

# INTEGRATED CROP MANAGEMENT: AGRONOMIC STRATEGIES TO IMPROVE ALFALFA PEST MANAGEMENT

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## ABSTRACT

Agronomic practices have large and long-lasting effects on pest management in alfalfa. Among the most important of these are stand establishment technique, variety selection, harvest management practices, and irrigation management. With alfalfa, any technique that results in a high yielding crop, deep root system, and vigorous canopy are best able to resist weed, insect pest, and disease intrusion and minimize the necessity for pesticides. Considered as a whole, these consist of an ‘**Integrated Crop Management**’ approach to pest management. It is important to adapt crop management techniques as a component of IPM.

## INTRODUCTION

While it is sometimes tempting to look only at quick solutions (pesticides) when confronted with a pest problem, it is well known that a range of agronomic practices have profound and important influences on the success of pest management. Taken as a whole, these ‘packages of recommended practices’ should be considered as an *Integrated Crop Management* approach to pest control that not only can improve yields, but improve the resilience of crops to unwanted pest intrusions. In some cases, cost-effective pesticide measures are not available, and incorporation of agronomic methods, pest avoidance, or mitigation are the major tools available to growers.

For example, it may not be immediately apparent that the choice of variety may influence disease or weed pressure, or that an early cutting may improve insect control (or alternatively, increase weed intrusion), or that irrigation technique affects gopher infestation. However, these practices do have major effects on specific pests. When examining insects, weeds, diseases, nematodes, or rodents, it is often a ‘dance’ between the population of the pest and the ability of the crop to sustain or minimize damage, not necessarily to completely avoid damage. Pesticides are an important tool, but



*Figure 1. Stand decline leading to weed intrusion at the tail ends of a flood-irrigated alfalfa field, Yolo Co., CA. Standing water leads to root diseases and stand loss. Irrigation management is one of many agronomic practices that have important impacts on weeds and diseases.*

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use of agronomic practices are essential when implementing an ‘Integrated Crop Management’ approach to managing economic pests. In this article, we review many of the agronomic factors that affect pest management.

## THE IMPORTANCE OF STAND ESTABLISHMENT

In many respects, a package of proper stand establishment methods is the most potent weapon in the arsenal for growers fighting pests, including insects, weeds, diseases, nematodes, and rodents. This includes site selection (including crop rotation), soil preparation and fertility, variety selection, timing, and seeding method.

The best control method for pest management is a vigorous, deep-rooted alfalfa stand capable of smothering germinating weeds and resisting disease and insect intrusion. This begins by optimizing early-season stand development. See Undersander et al., 2011; Putnam et al., 2012; Mueller et al., 2007 for full review of stand establishment techniques.

**Site Selection/Soil Preparation/Soil Fertility.** High-level crop production depends upon the basic soil resource. Thus a thorough understanding of soil limitations of a given field, and selection of the best sites on a farm for alfalfa production are important in an integrated crop management approach. The requirements for alfalfa include a neutral pH, limited salinity, good drainage, excellent water-holding capacity, and good soil fertility (Orloff, 2007). On soils that have limitations, for example low or high pH, or low soil fertility or high salinity, take measures to mitigate these problems to improve plant growth before planting (Meyer et al., 2007). Supply of adequate phosphorus, P and potassium, K at planting encourages rapid stand establishment and growth, allowing the crop to out-compete weeds. Conversely avoid excess nitrogen (N) supply during early growth as this only encourages grassy weed growth. There are some minor exceptions to this rule, e.g. when planting in cooler soils or at a sub-optimal time (see Long and Putnam 2013).

**Soil Preparation.** For pest management issues, several soil prep criteria are especially important: 1) Elimination of soil compaction or hard pans for deep root development, 2) Steps to encourage excellent drainage, 3) final land leveling to avoid high and low spots in the field, and 4) good seedbed preparation. Sub-surface impediments will influence rooting depth, limit water uptake and encourage saturated soil conditions, which provide ideal habitat for disease organisms. On sodium-affected saline soils, gypsum applications will improve infiltration along with deep tillage, to prevent puddling which causes diseases. Problems with drainage are particularly a problem on heavy soil types. Thus, we recommend ‘deep ripping’ to 18-inches for heavy soil types prone to



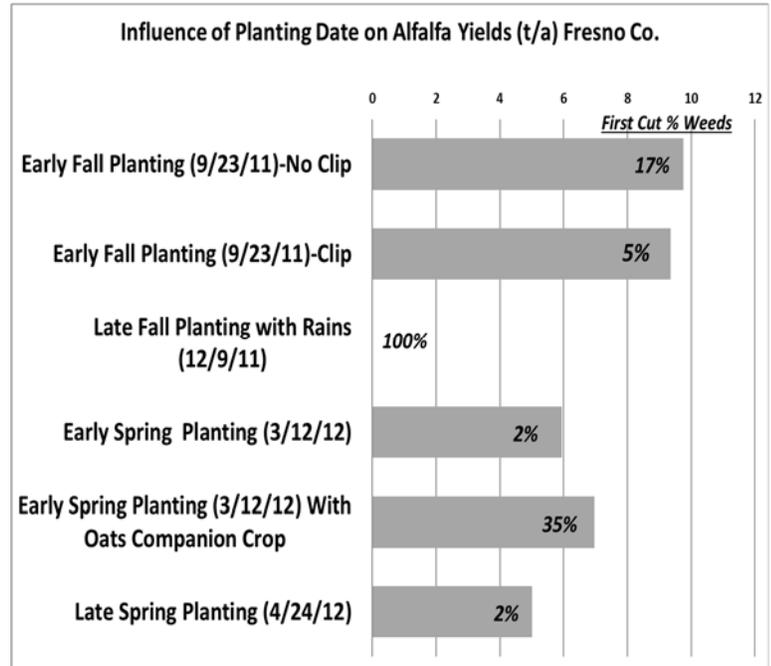
**Figure 2.** Seeding depth has a large effect on pest management. Failure to emerge causes ‘gaps’ that allow weed intrusion, and delays give weeds the upper hand. Seeding depths between 1/4” and 3/8” are ideal. Poor seedbed preparation can cause seed to be planted too deep. Slow emergence also affects diseases through poor root development.

compaction. Finally, tillage has major influences on pest management in two ways:

- *Lack of land leveling* (for check-flood irrigated fields especially) causes opportunity for standing water which in turn creates *Phytophthora*, *Pythium* and other disease problems and stand death from lack of oxygen. On high spots plants suffer from lack of water during irrigation, resulting in plant dieback. Stand death then allows weed intrusion (Figure 5).
- *Poor final seedbed preparation* (lack of firmness) results in poor seeding depth, resulting in poor stands, which leads to weed intrusion. Seedbed should not be cloddy, or too ‘fluffy’ – ideally a footprint should be maximum of ½ inch deep.

**Stand Establishment Timing.** The timing of stand establishment is particularly important for pest management, particularly for prevention of weed intrusion. For many years, alfalfa scientists have recommended early fall plantings (not winter plantings!) for optimum plant growth. This is because fall planting encourages deep root development versus foliar development, enabling the crop to resist weed competition and diseases. In California’s Central Valley and deserts, this means timing from August through October, depending upon latitude. In the intermountain region both early spring and late summer (August) plantings are viable, but fall plantings are preferred. A trial in Fresno County showed the advantage of fall planting on weeds and yields – a late fall planting failed due to cold and rain – which allowed full weedy fields (Figure 3). On organic fields, light clipping or grazing can reduce weeds on new alfalfa fields. Spring planted yields were nearly half those of early fall plantings.

*Why is this relevant to pest management?* This is particularly important for weed management. Envisioning the competition between the crop and the weed as an unequal ‘dance’ wherein the most aggressive plant ‘wins’, the tiny alfalfa seedlings don’t have much of a chance with aggressive winter weeds (e.g. mustards, groundsel, ryegrass) or, with spring planting, aggressive summer weeds. However, if growers are able to tip the balance favoring the crop, planting in very advantageous weather windows, when summer weeds are phasing out and before winter weeds get started, this timing avoids particularly aggressive weeds (e.g. Nov.-Dec., and May-June), this goes a long way towards weed management.



**Figure 3.** Influence of planting date on yield and weed intrusion, organic trial, Fresno County, 2011-12. Early seeding has a large effect on yield as well as risk of weed intrusion. Oats improved yields slightly but had lower alfalfa percentage. Note failure of late fall planting and success of clipping to control weeds.

**Method of Seeding.** There are many viable methods of seeding, including broadcast and row seeding (grain drills), billion seeders, or seeding by air applicators or airplanes. The goal is to have a well-distributed thick stand seeded at proper depth (Figure 2). These influence pest management if they fail to result in an even, rapidly germinating stand. Regardless of method, the method should result in the following:

- Distribution of approximately 50-150 seeds per square foot distributed uniformly (note that normally only 50-80% of these typically are established). This normally occurs with a 15-25 lb./acre seeding rate
- Seeding depth about ¼ inch or slightly deeper, depending upon soil type.
- Excellent firm soil-seed contact to enable moisture absorption for seed germination.

Broadcast methods are slightly better than drilled methods for early canopy closure and thus weed competition, but narrow-row grain drills at a proper density can also be used successfully, and after sometime, differences are minor.

**No-till or Conservation-till methods.** Seeding into stubble is also viable for alfalfa under specific soil types if deep tillage or land leveling isn't necessary, for example in non-leveled pivot fields. Crop residue on soil surface can suppress weeds (but be careful to allow space for germinating seedlings). No-till alfalfa into grain stubble or crop residue prevents soil erosion and can help protect the young seedling from wind damage. However, examine soil impediments to make sure they don't present long-term problems that need to be rectified before planting.

**Early Weed Management.** Early weed management in the alfalfa seedling stage is a crucial strategy to prevent later, long-term weed intrusion. Alfalfa is a very weak seedling compared to aggressive weeds. Many growers have reported highly successful stand establishment methods using conventional or round-up ready herbicides during the seedling stage for preventing weed problems for a year or more. This may make the 'in-season' herbicide application unnecessary. A list of herbicides registered for seedling alfalfa and the weeds they control can be found on the UC IPM website for alfalfa, [ipm.ucanr.edu](http://ipm.ucanr.edu).

**Companion Crops: Low Density of Oats.** Planting a low density of oats with alfalfa can suppress weeds without the use of herbicides and reduce erosion during stand establishment. However, care should be taken to prevent excess competition from the oats by using low seeding rates and harvesting the oats early. You can kill a young alfalfa stand with oats if you're not careful. The first cutting will have lower alfalfa content but, in combination with the harvested oats, will provide higher yields of forage than pure alfalfa stands. The next two cuttings are usually only slightly affected and there may be limited effects on later cuttings or stand life, provided the oat seeding rate is not too high (i.e., above 20 lb./acre). The ideal seeding rate for oat in California is 8 to 16 pounds per acre with the standard alfalfa seeding rate. Do not apply nitrogen; it may make the oats too competitive. Curing time for the first cutting may be several days longer than that for pure alfalfa. See Canevari et al., 2000 for additional information.

**Pre-Irrigation to establish stands.** If possible, pre-irrigate and cultivate to eliminate weeds before planting. This is especially important for organic farmers whose herbicide options are few, or for fields with a known high density of weeds. Although crop rotation, logistics, and availability of water may be limitations, this technique goes a long way towards reducing weed pressure. Pre-irrigation has the added advantage of filling the soil profile to provide good deep root growth for a young stand. Lightly harrow the weeds or spray them with glyphosate to avoid bringing up more weed seeds that may be buried deep in the soil.

## VARIETY SELECTION

One of the most important decisions in managing pests in alfalfa is variety selection. Choose a seed type for planting that has the right dormancy for your area and that has high levels of insect pest, disease, and nematode resistance for issues of concern (Table 1). *Fall Dormancy* (the winter activity or fall growth of a variety) ranges from dormant (FD Ratings 2-4) to semi-dormant (5-7), to non-dormant (8-11). For pest management, the major effect of dormancy is its linkage to stand persistence – in general more dormant varieties are somewhat lower yielding but have greater stand persistence. Many non-dormant lines will ‘go out’ quickly in a region, thus allow greater weed intrusion. *Varietal Pest Resistance* ratings (Table 1) are often the ONLY cost-effective ways to resist diseases and some insects, and an important IPM tool. Choose those lines with resistance to known pest problems. For example, if you have trouble with pea and blue alfalfa aphid infestations in your area, choose a variety that is highly resistant to these aphids to help control them (Table 1). A completed list of currently-marketed varieties and their pest and disease resistance levels can be found on-line from the National Alfalfa and Forage Alliance (NAFA, 2018). The UC Alfalfa and Forages website also has yield performance information on varietal selection for different growing areas in California at [alfalfa.ucdavis.edu](http://alfalfa.ucdavis.edu).

*How Varietal Resistance Works.* Remember that variety resistance is partial (Table 2). This is an important concept- only a portion of alfalfa populations are resistant to a given pest. It surprises many people that a 50% resistance is considered “Highly Resistant”. This actually works since in viable alfalfa stands, a grower can afford to lose large portions of the initial seeded crop (if well distributed and at proper density) and still realize high yields if the remaining stand is well-distributed (Figure 4).

**Table 1.** Recommended Fall Dormancy range and pest resistance ratings for different regions of California. Alfalfa has a greater range of genetic pest resistance characteristics than many crops.

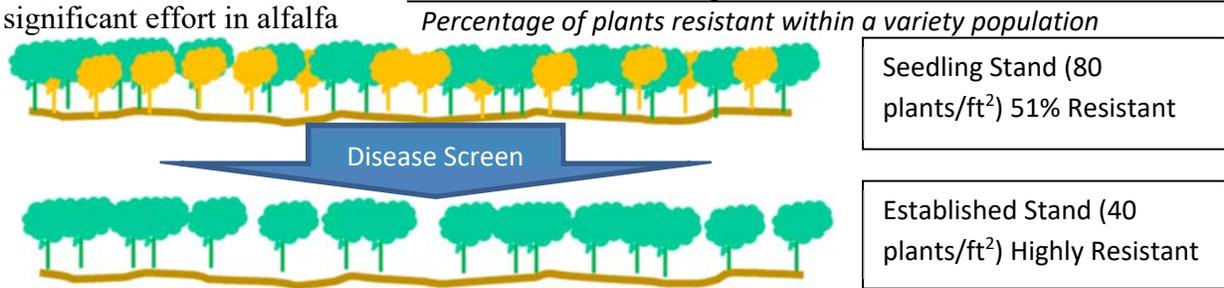
Zone	FD	SAA	PA	BAA	PRR	BW	FW	VW	ANT	STN	RKN
<b>Intermountain</b>	2-4	S	R	R	R	R	HR	HR	HR	HR	R
<b>Sacramento</b>	4-8	MR	HR	HR	HR	MR	HR	R	R	HR	R
<b>San Joaquin</b>	7-9	R	HR	HR	HR	MR	HR	R	R	HR	R
<b>Coastal</b>	5-7	MR	HR	HR	HR	MR	HR	R	HR	HR	R
<b>High Desert</b>	4-8	R	R	HR	R	MR	HR	HR	HR	HR	HR
<b>Low Desert</b>	8-11	HR	HR	HR	HR	S	HR	S	R	R	HR

*FD=Fall Dormancy; SAA=Spotted Alfalfa Aphid; PA=Pea Aphid; BAA=Blue Alfalfa Aphid; PRR=Phytophthora Root Rot; BW=Bacterial Wilt; FW=Fusarium Wilt; VW=Verticillium Wilt; ANT=Anthracnose Race 1; STN=Stem Nematode; RKN= Southern Root Knot Nematode.*

**Choose High Quality, Certified Seed.** In addition to varietal selection, it is important to use certified seed that has high germination, and will be free of pests at planting. A significant effort in alfalfa

**Table 2.** Definition of Resistance Categories in Alfalfa

Abbreviation	Category	Percent Resistance <sup>1</sup>
HR	High Resistance	>51%
R	Resistant	31-50%
MR	Moderate Resistance	15-30%
LR	Low Resistance	6-14%
S	Susceptible	<5%



**Figure 4.** Changes in Plant population during stand establishment with 51% disease resistant varieties. Stand loss of 50% normally still results in a vigorous, healthy stand in alfalfa.

seed production involves growing seed that is genetically true to that variety, and free of impurities, including weed seeds, diseases, and nematodes. Dodder (*Cuscuta* spp.) is a very noxious weed that can infect fields coming from the seed for many years after planting—choice of certified seed is your major weapon for this pest. There is a long list of noxious weeds that are prohibited in certified seed (e.g. starthistle, spurge, foxtails), that are found in low-quality seed (CCIA, 2018). Certified seed fields are rigorously inspected from time of planting through harvest and the seed cleaning process ensures no pests and weeds are brought into the field at planting. Stem nematode can often be found on alfalfa seed, another pest which is screened by seed certifiers. Certified seed also generally comes pelleted with an appropriate rhizobacterial inoculant to ensure good nitrogen fixation by bacteria that form symbiotic nodules on the alfalfa roots, along with fungicide seed treatments to help control seedling diseases.

## IRRIGATION MANAGEMENT

Water availability has such a large effect on crop growth and yield, and therefore competitiveness with weeds and pests. Conversely excess water favors weeds, nematodes, diseases and lack of oxygen is a key limitation for alfalfa root health. Therefore, irrigation method has important effects on pest management during establishment and in established stands.

*Stand Establishment Period:* Irrigation technique can cause disease and weed problems during early growth. Sprinkler irrigation is highly preferred for stand establishment, since it is easier to ‘finesse’ water amounts. Stand establishment is not feasible with subsurface drip irrigation (SDI). While “flooding up” stands using flood irrigation is feasible in some situations, it is higher risk than utilization of sprinklers, especially for *Phytophthora*, *Pythium* and other seedling diseases. Pre-irrigation is ideal, followed by sprinkler irrigation. Otherwise, if planting into dry soil, the first irrigation should irrigate to a depth of 10-12”, followed by shallow irrigations to assure moisture availability to the seedling. Controlling crusts is a key component of the

‘finessing’ of emergence with irrigation. However, watch it! Over-irrigation or too-frequent irrigations during stand establishment can kill seedlings, causing diseases and larger gaps in the stand. Check to see if moisture is at the level of the depth of the root- if so, leave it for a day or so. Remember that roots don’t grow in search of water, they grow in the presences of water! So if there is moisture at 10” but not in the top 3” where the roots are, you need to irrigate the young seedling. On the other hand, growers sometimes make the mistake of over-irrigating new stands, causing standing water and death of seedlings.

*Established Stands.* Irrigation of established stands influence pests primarily through standing water on the surface of the soil (poor infiltration or irrigation management), but also by excess wetting of the canopy causing leaf diseases.

Flood irrigated fields are famous for stand decline on the tail ends of fields (Figure 1). Watering should occur according to the demand of the crop (evapotranspiration demand), adjusted upward for the inefficiencies of irrigation, and no more. Standing water and saturated soils are the enemy of alfalfa. Lack of oxygen leads to death of plants, leading to weeds and disease. Timing, frequency and amount must all be analyzed for their effects on obtaining an adequate supply while preventing excess moisture.

*Effect on nematodes.* Irrigation water from surface sources can result in the movement of stem nematode and other species into fields not previously infected.

*Effects on Rodents.* Flooding helps control rodents by drowning and pushing them out of burrows where they are vulnerable to predators. For subsurface drip irrigated fields, leave the option to flood irrigate by putting in checks, to help manage rodent pests if needed.

## HARVEST MANAGEMENT

Harvest Schedule for Weeds and Diseases.

Cutting alfalfa early (i.e. < 28 days) can help with removal of weeds and remove insects in the short term. This is an important strategy for dealing with weeds or insects that have become difficult. It also helps with forage quality, However, continuous short cutting schedules also stresses the plants, resulting, in weed and disease intrusion into fields. If fields are cut early on a continuous basis, this depletes root resources and reduces regrowth potential. Frequently-harvested fields are famous for weed intrusion and stand loss. Thus, if growers cut early for high quality or to remove weeds or insect



*Figure 5. Lack of careful soil levelling caused uneven water distribution during germination using flood irrigation (top), leading to early weed intrusion (bottom) – an effect likely to be present for many years. Careful soil leveling and use of sprinklers during germination are important.*

pests, we recommend that growers allow the subsequent cuttings to grow longer to help maintain plant health.

*Cutting for Insect Management.* Armyworms and alfalfa caterpillars can be managed by early cutting. However, watch the value of the hay; if the value of the yield gained from extra growth exceeds the cost of the pesticide application, then a spray is justified. Alfalfa weevils cannot be controlled by early harvest because they will continue to feed on the stubble under the windrows, weakening stands.

*Traffic Damage.* Wheel traffic can heavily damage alfalfa stands by compacting soil and impacting plant growth. Minimize trips into fields and do not continually drive in the same place, to avoid soil compaction. It is well known that harvesting traffic (balers, tractors, rakes, swathers, and bale pick-up units) have large effect on the regrowth potential and stand longevity of alfalfa. The mechanism for damage is both due to the effect on soil compaction, and the crushing of young re-growing shoots, which reduces canopy cover. Weeds and root diseases result from traffic damage. Innovative growers have been able to restrict damage from traffic to lower levels.

*Equipment Sanitation.* Clean equipment when moving from fields known to be infested with diseases or nematodes. Many pests and diseases hitchhike on farm machinery in plant and soil debris, easily spreading them to healthy fields. For example, stem nematode can move from infected to healthy fields on hay swathers during cutting. Maintaining clean equipment by cutting infested fields first, then healthy ones, or cutting grass hay first, or washing plant and soil debris off the sickle bars will help prevent the spread of stem nematodes in alfalfa production.

## CROPPING SYSTEMS

**Back-to-Back Alfalfa.** Do not plant alfalfa immediately after an alfalfa crop. At least one year of crop rotation, preferably two years are important for reducing disease, nematode, and rodent pressure, as well as insects.

**Crop Rotation Impacts.** Crop rotation is another key tool to reduce pest pressure for diseases and weeds especially. Several weeds especially favor annual crops (such as tomato) but not alfalfa, and visa-versa. Monitor and control weeds, nematodes, and diseases in rotational farming systems, especially for managing difficult to control weeds in alfalfa, such as curly dock and nutsedge. Watch for residual problems with herbicides in terms of plant back restrictions. When sampling the soil to assess for nutrients prior to planting (especially for phosphorus) watch for areas of low production. Sample these areas separately for soil analyses to ensure that nutrients are readily available and the pH of the soil is about neutral to ensure a healthy stand. Healthy plants are better able to withstand pest pressure, leading to fewer pesticide inputs. A suggested rotation includes tomatoes, wheat, and sunflower, for at least two years.

**Overseeding.** Weevils are key pests of alfalfa, including the western and Egyptian strains. These insects feed on the alfalfa foliage during late winter and early spring and cause significant yield and quality losses to the first and sometimes second hay cutting. One practice to manage this pest without the use of insecticides is to overseed a forage into the alfalfa crop in the fall that is not

preferred by weevils. This includes berseem clover, red clover, and forage grasses such as oats. The overseeded crop will fill in and make up for a loss of production from weevil damage to the alfalfa. However, this IPM practice is only recommended in the last year of production because it can result in alfalfa stand decline and also changes the forage quality and marketability of the hay. For more information, see [Overseeding older alfalfa stands](#), Leinfelder-Miles 2016.

## SUMMARY

There are a number of agronomic practices that can help tip the balance favoring the crop over pests, and help minimize pesticide use in alfalfa production. Key among these are proper stand establishment methods, variety selection, harvest management, and irrigation practices. Issues of regulatory compliance with pesticide use, along with health and safety, economics, and problems with [insecticide resistance](#), make it critically important to reduce our reliance on pesticides to ensure that these tools remain available. Paying attention to preparing a good seed bed, planting early, choosing the right seed variety for your area, and watching nutrient and irrigation needs of the crop can go a long way to ensuring a healthy productive alfalfa stands requiring fewer pesticide inputs. Taken together, these should be considered an 'Integrated Crop Management' approach to pest management.

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