seedling growth. Earlier fall plantings (September-October) require irrigation for stand establishment, and they germinate before winter weeds. Later plantings (November) that utilize rainfall for germination often contend with increased winter weed competition.

In the Intermountain Region, perennial grasses are typically seeded from February to April, just as alfalfa breaks dormancy. With this planting date, perennial grasses establish slowly and do not yield much the first year. An alternative is to plant in late summer after the second to last or the last cutting of the season. This results in nearly full grass production the following year. Weed control is another consideration when selecting a planting date. In spring seedings, winter annual weeds are controlled at seedbed preparation. However, in a late-summer seeding, winter annual weeds begin to emerge after seeding, and these may reduce quality.

Yield, soil fertility, and harvest considerations. Perennial grasses seeded into existing alfalfa stands

eventually result in mixed stands with a dominance of grasses. Fertilizers should be applied according to the needs of the grass crop if maximum production is desired. Recommended nitrogen rates range from 30 to 60 pounds per acre (33 to 67 kg/ha) per season.

OVERSEEDING ANNUAL LEGUMES

Overseeding legumes into declining alfalfa stands offers several advantages to overseeding grasses. Legumes have higher crude protein and lower fiber than grasses, and they are usually suitable for the dairy market. Clover-alfalfa mixed hays also make excellent feed for horses, beef cattle, and sheep. Clovers generally survive longer than alfalfa on heavier-textured, saturated soils and have shown to not be affected by the alfalfa weevil or by the alfalfa caterpillar.

There are a number of annual legumes that can be sown into existing alfalfa fields, including arrowleaf clover (*Trifolium vesicolusum*), crimson clover (*Trifolium incarnatum*), Persian clover (*Trifolium resupinatum*), various annual medics (*Medicago* spp.), and common vetch (*Vica sativa*). However, for California, the highest-yielding and most immediately adaptable annual legume for overseeding appears to be berseem clover.

Berseem clover (*Trifolium alexandrinum*) (see plate 14) is a vigorous, upright annual clover that closely resembles alfalfa. When overseeded into alfalfa, berseem clover can significantly increase yield for the first three to four harvests (see plate 15). Berseem-alfalfa forage is of excellent quality, is bloat resistant, and is received favorably by horse and dairy markets. Yields of sole-cropped berseem have averaged about 6.8 tons per acre (15.2 metric t/ha) by July at Davis and up to 8.5 tons per acre (19 metric t/ha) in the Imperial Valley.

Seeding date and rate. In California's Central Valley, berseem clover is planted in the fall, from September to early November with early October being the optimum in most locations. Berseem clover grows quickly, when provided an irrigation for germination. It tolerates short periods of frost, though it is not as frost tolerant as small grains or alfalfa. Berseem clover is able to withstand saturated conditions on poorly drained soils. Midwinter or spring plantings have not been as successful in the Central Valley as have fall plantings.

Berseem clover seed is similar to alfalfa in size and shape. It requires a shallow planting depth of less than ½ inch (12.5 mm), with a fine-textured to medium-textured seedbed for rapid germination. Seeding rates from 6 to 12 pounds per acre (6.7 to 13.4 kg/ha) have been shown to maximize the yield potential but still keep a good balance of alfalfa to clover.

Inoculation. The *Rhizobium* bacterium that fixes nitrogen in association with berseem clover differs from that which nodulates in alfalfa. Therefore, *Rhizobium leguminosarum biovar trifolii* bacteria inoculum specific to berseem clover should be used to inoculate the seed before seeding, except in cases where a field has previously grown berseem clover. This is an important step at planting to encourage proper development of nitrogen-fixing nodules on the roots.

Berseem has shown a vigor and growth response when manure waters were used as a source of irrigation. This offers good potential for use in a dairy operation to manage manure utilization, especially given the need for high-quality forages at dairies.

Yield, harvest, and forage quality considerations. Berseem clover overseeded into alfalfa has boosted annual yields by up to 2 tons per acre (4.5 metric t/ha) over alfalfa alone, mostly in the first three harvests. The optimal temperature for berseem clover is cooler than that for alfalfa, though berseem clover is not as frost tolerant as alfalfa. Therefore, under most conditions, the winter and spring growth of berseem clover exceeds that of alfalfa. However, it is often a challenge to cure hay in the early spring due to frequent rains. This is probably the major drawback to the use of berseem clover for hay. This problem may be managed where the option for silage, greenchop, grazing, or haylage exists. Excellent-quality berseem hay can be produced from the second through fourth cuttings. By midsummer, the growth of berseem clover slows, the plants flower early, production is much lower, and stand removal is often necessary.

When harvested on the same schedule, berseem clover has a similar acid detergent fiber (ADF) and total digestible nutrient (TDN) value, and has a slightly lower crude protein (CP) than alfalfa. Berseem clover does not generally cause bloat and has been used for centuries in Egypt as an animal feed. Berseem clover hay can enter the same markets as good-quality and premium-quality alfalfa, but it is also suitable for the horse market (see plate 16). Care should be taken to prevent high-moisture berseem-alfalfa hay from molding, especially for the horse market.

Weedy fields have not been as successful for berseem clover–alfalfa overseeding due to the limited availability of registered herbicides to control broadleaf weeds. In these situations, a higher seeding rate should be used to help berseem clover compete with weeds.

Phoma blackstem (*Phoma* spp.) is a fungal disease that sometimes affects berseem clover. Symptoms include a blackening of leaves and stems, sometimes leading to plant death. Because this disease is favored by wet conditions, only the first cutting of berseem is affected. Berseem clover is also susceptible to viruses that can cause severe yield and stand loss. The variety Joe Burton has greater tolerance than Multicut and other cultivars to these viruses. Joe Burton and Multicut are the varieties currently best adapted to the Central Valley.

OVERSEEDING PERENNIAL LEGUMES

Overseeding perennial legumes may extend the life of a depleted alfalfa stand for 2 to 3 years. Red clover (*Trifolium pratense*) (see plate 17) is usually the best perennial legume for overseeding into alfalfa for hay production. Red clover is higher yielding than many of the other clovers and has an upright growth habit suitable for haymaking. Because it is known for its tolerance of poorly drained soils, it will perform better than alfalfa in areas of poor drainage, such as field ends or areas compacted by harvest equipment.

Seeding date and rate. Perennial clovers are slower to establish. Therefore, they should be planted in the fall in the Central Valley, late fall in the Imperial Valley, and midsummer in the higher elevations. By midseason, red clover generally has filled in the areas of missing alfalfa and begins to contribute significantly to yield. Maximum production may be realized in the second year.

Overseeding red clover at the rate of 8 to 12 pounds per acre (9 to 13.5 kg/ha) is likely to be sufficient under most conditions. Light tillage to loosen the soil crust is necessary. Broadcast or drill methods of planting can be used. Small-seeded crops like red clover require good contact between the soil and the seed, so rolling is often beneficial. Applying an irrigation for germination is recommended to insure an early uniform plant population.

Yield, forage quality, and harvest considerations. Red clover forage is comparable to alfalfa with regards to total digestible nutrient and crude protein values and is very competitive against weeds. Yields are highest in the spring and fall and decline during hot summer weather. Red clover has increased yields by 2 tons per acre (4.5 metric t/ha) where alfalfa stands were in poor condition. Its higher moisture content than alfalfa and longer curing time increases the risk of rain damage. Therefore, in dairy-producing areas, red clover is usually green-chopped or ensiled at the first cutting. This insures quick removal of forage and avoids the potential for damaged hay. Rain-damaged clover takes on a darker brown color than normal, making it visually less attractive in the horse market. Once the weather favors good hay-making conditions, clover-alfalfa mixtures produce an excellent-quality product.

OVERSEEDING ALFALFA INTO ALFALFA

When an alfalfa stand falls below the minimum population for optimal production it is often tempting to think that overseeding alfalfa into the existing stand may help. To the contrary, the majority of attempts at overseeding have resulted in stand failure or in no yield benefit at year's end (see sidebar at right). Overseeding alfalfa into established alfalfa has been practiced in the Imperial Valley, and it has perhaps been more successful there than elsewhere in California.

It is important to evaluate the original cause for alfalfa disappearance to be able to judge the probability of success of overseeding alfalfa. When did plant losses begin to occur? Were losses due to poor soil drainage, salt effects, aggressive cutting schedule, poor tailwater management, equipment traffic damage, rodents, diseases, or other problems? Are there factors such as impermeable soil layers that initially caused the stand loss? A careful analysis of these issues may prevent the wasting of seed and money on a reseeding project.

Since the problems of overseeding into a new stand or older alfalfa stand differ, they are discussed in two separate sections.

Overseeding Alfalfa into Young Alfalfa Stands

There are circumstances during alfalfa establishment that may create less-than-optimal stands just after seeding. Seedling stands with a population that falls below 10 plants per square foot may be a good choice for overseeding. Factors that contribute to poor stands are

- poor seed quality (low germination)
- excessively deep or shallow seed placement
- poorly prepared seedbeds
- disease, weeds, or insect pest problems
- flooding
- inadequate irrigation uniformity
- environmental factors (drought, wind)

Problems with overseeding alfalfa into existing alfalfa stands

Most attempts at reseeding alfalfa into older alfalfa stands result in failure. The major factors that contribute to this failure are

Competition for light, water, and nutrients. Alfalfa seedlings are slow to establish, making them weak competitors when growing near other established plants. An alfalfa seedling surrounded by mature alfalfa plants and weeds has little chance to utilize the water and light needed for establishment (see plate 18).

Autotoxicity. Alfalfa germination is inhibited by naturally occurring chemicals released from decomposing leaves, stems, and roots of mature alfalfa plants.

Disease. Soilborne diseases can develop after years of continuous alfalfa growth. Equipment compaction, weeds, and buildup of other pests also create an environment that is less than ideal for the survival of new plants.

Growers are often faced with the question of whether newly seeded fields can be improved by overseeding. When overseeding is timed so that existing alfalfa plants are still small, less than 6 inches (15 cm) tall, and adequate soil moisture is available for germination, the success rate is high.

Successful planting practices have included the use of a disc-type grain drill (or no-till drill) without tillage to place seed ½ to ¾ inch (12.5 to 19 mm) deep, with minimal disturbance of existing plants (see plate 19). If broadcast seeding methods are used, the seed should be pressed into the soil with a smooth or ring-type roller. Use of a spring or spike-tooth harrow is not recommended since it can remove or damage many young plants that have less than a 6-inch (15-cm) root. When weeds are a problem, excess tillage or disturbance should be avoided to protect the existing alfalfa population. Weed problems can be controlled using postemergence selective herbicides (see table 7).

It is important to overseed into the stand as soon as possible after the problem is identified. Overseeding should occur when the existing plants are small. Large alfalfa plants create greater competition with the emerging seedlings. Although there is some competition and allelopathy (suppression of growth of one plant species by another due to the release of toxic substances) from the existing young alfalfa plants, this hazard of overseeding is not as great as when alfalfa becomes mature and fully established.

Common overseeding rates range from 10 to 20 pounds per acre (11 to 22 kg/ha). It is important to provide adequate soil moisture in overseeded alfalfa to ensure rapid and uniform germination, similar to the requirements for a newly seeded alfalfa field. This moisture can be from rainfall or from sprinklers or flood irrigation. Competition from existing plants can be severe if the crop is not well watered.

Compatibility with and crop safety of herbicide treatments for overseeding alfalfa should be checked. If the existing crop has been sprayed, some alfalfa herbicides will damage the newly germinating seedlings. Review the herbicide history of the field and read the pesticide label before overseeding.

Overseeding Alfalfa into Established Alfalfa Stands

Some areas of the United States claim good success by reseeding alfalfa every couple of years to maintain a stable plant population. However, reseeding alfalfa into established stands can be problematic. Most efforts to overseed alfalfa into well-established alfalfa stands have proven to be unsuccessful or do not result in significant yield or economic gains (see plate 20).

In California, overseeding alfalfa is commonly practiced in the Imperial Valley, where it appears to be more successful than in the Central Valley. There are several factors that contribute to this success. Overseeding is typically done in late fall, which is more favorable for seedling development due to cool temperatures and short day lengths. Warm winter temperatures in the desert create a favorable environment for germination and seedling development, and it is easier to manage water applications for seedling development in a region with less than 4 inches (10 cm) of rainfall. The desert environment provides opportunities to harvest alfalfa in December, January, or February (either through grazing or haying), so that existing plants do not excessively compete with young seedlings.

The most common cause of stand loss may be "scald," or stand death due to oxygen depletion in the root zone during irrigation in the high temperatures of summer. This is a particular problem in the Imperial Valley, but it is also common in other flood-irrigated areas. Other causes of stand loss are frequent harvests and wheel traffic compaction. Winter flooding is an important cause of stand loss in the Central Valley and on heavy soils. Stand loss is a frequent occurrence in the "tail ends" of flood-irrigated fields due to irrigation mistakes or inadequate drainage.

Growers attempt to overseed these areas in an effort to increase the alfalfa stand. Even in the Imperial Valley, these efforts are often frustrating and unsuccessful. Often, a good plant population appears to have been established, but later in the season, seedlings die and the stand declines. If the original cause of the alfalfa loss is not corrected, the new seedlings are subject to the same hazards that originally damaged the stand.

Although overseeding alfalfa into existing alfalfa stands can improve stand density in some situations, the practice is not recommended as the first choice. If economics favor rotating to a different crop, crop rotation holds a number of agronomic advantages, such as breaking disease cycles and creating opportunities for weed control. If economics favor continuation of the alfalfa crop, overseeding alfalfa may be successful, depending on the situation and the method used (see above). However, growers should be aware of the many reasons that overseeding alfalfa into alfalfa often fails as a method to sustain successful alfalfa stands.

COMPANION CROPPING IN SEEDLING ALFALFA

VULNERABILITY OF SEEDLING ALFALFA

ALFALFA SEEDLINGS DEVELOP SLOWLY, ALLOWING WEEDS OR ENVIRONMENTAL CONDITIONS TO AFFECT THE YOUNG PLANTS. Environmental factors such as wind, water erosion, and soil freezing can have a substantial impact on seedling development. These factors lower the population of alfalfa plants and reduce seedling vigor, thereby reducing the yield. Weed and erosion control during the period of alfalfa establishment is critical to a productive alfalfa crop.

Most weeds are of lower nutritional value than alfalfa. The greater the weed competition during establishment, the more serious the negative impacts on alfalfa vigor and population, thereby making the stand vulnerable to further weed invasions. In addition, weed seeds produced during stand establishment enter the soil bank and contribute to later weed infestations.

The intent of companion cropping is to plant a crop that will cover the soil more quickly than the primary crop and be of higher forage quality than germinating weeds.

Alfalfa seedlings offer little protection to the soil from rain or wind erosion. In addition, alfalfa seedlings can be killed or damaged by blowing soils or moving water. It takes months for the alfalfa plant to develop a root structure sufficient to hold the soil in place or to develop a canopy that reduces soil erosion. Once established, however, alfalfa is an excellent soil stabilizer.

Planting a companion crop is an alternative to chemical weed control and is a strategy to lessen the effect of soil erosion in the establishment year. Companion crops may also increase early-season forage yield. The primary hazard of companion cropping is excessive competition with young alfalfa seedlings.

RISKS AND BENEFITS OF COMPANION CROPPING

The intent of companion cropping is to plant a crop that will cover the soil more quickly than the primary crop and be of higher forage quality than germinating weeds. A companion crop in alfalfa should suppress weeds but not compete excessively with young alfalfa seedlings. This balance between weed suppression and the negative competitive effects on the young alfalfa plants is the challenge in companion planting. The success or failure of companion cropping depends on the companion species, cultivar, time of year, seeding rate, harvest schedule, and environmental conditions. Growers should carefully weigh the risks of companion planting (the potential for reduced alfalfa stand, vigor, and forage quality), with the potential benefits (reduced numbers of weeds, reduced need for herbicides, better erosion control, and increased yield).

OAT AS A COMPANION CROP IN SEEDLING ALFALFA

Oat has long been used as a companion crop to suppress weeds and prevent erosion during alfalfa establishment (see plate 21). Oat typically increases the total yield during the first harvest. However, oat is very competitive and may reduce the alfalfa stand if planted too early or if an excessive oat seeding rate is used.

Seedbed Preparation and Planting Method

Field preparation for alfalfa planted with an oat companion crop is similar to that for alfalfa planted alone. When planting without herbicides, preirrigate and cultivate germinated weeds before planting.

Planting oat with alfalfa is a two-step process because of the difference in seed sizes. Oat may be broadcast-planted by ground or air and incorporated with a harrow or disc prior to alfalfa seeding. Alfalfa is then broadcast or drill-planted at the standard seeding rate and covered lightly with a ring- or smooth-type roller (Alfalfa seed should be planted less than ½ inch [12.5 mm] deep.) Drill-seeding oat is also an option, but many grain drills are not calibrated to plant oat at rates low enough for companion plantings. Grain drills with fertilizer or small seed attachments that allow independent seed settings have been successfully used.

Seeding Rates, Dates, Nitrogen, and Weeds

Oat seeding rate is critically important to maximize yield and weed suppression without harming the alfalfa. High seeding rates, greater than 20 pounds per acre (22 kg/ha) of oat seed, increase yield and weed control but may have a long-lasting negative effect on alfalfa stand and vigor (see plates 22 and 23). Very low seeding rates, below 8 pounds per acre (9 kg/ha) may not have a measurable effect on yield or weed suppression. A seeding rate of approximately 8 to 16 pounds per acre (9 to 18 kg/ha) of oat seed is recommended. The best seeding rate may depend on the time of seeding and other factors that affect tillering and the competitiveness of the oat.

The optimal time to plant alfalfa in California's Central Valley is mid-September through mid-October. Very low seeding rates of oat as a companion crop are required when seeded in the fall. At later planting dates, a seeding rate of up to 20 pounds per acre (22 kg/ha) of oat as a companion crop may be appropriate.

Do not apply nitrogen to an alfalfa-oat seeding, as the oat may become too competitive. The negative impact of an excessive oat growth on seedling alfalfa can be seen for several cuttings and can even continue into the following year.

Oat fills the spaces between developing seedlings and competes with many weeds. Higher oat populations (a function of plant density and vigor) cause greater weed suppression. Bromoxynil (Buctril) or 2,4-DB herbicide can also be used for additional broadleaf weed control, as they are labeled for both oat and seedling alfalfa.

Varieties

A short-statured, midseason oat variety works best with an early-fall planting and is less likely to lodge and reduce alfalfa growth. Taller varieties have a tendency to lodge in the spring, damaging the alfalfa stand. Oat varieties should be leafy and fine-stemmed if they are to be sold as hay. Varieties with these characteristics and appropriate disease resistance should be used (see table 5).

Yield and Harvest Considerations

Oat companion crops generally increase first cutting yields by 1 to 2.5 tons per acre (2.2 to 5.6 metric t/ha) in Central Valley studies. However, the alfalfa component is low, and the alfalfa yield is also reduced in the second and third cutting compared to alfalfa seeded alone. The degree of alfalfa yield reduction varies with oat seeding rate and the vigor of the oat.

Provided the oat seeding rate is less than 20 pounds per acre (22 kg/ha), the yield reduction ranges from 0.1 to 0.8 tons per acre (0.2 to 1.8 metric t/ha) in the second cutting and 0.1 to 0.3 tons per acre (0.2 to 0.7 metric t/ha) in the third cutting. By the fourth cutting, yields may be equal to alfalfa seeded alone. The oat companion crop may increase yield from 1.0 to 2.5 tons per acre (2.2 to 5.6 metric t/ha).

The timing of harvest affects the quality of the oat-alfalfa hay, the overall yield, and the oat's competitive effects on the alfalfa. Earlier harvests of oat provide a lower-yielding but higher-quality forage and reduced competition for the seedling alfalfa. Lodged oat creates a considerable hazard for the developing alfalfa seedling by shading and smothering the young plants; the oat crop should be removed as soon as possible to protect the developing alfalfa seedling.

Erosion Control

Another incentive for companion cropping is to protect the soil from wind or water erosion. This is a problem on light sandy soils, loamy soils, or sloped soils. A tall crop such as oat reduces wind velocity near the soil surface and allows less dislodging of soil particles. Also, the additional leaf canopy reduces the size and speed of rain droplets and protects the soil from rapid water runoff. Although most California alfalfa fields are flat and without threat of water erosion, some fields are prone to erosion. In this situation growers may want to consider companion cropping with oat or no-till planting of alfalfa to reduce erosion.

BERSEEM CLOVER AS A COMPANION CROP IN SEEDLING ALFALFA

Berseem (or Egyptian) clover is an upright, cool-season annual forage legume that can be seeded successfully

with alfalfa (see plate 24). Unlike oat or other grasses, berseem clover provides a forage quality very similar to that of alfalfa. While seeding oat with alfalfa is a practice dating back many years, the use of berseem clover as a companion crop with alfalfa is relatively new.

Similar to oat, a berseem clover companion crop may improve first-cut yields. Unlike oat, berseem clover also contributes significant forage beyond the first cutting, typically for the first 4 cuttings in the Central Valley. As a cool-season annual, berseem clover declines significantly during the hot summer periods as the alfalfa dominates. Berseem clover is not as competitive with alfalfa as oat is. Its growth habit is similar to alfalfa and will not shade alfalfa as much as oat. Hence, it will typically not have as significant a competitive effect on alfalfa seedlings, but it also will not have as great a suppressive effect on weeds.

Land Preparation and Seeding Method

Land preparation methods for alfalfa with a berseem clover companion crop are no different than for alfalfa seeded alone. The seedbed should be level, fine, and firm. Excessive roughness or fluffiness of the seedbed can bury the seed too deep and prevent good germination.

Berseem clover seed can be mixed with alfalfa seed and broadcast or drilled. Or, the crops can be seeded separately in a cross-planting arrangement to fill in gaps, but this increases cost. Seeding depth should be similar to alfalfa, not exceeding ⅜ inch (9.5 mm), except for sandy soils, where a depth of ⅝ inch (16 mm) is acceptable.

Seeding Rate and Date

Research has shown that a wide range of berseem clover seeding rates is acceptable when planted with alfalfa. A seeding rate of 6 to 8 pounds per acre (6.7 to 9 kg/ha) of berseem clover planted with a full seeding rate of alfalfa (20 to 25 pounds per acre [22 to 28 kg/ha]), has been found to produce a yield benefit while minimizing competition with alfalfa and providing some competition with weeds. Lower berseem clover rates of 3 to 6 pounds per acre (3.4 to 6.7 kg/ha) may be acceptable if excellent seedling growth conditions are present. Berseem clover seeding rates above 12 pounds per acre (13 kg/ha) are probably unnecessary, increasing costs and causing excessive competition with alfalfa seedlings.

Alfalfa companion-cropped with berseem clover should be seeded at a time optimum for alfalfa, the primary crop. Mid-September planting is optimal for the Sacramento Valley, early October in most parts of the San Joaquin Valley, and mid-October for the Imperial Valley. Companion cropping with berseem clover is not recommended for the Intermountain Region, which has a shorter time for stand establishment.

Weed Problems

Berseem clover does not grow as rapidly as oat under winter conditions and will not compete with winter weeds as well as oat does. However, berseem clover grows more rapidly than alfalfa during the winter. Berseem clover survives winter weed infestation better than alfalfa seedlings alone but does not prevent weed competition with alfalfa seedlings. A berseem clover companion crop does not always eliminate the need for herbicides. The use of a berseem-alfalfa mixture should be coupled with other weed control strategies such as pre-irrigation to germinate weeds followed by cultivation. Some selective postemergence herbicides may be used for later-developing weeds, but only a few herbicides are registered and can be used in a mixed crop (see table 7).

Seed Inoculation and Soil Fertility

If properly inoculated, berseem clover obtains most of its nitrogen requirement from the atmosphere through symbiosis with *Rhizobium* bacteria. Therefore, berseem clover seed should be inoculated with bacteria specific for berseem clover (*Rhizobium leguminosarum biovar trifolii*). The soil fertility requirement for a mixed berseem-alfalfa crop is similar to that for alfalfa alone.

Yield and Harvest Considerations

Berseem-alfalfa mixtures typically yield more than alfalfa alone for the first three to four cuts in the spring. Thereafter, berseem clover yields rapidly decline to very low levels by late summer. Berseem-alfalfa mixtures are higher yielding (10 to 40 percent) than alfalfa planted alone for the first three cuts in the Central Valley. These early harvests are dominated by berseem (60 to 90 percent of the dry matter weight, or DM) (see plate 25). From approximately the fourth cutting to the end of the season, alfalfa dominates the mixture. There may be a small degree of suppression of alfalfa yields after the berseem clover disappears in the summer, but this depends on the seeding rate, timing, and other factors.

Probably the major disadvantage of berseem-alfalfa mixtures is the high yield of high-moisture forage harvested early in the season. Berseem takes longer to cure than alfalfa due to the high moisture content of the forage. Berseem-alfalfa mixtures are ideally suited to systems where the first harvest is taken as a grazing crop or for greenchop or silage.

Phoma blackstem, a foliar disease of berseem clover, may reduce the yield of berseem clover in wet winters. The disease is characterized by blackened lower leaves and, in later stages, by black lesions on the stems. This disease apparently does not affect alfalfa. Single-cut berseem clover varieties (such as Fahl and Tabor) are most severely affected. A winter grazing or clipping may remove excessive winter growth that encourages foliar diseases.

Pest Interactions in Mixed Alfalfa Crops

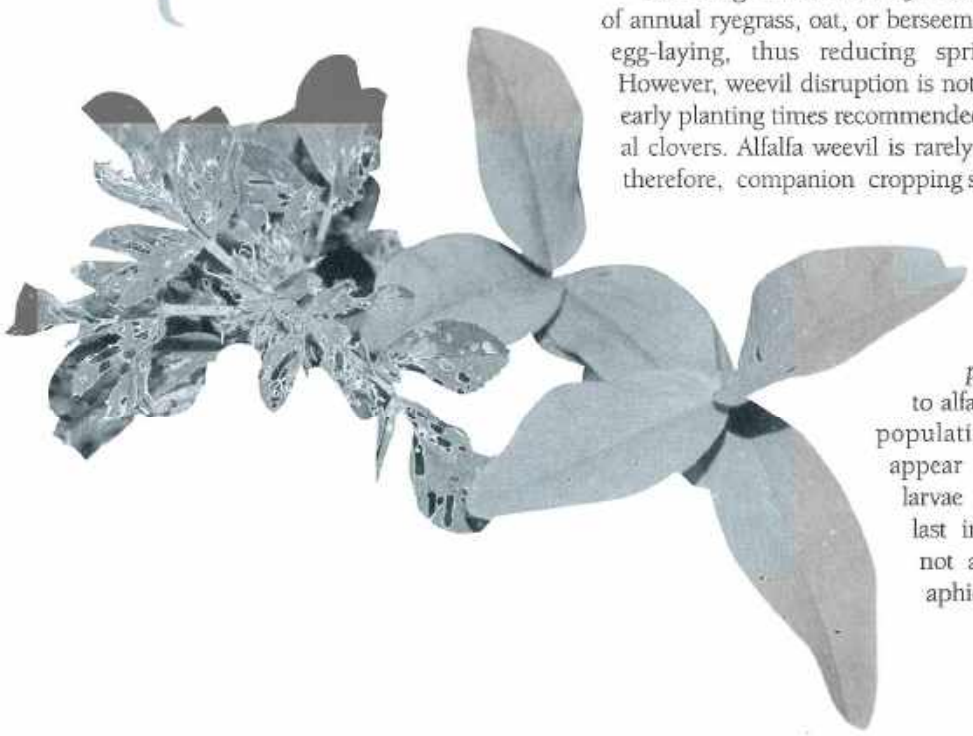
OVERSEEDING AND COMPANION CROPPING IN ALFALFA MAY HELP MANAGE INSECT AND WEED PESTS. These practices may reduce the need for insecticides and herbicides, reducing expenses and eliminating plant-back restrictions.

Overseeding with other species (such as berseem clover or oat) may help mitigate yield loss caused by weevils, since they do not feed on grasses or clovers

INSECTS

The alfalfa weevil (*Hypera postica*) and the Egyptian alfalfa weevil (*Hypera brunneipennis*) are major alfalfa pests in California. The larvae feed on foliage and cause substantial yield losses in the first and sometimes second harvest. Overseeding with other species (such as berseem clover or oat) may help mitigate yield loss caused by weevils, since they do not feed on grasses or clovers (see plate 26). It should be pointed out that overseeding does not prevent weevil damage to alfalfa, but enables normal or increased yields in overseeded fields due to lack of a pest effect on the overseeded species. However, a weevil control treatment may be necessary when high feeding damage exists to maintain the alfalfa component in the hay mixture.

Soil tillage in December-January for seedbed preparation of annual ryegrass, oat, or berseem clover can disrupt weevil egg-laying, thus reducing spring larvae populations. However, weevil disruption is not a benefit observed in the early planting times recommended for overseeding perennial clovers. Alfalfa weevil is rarely a pest in seedling alfalfa; therefore, companion cropping seems to have little effect on this pest.



The blue aphid (*Acyrthosiphon kondoi*) and the pea aphid (*Acyrthosiphon pisum*) can be detrimental to alfalfa yield when high insect populations are reached. They appear shortly after the weevil larvae hatch in spring and can last into summer. Grasses are not a preferred host of these aphids, so overseeding with

ryegrass or cereals will not contribute to the aphid problem and may mitigate yield losses in infested alfalfa fields. Aphids can occur in berseem clover, where they are important vectors of viruses. Virus outbreaks occur in a minority of years, when aphid populations are high. The berseem clover variety Joe Burton has improved virus resistance compared with Multicut. Although threshold levels have not been established, experience to date indicates that chemical control for aphids in berseem clover is rarely necessary.

WEEDS

Overseeding can be useful in suppressing winter- and summer-germinating weeds. When winter-grown annual ryegrass, oat, cereals, or berseem clover is overseeded, little opportunity exists for winter weeds to become a problem. Of the four species, berseem clover suppresses weeds to a lesser degree. Overseeding often eliminates the need for a herbicide application. Annual species planted into alfalfa have also delayed the germination of summer weeds into the second or third cutting (see plate 27).

The opposite is the case for perennial grasses or perennial clovers. Their slow establishment period in winter does allow some winter weeds to develop. However, once the perennial species are well developed and reach midseason growth, weed population declines. By the second year, perennial forages fill in the areas of a poor alfalfa stand, grow more vigorously, and provide excellent control of weeds. If weeds are expected to be a problem at planting, consider pre-irrigation prior to overseeding to germinate weed seeds. Weeds can then be removed by tillage during seedbed preparation. Other options for weed removal include mowing, grazing, or the use of selective herbicides (table 7).

TABLE 7.
HERBICIDE COMPATIBILITY FOR CROPS OVERSEEDED INTO ALFALFA

Overseeded crop	Nonselective herbicide common name (brand name) *Herbicide applied prior to planting to kill existing weeds*		Selective postemergence herbicide common name (brand name) *Herbicide applied after crop and weeds have emerged*					Preemergent herbicides in established crop, common name (brand name) *Herbicide applied to established crop prior to weed germination*	
	gramoxone (Paraquat)	glyphosate (Roundup)	2,4-DB (Butyrac)	bromoxynil (Buctril)*	imazethapyr (Pursuit)*	sethoxydim (Poast)	clethodim (Prism)	trifluralin (Treflan)	EPTC (Eptam)
Annual clover	△	△	△	NA	△	△	△	NA	NA
Perennial clover	△	△	△	NA	△	△	△	△	△
Grasses (annual and perennial)	△	△	△	△	■	■	■	■	■

Key: △ = little injury to overseeded crop. ■ = serious injury to overseeded crop may occur. NA = no information available.

Note: Herbicides are labeled for alfalfa, and some injury to the overseeded crop may occur. Consult label and follow label directions carefully. Check with manufacturer or agricultural commissioner for interpretation of labels for local use.

* Pursuit and Buctril are not registered for use on clovers as a pure crop.

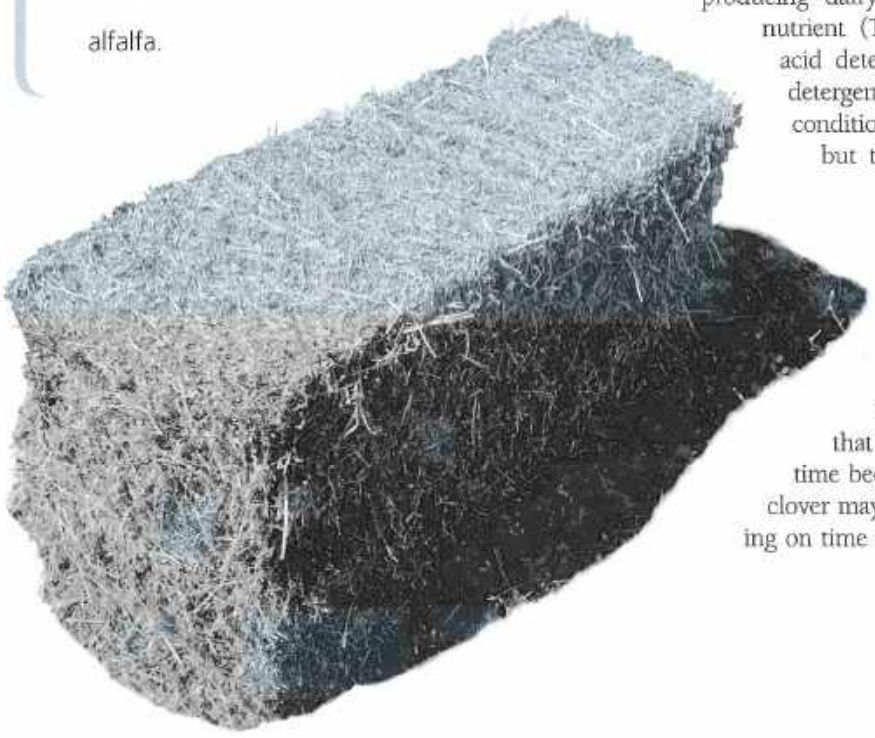
Quality, Market, and Economic Considerations of Mixed Alfalfa Crops

FORAGE QUALITY

BECAUSE THE SPECIES CHOSEN FOR THE MIXED ALFALFA FORAGE WILL INFLUENCE THE FINAL MARKET DESTINATION, GROWERS SHOULD DEFINE THEIR FORAGE QUALITY AND MARKET GOALS BEFORE THEY DECIDE WHICH SPECIES TO USE. Growers should note that overseeding is likely to move alfalfa from the category of "alfalfa hay" to "mixed alfalfa hay" or "mixed grass hay" for the purposes of marketing, according to the California hay quality guidelines (Matthews and Putnam 1998; see table 8). However, not all mixtures are lower in quality compared with alfalfa, and mixtures may be higher in forage quality if weeds are displaced or legumes are used.

Not all mixtures are lower in quality compared with alfalfa.

Mixtures of alfalfa and clovers (berseem clover and red clover) usually do not reduce the nutritional value of the forage compared with alfalfa alone. Clover-alfalfa mixtures are usually eligible for dairy markets, even for high-producing dairy cows. The total digestible nutrient (TDN) values, predicted from acid detergent fiber (ADF) or neutral detergent fiber (NDF), under most conditions should be similar to alfalfa, but the crude protein (CP) levels may be slightly lower. As in alfalfa, the forage quality of these clovers is highly dependent on the cutting schedule and maturity. The maturity of the clover crop at harvest may be different than that of alfalfa harvested at the same time because the growth rates for the clover may be greater or lower, depending on time of year. It is important to test



clover-alfalfa hay mixtures to predict the feeding value for dairy cows, as is done with alfalfa.

Mixtures of berseem or red clover with alfalfa have proven to be very acceptable to the horse market, provided that the hay is generally free of weeds and not moldy or excessively dry. Protein levels may be slightly less than that of alfalfa, a characteristic that is often desired by horse owners.

Annual and perennial grass-alfalfa mixtures are very popular in the horse market. A 50-50 grass-alfalfa mixture with bright green color, free of weeds and mold, is considered high-quality feed for horses and often demands prices similar to or higher than those of good or premium dairy hay. Grass-alfalfa mixtures are usually lower in protein and higher in fiber than alfalfa. However, the lower protein in grass-alfalfa hays may be appropriate for most horse diets. Approximate ranges of forage quality values are shown in table 9.

Phytoestrogens are present in many legumes, including alfalfa, red clover, berseem clover, and also in some grasses. Phytoestrogens are naturally occurring plant compounds that contribute to poor reproductive performance in grazing animals, especially sheep. This is more of a concern with red clover than with alfalfa or berseem clover, and it is also more of a concern under grazing conditions than with hay. Bloat can also occur when grazing alfalfa or other legumes, but no cases of bloat have been reported for berseem

TABLE 8.
CATEGORIES OF HAY PRODUCTS, ACCORDING TO THE 1998 CALIFORNIA HAY QUALITY GUIDELINES

Hay category	Composition
Alfalfa	>90% alfalfa
Mixed alfalfa	50%–90% alfalfa
Grass	>90% grass
Mixed grass	50%–90% grass

Source: Matthews and Putnam 1998.

TABLE 9.
RANGE OF CRUDE PROTEIN (CP), ACID DETERGENT FIBER (ADF), AND NEUTRAL DETERGENT FIBER (NDF) VALUES OF ALFALFA AND OVERSEEDED SPECIES

Species	Stage at swathing	CP (%)	ADF (%)	NDF (%)
Alfalfa, supreme*	vegetative or early bud	22–26	<27	<34
Alfalfa, premium*	late vegetative or bud	20–24	27–29	34–37
Alfalfa, good*	early flower to midflower	18–22	29–32	37–40
Alfalfa, fair*	midflower	16–20	32–35	40–45
Red clover	early bloom	18–20	27–32	35–42
Red clover	late bloom	16–19	30–35	40–45
Berseem clover	early bloom	18–22	24–30	36–42
Berseem clover	late bloom	16–20	29–35	40–45
Annual ryegrass	vegetative	14–16	27–33	40–48
Annual ryegrass	early bloom	12–15	38–42	45–55
Orchardgrass	vegetative	15–18	30–34	45–50
Orchardgrass-tall fescue mix	early heading	10–14	32–37	50–65

Note: Values given are approximations only. Growers should expect a minimum of 0.5% variation in lab test results. Actual values vary widely depending on maturity at harvest, variety, presence of weeds, and other factors. Obtain lab values for forage mixtures to predict feeding value.

*See table 11 for definition of alfalfa quality designations.

clover. If an overseeded species is to be grazed, the selection of the species and variety for bloat-resistance and management of phytoestrogens should be considered. The factors of importance for good grazing management (type of animal, condition, feeding history, supplementation, grazing intensity) must be considered in detail.

Harvesting at the appropriate physiological maturity is important in determining forage quality. For dairy markets, the crop should be harvested before the crop is overly mature to maintain forage quality. Harvesting alfalfa, berseem clover, and red clover (see plate 28) in the late vegetative or early bud stage (see table 4) elevates quality for dairy markets but lowers yield.

For cereal grasses intended for dairy markets, harvest in the boot stage (see table 4), before the plant is in flower and well before seed heads have formed. If this is not possible, it is best to wait until dough stage, which is more appropriate for horse or dry-stock hay and higher yield (table 10) (see plate 29).

Mixed hay should be free of mold or heat damage from improper moisture at baling. Heating can decrease the amount of forage protein available to the animal.

Obtaining lab values of acid detergent fiber (ADF), neutral detergent fiber (NDF), and crude protein (CP) is important to help determine feeding values. Total digestible nutrients (TDN) is an index calculated from ADF; relative feed value (RFV) is an index calculated from ADF and NDF. With several of these species, the potential energy yield (TDN) may be different than that used for alfalfa, so some caution should be used in applying alfalfa TDN equations to mixtures. Forage hay quality

TABLE 10.
PRIMARY OR PREFERRED MARKETS FOR HAY COMPOSED OF MIXTURES OF ALFALFA AND VARIOUS SPECIES

Market*	Species mixed with alfalfa				
	Berseem clover	Red clover	Oat or cereals	Orchardgrass	Ryegrass
High-producing dairy cattle	▲	▲			
Dairy cows in late lactation	▲	▲		▲	▲
Dry cows and heifers		▲	▲	▲	
Beef cattle		▲	▲	▲	
Horses	▲	▲	▲	▲	▲
Sheep	▲	▲	▲	▲	▲

*The forage quality of mixed forages is highly dependent on the cutting schedule; changes in cutting schedule have a large impact upon potential markets.

TABLE 11.
CALIFORNIA HAY QUALITY DESIGNATIONS FOR ALFALFA AND ALFALFA MIXTURES, IN TERMS OF TOTAL DIGESTIBLE NUTRIENTS (TDN) AND ACID DETERGENT FIBER (ADF), WITH DRY MATTER (DM) PERCENTAGE

Category*	TDN (90% DM)†	ADF (100% DM)†
Supreme (Extra Premium)	>55.9	<27
Premium	54.5–55.9	27–29
Good	52.5–54.5	29–32
Fair	50.5–52.5	32–35
Low	<50.5	>35

Source: Matthews and Putnam 1998.

*Quality categories as of 1999 for pure stands and mixtures with >50% alfalfa.
† These values are approximations only. Growers should expect a minimum of 0.5% variation in lab test results.

designations for dairy markets are Supreme (Extra Premium), Premium, Good, and Fair (table 11). Horse hay quality is determined largely by condition, appearance, and curing of the hay, as well as to a smaller degree by lab analysis.

MARKETING

Alfalfa overseeded with grasses or legumes has a significant effect on the preferred markets for the hay product (see table 10). High-producing dairy cattle require forages that are low in fiber and high in protein. It is often difficult to substitute grain or other feeds to equal the animal response obtained from high-quality forages for this class of animals. Clover-alfalfa mixtures are well suited for high-producing dairy cows, but plant maturity has a large effect on its feeding value. To maintain the highest quality, harvest schedules should be kept at sufficiently short intervals (mid- to late bud stage, see table 4) to keep fiber levels within acceptable ranges for lactating dairy cows.

Clover hay (berseem and red clover) cures with a brownish tinge, which sometimes causes reluctance among buyers and will challenge hay marketers (see plate 30). This is a cosmetic issue only and does not lower the true feeding value of the hay. The quality of clover hay is often equal to that of alfalfa hay.

If alfalfa mixtures do not meet premium quality standards, they may be of use for dairy animals in late lactation or for nonlactating and growing animals. Such hay is typically of lower market value. Clover-alfalfa mixtures are also suitable for lactating sheep and for finishing lambs or cattle and can be fed as greenchop, silage, or hay.

Grass-legume mixtures are well suited for maintenance feeding of sheep, beef cattle, late-lactation or nonlactating dairy cattle, and heifers. These animals have a lower protein requirement than the high-producing dairy cow, and the higher forage fiber content will not reduce performance in these animals.

Alfalfa is well suited to horses because it is an excellent source of protein, calcium, and energy. However, some horse owners believe 100 percent alfalfa feed is too "rich" for horses, and they may prefer a mixed alfalfa-grass forage. Horse owners may prefer to see some grain in their cereal grass-alfalfa hay, so harvest for the horse market should be later than harvest for dairy cattle. For horses that are inactive and are not growing or lactating, mid- to late-maturity alfalfa hay is a more appropriate feed than early-maturity alfalfa. Horses are especially sensitive to dusts and molds, so any hay sold to the horse market should be free of these defects. Many horse owners place a premium on clean hay.

ECONOMICS

Good-quality alfalfa mixtures should be very competitive in the market with oat or wheat hay, corn silage, sudangrass, or other available forages, and they are often very competitive with pure alfalfa. The primary economic considerations for overseeding or companion cropping in alfalfa are the potential for changes in forage quality, increases in yield, and the cost of the operation chosen. An example of production costs is provided in table 12.

Oat-alfalfa forage has a lower quality than pure alfalfa, which in most cases will be compensated for by higher yield (see plate 31). Orchardgrass-alfalfa mixtures may also generally be lower-priced than pure alfalfa, but they can be marketed in the horse market at little or no price penalty. In many instances high-quality clover-alfalfa forage can be substituted for equal quantities of alfalfa in dairy rations, so it will have a competitive price-yield relationship to pure alfalfa.

TABLE 12.
SAMPLE COSTS FOR OVERSEEDING ANNUAL RYEGRASS AND BERSEEM CLOVER INTO A DEPLETED STAND OF ALFALFA, COMPARED WITH THE MANAGEMENT OF ALFALFA WITHOUT OVERSEEDING

	Cost per acre ($)*		
Item	**Annual ryegrass**	**Berseem clover**	**Alfalfa (no overseeding)**
OVERSEEDING STAND ESTABLISHMENT			
Seedbed preparation (harrowing 1x)	9	9	—
Seeding (broadcast or drill)	7	7	—
Seed costs	3	16	—
Cover or roll field	9	9	—
Irrigate 1 x (8" water)	15	15	—
Total stand establishment	43	56	—
PRODUCTION			
Herbicide (winter weed)	0	0	15
Herbicide (spring and summer)	0	0	25
Insecticide (weevil in early spring)	0	0	20
Irrigation ($25/acre-foot): 12" water for ryegrass, 24" water for clover-alfalfa, through June	25	55	55
Yield expectation (3 harvests ryegrass, 4 harvests berseem clover & alfalfa)†	3.5 tons/acre	4.4 tons/acre	3.5 tons/acre
Harvest costs (swathing, baling, and roadsiding at $30/ton)	105	132	105
Total production cost	130	187	220
Total production and stand establishment cost	**173**	**243**	**220**
Estimated total cost/ton	**49**	**55**	**63**

* Comparison of harvest from April through early July. Includes labor, fuel, and application costs where appropriate. Does not include overhead or fixed costs.

† Yield expectation based on replicated field trials in California.

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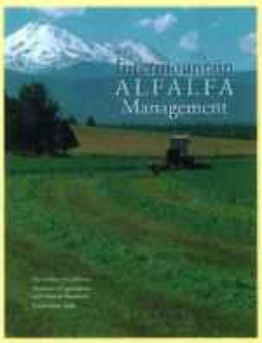

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