



USAID | **IRAQ**
FROM THE AMERICAN PEOPLE

ALFALFA PRODUCTION GUIDE FOR IRAQ



2011

This publication was produced for review by the United States Agency for International Development. It was prepared by USAID-*Inma* Agribusiness team for a consortium led by The Louis Berger Group, Inc.

ALFALFA PRODUCTION GUIDE FOR IRAQ



General information: info@inma-iraq.com
Website: www.inma-iraq.com

DISCLAIMER

The author's views expressed in this publication do not necessarily reflect the views of the United States Agency for International Development or the United States Government.

Table of Contents

Introduction.....	1
Soil Type and Site Selection.....	4
Field Preparation.....	6
Fertilization.....	8
Irrigation.....	20
Seeding, Fertilizing & Germination.....	27
Alfalfa Varieties.....	33
Weed Control.....	36
Insects in Alfalfa.....	43
Crop Damage.....	50
Common Cutting Schedule-Strategies....	88
Curing and preservation of Alfalfa.....	95
The Alfalfa Haymaking Process.....	117
Conclusion.....	138

Introduction

Alfalfa, *Medicago sativa*, is considered the “Queen of Forages” worldwide and is unrivaled among forage crops due to its combination of high quality, high yield, stand persistence, wide adaptation, biological nitrogen (N) fixation, and soil benefits. Alfalfa,



known as Lucerne in many parts of the world, is a perennial forage legume which normally lives 4 to 8 years, but can live more than 20 years, depending on variety and climate. An interesting alfalfa fact lies in the language origin of the name of the plant. Etymologically, its name is said to be derived from “al-fac-facah”, meaning “father of all foods” in ancient Arabic. Historical records of alfalfa place its origins in the areas now known as Iraq and Iran.

Alfalfa is one of the most palatable forages,

providing high energy and protein for dairy and beef cows as well as other types of livestock. It is an “engine of human food production,” eventually transformed into milk, cheese, meat, wool and honey. It provides a livelihood to thousands of farmers, contributes to wildlife habitat, protects the soil, and provides open spaces. It is the first choice of many farmers and ranchers as the premier perennial forage legume.

Alfalfa may be fed safely to a wide range of livestock, primarily ruminants (cows, sheep and goats), as well as non-ruminants (principally horses). Alfalfa is utilized as hay, silage, green chop, pelletized, cubed or grazed.



The major advantage of feeding alfalfa to livestock is its high nutritional value, especially its high-digestibility, energy and protein content compared to other common forage crops. Dietary carbohydrates (both rapidly and slowly available) provide energy, and are quantitatively the most important nutrient in the diet of livestock. Protein is necessary for livestock growth, maintenance, lactation and reproduction. Alfalfa, a forage legume, is richer in mineral content compared to grasses, and is a good source of calcium, phosphorus, and magnesium, which are critical for the formation and maintenance of the skeleton and teeth, for muscle contraction, and are major components in milk.

Alfalfa is highly valued by farmers for its rotational benefits, including soil improvement and benefits to subsequent crops. Alfalfa is most often grown in rotation with wheat, corn and cotton. Alfalfa has unique production features in the desert areas of Iraq that are distinct from higher rainfall areas.

The obvious differences are related to the need for irrigation water, but a range of other factors are also unique to arid production systems, including cutting schedules, stand establishment methods, stand life, pest management, and variety selection. Alfalfa is a very adaptable plant and can be grown under a wide range of soil and climatic conditions.



Soil Types and Site Selection

Alfalfa can also be grown on a wide range of soil types, but a key requirement is good internal drainage and lack of subsoil impediments. To establish an alfalfa crop, growers must first consider subsoil impediments and shatter those layers with deep tillage. This may be difficult in Iraq where growers generally have small fields and limited access to deep tillage machinery. Therefore, it is necessary for the farmer to know his fields and avoid planting alfalfa on fields where standing

water after irrigation is a problem. Alfalfa performs best on well-drained, relatively deep soils with a minimum rooting depth of 0.9 to 1.2 m. Limitations to rooting depth may be caused by physical or chemical factors, such as hardpans, stratified soils, or salts that restrict productivity and lower yield. Poor drainage or a high water table may also limit root growth. Ideally alfalfa should not be planted on extremely sandy soils or on heavy clay soils.



Note the stratified layer at about 60 cm depth

Fertility problems should be addressed before planting. ***Application of any fertilizer or soil amendment should be based on the results of soil tests.*** Soil amendments of gypsum and/or sulfur are sometimes used on salt-affected soils. Alfalfa frequently responds to an application of phosphate. Fertilization is covered in more detail later in this manual.

Field Preparation

Good seedbed preparation involves ripping or chiseling and the use of finishing discs, harrows and ring rollers to produce a firm, trash-free seedbed.

Alfalfa fields should be worked as deeply as possible with the equipment available. The field should first be plowed and then chisel plowed to open up the soil for drainage and root penetration. Fields with center pivot irrigation should be smoothed as much as possible to eliminate depressions and high spots.



Fields, which will be flood irrigated, should be leveled to insure complete coverage of the soil surface with the irrigation water.



Land Plane

If it is not possible to do precision leveling in a flood irrigated field, the width of the individual flooded bordered checks should be reduced. The check is the space between the two earth berms (borders) used to contain the water. The width of the check is also affected by the soil type. Sandy soils with high water infiltration rates require narrower checks, perhaps as narrow as 3m width.

Clay soils with very low infiltration rates can have much wider checks if they are precision leveled. Checks of 15m width or more are common on precision leveled soils with a low infiltration rate. Infiltration rate is the rate that water penetrates the soil. This happens very quickly in sandy soils and very slowly in clay soils.

The soil surface should be worked sufficiently with a disc to produce a good seed bed with no large clods. Borders built for flood irrigation should be rounded down with a gradual slope and planted to alfalfa with the rest of the field. This will help increase yield and help to control weeds, which would otherwise grow on unplanted borders.

Fertilization

Providing an adequate supply of nutrients is important for alfalfa production and is essential



for maintaining high and profitable yields.

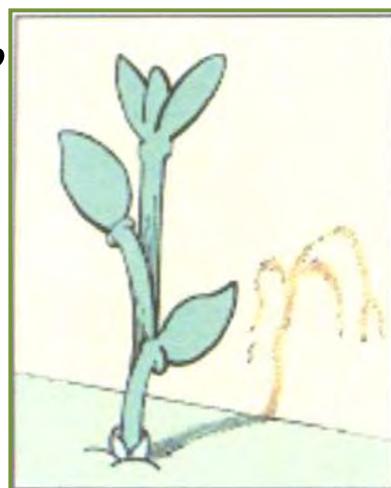
Supplying proper plant nutrition requires complex and often difficult management decisions, such as

- An analysis of which nutrients are needed (*soil test & plant tissue analysis*)
- Selection of the proper fertilizer
- Determination of the application rate
- Timing

- Placement
- Economics
- Field record keeping
- Environmental considerations

Before applying fertilizer to alfalfa, first consider other factors that may limit yield. It makes no sense to apply fertilizers when another factor is more limiting to plant growth. For example, an application of phosphorus, even when phosphorus is deficient, may not increase yields if water is not sufficient to allow plants to grow in response to the applied fertilizer.

A key aspect of designing a fertilization program is evaluating the nutritional status of the alfalfa crop. Nutritional status can be evaluated by **visual observation, soil analysis, or plant tissue testing**. Using all three in combination provides the best results.



At this time there does not appear to be any reliable laboratories in Iraq, which can give soil test or plant tissue analysis results in which farmers can have confidence. This manual will briefly discuss soil and tissue analysis anticipating that laboratory services will be available soon in Iraq.

STEPS TO EVALUATE NUTRITIONAL STATUS OF ALFALFA CROP



- 1. Take a soil sample*
- 2. Determine area of field to take plant tissue samples (collect from healthy and affected plants)*
- 3. Handle plant samples carefully*
- 4. Label bags (date, field name, section #) - keep a record*
- 5. Send dry soil or plant samples to Laboratory*
- 6. Maintain records of results-*

“Hidden Hunger”

Mild nutrient deficiencies are not easily detected with visual observations and can only be detected by soil and tissue analysis.

Soil tests provide an estimate of nutrient availability for uptake by plants and are most useful for assessing the fertility of fields prior to planting. Soil sampling methods are critical, since soil samples must adequately reflect the nutrient status of a field. Although a single representative sample of an entire field provides an average value, it is not the best way to develop recommendations for parts of the field that are less productive.

The best technique is to divide each field into two or three areas, representing good, medium and poor alfalfa growth areas.

The best time to sample soil is soon after irrigation or rainfall, when the probe can easily penetrate the moist soil. Before taking a soil sample, remove debris or residual plant material from the soil surface. The sample

can be taken with a shovel, but a hollow, open-faced soil probe, is preferred. **(See photo - right)** Sample the top 15 to 20 cm of soil unless a salt problem is suspected. If this is likely, then the second 30 to 60 cm and even the third 60 to 90 cm should also be sampled. Take 15 to 20 cores at random from each area and mix them thoroughly in a plastic bucket to produce a single 0.5 L composite sample for each area. Since there is usually less variability, only 8 to 12 cores

need to be composited for the deeper, second and third 30 cm samples. Place each sample in a separate double-thick paper bag and air dry the soil at room temperature before taking it to the laboratory.



Hollow, open-faced soil probe

To get a complete assessment of the nutrition status of an alfalfa field, perform all the soil and tissue tests cited in the table below:

Suggested Tests for a Complete Examination of Soil and Alfalfa Tissue

Soil	Plant Tissue
pH	Phosphorus (PO ₄ -P)
Phosphorus	Potassium
Potassium	Sulfur (SO ₄ -S)
Electrical Conductivity	Boron
Calcium, Magnesium, Sodium	Molybdenum
Sodium Adsorption Ratio	Copper

Interpretation of results of soil values determined by soil test

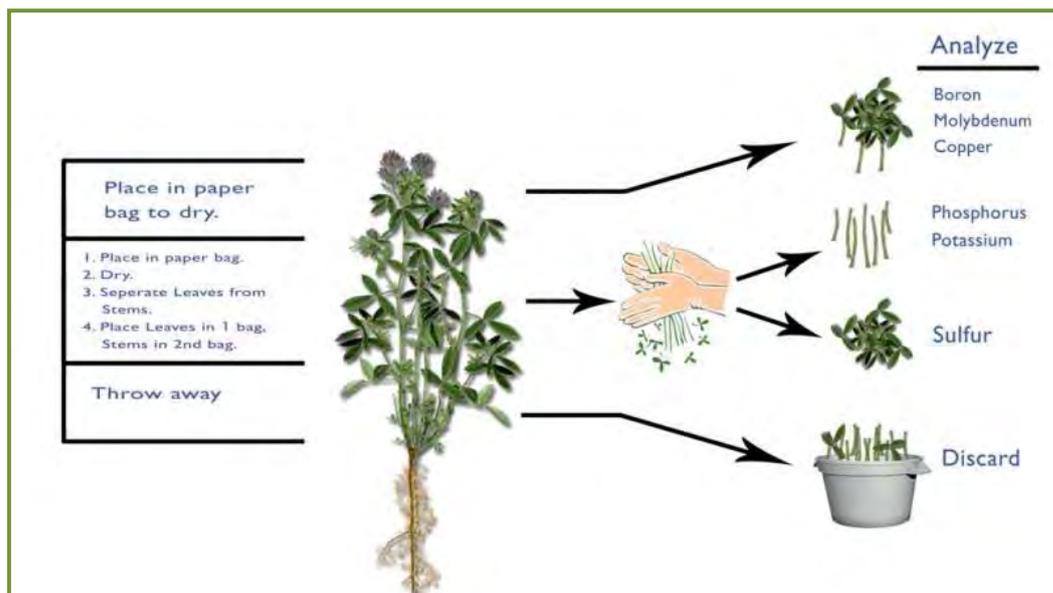
N u - trient	E x - tract	Defi- cient	Mar- ginal	Ade- quate	Hig h
Phos- phoru s	Bicar- bonate	<5	5–10	1 0 – 20	> 2 0
P o - tassiu m	A m - moniu m ace- tate	<40	4 0 – 80	8 0 – 125	> 1 25
B o - ron	Satu- rated paste	0.1 _c	0.1– 0.2	0.2– 0.4	>0. 4 _d

Plant tissue testing is the most precise method of determining the nutrient needs of alfalfa. Plant tissue tests are the best reflection of what the plant has taken up and are far more accurate than soil tests, particularly for sulfur, boron, and molybdenum. Plant tissue tests are useful in monitoring nutritional status and evaluating the effectiveness of current fertilization practices.

The best time to take a tissue sample is when the crop is at the **one-tenth bloom growth stage** or when re-growth length measures 0.6 to 1.3 cm. Since alfalfa is occasionally cut before one-tenth bloom (e.g., bud stage) to attain high-quality forage, preliminary research results indicate that phosphorus concentration should be 1,200 ppm $\text{PO}_4\text{-P}$ at mid bud and even higher, and 1,600 ppm at very early bud stage. Other nutrient concentrations should be approximately 10 percent higher than when sampled at the one-tenth bloom growth stage.

Samples can be collected at any cutting, but collection at first cutting is preferred because it is the best time to detect a sulfur deficiency. Collect 40 to 60 stems from at least 30 plants in each of the same areas from which the soil samples were collected.

Different plant parts are analyzed for different nutrients. Cut each sample into three sections of equal length.



Discard the bottom one-third; place the top one-third in one paper bag and the middle one-third in another. Dry the samples in a warm room or oven. After drying, separate leaves from stems in the middle one-third sample by rubbing the sample between your

hands. Put leaves and stems into separate bags. Charts below list the analyses that should be performed on the samples, and guidelines for interpreting plant tissue—test results.

Tissue tests can determine only the single most limiting nutrient affecting plant growth—the concentration of other nutrients may actually increase due to reduced growth. Therefore, correct the most severe deficiency first. After it is corrected, take new plant tissue samples to determine if other nutrients are deficient. Low concentrations of a nutrient in plant tissue may not always indicate a deficiency in the soil. Remember that plant analysis reflects nutrient uptake by the plant; a problem affecting roots, such as nematodes, can affect nutrient uptake as well.

Plant Tissue Value						
Nutrient	Plant Part	Unit	Deficient	Marginal	Adequate	High
Phosphorus (PO ₄ -P)	Middle third, stems	ppm	300–500	500–800	800–1,500	Over 1,500
Potassium	Middle third, stems	%	0.40–0.65	0.65–0.80	0.80–1.5	Over 1.5c
Sulfur (SO ₄ -S)	Middle third, leaves	ppm	0–400	400–800	800–1,000	Over 1,000d
Boron	Top third	ppm	Under 15	15–20	20–40	Over 200e
Molybdenum	Top third	ppm	Under 0.3	0.3–1.0	1–5	5–10f

Soil or Plant Tissue Test Result Recommendations				
Nutrient	Yield Level (M T / donum)	Deficient	Marginal	Adequate
Phosphorus (P2O5)	4.5	35-50	20-30	0-15
	6.75	50-75	30-40	0-20
Potassium (K2O)	4.5	85-110	40-55	0-35
	6.75	110-165	55-85	0-40

Irrigation

Since border-strip irrigation is dominant in Iraq, land leveling is often required to assure uniformity of irrigation. Solid set as well as center pivot irrigation systems are used in Iraq. While these two systems perform best on uniform surfaces, there is no need for precise leveling.



To be fully productive, alfalfa irrigation requirements in Iraq are shown in the following table:

Province	Crop Water Requirements# (mm/year)	Irrigation Re- quirements# (mm/year)
S u l a y - maniyah	1,118	877
Erbil	1,433	1,244
Dahuk	1,043	863
Ninawa	1,379	1,240
Kirkuk	1,450	1,249
Diyala	1,376	1,260
Baghdad	1,700	1,658
Anbar	1,470	1,444
Najaf	1,835	1,823
D i w a n i - yah	1,622	1,600
Muthanna	1,604	1,583
Dhi Qar	1,718	1,708
Maysan	1,545	1,495
Basrah	1,581	1,553

Generally, more water is required to leach salts and to compensate for irrigation inefficiencies, especially in Iraq where salinity is a problem. For that reason, the leaching requirement must be determined. Timing of irrigations is highly influenced by forage cutting schedules, since the soil must dry for harvest, approximately every 28 days.

Uniform seed germination and stand establishment is much easier to achieve under sprinkler or center pivot irrigation. Portable sprinkler systems are often used on flood irrigated fields in other desert production areas to germinate the seed and establish the stand. Once the stand is established the sprinklers are removed and flood irrigation is used for production.

When borderstrips are used, it is important to use the right stream size for the soil and land slope and to stop the flow at the right time so that just enough water infiltrates into the soil to satisfy the required irrigation depth.

The following table shows when to stop the water supply to a borderstrip.

Soil type	Stop the flow when advance reaches the# following portion of the borderstrips
Clay	Two-thirds of total length
Loam	Three quarters of total length
Sand	Almost end of borderstrip

Borderstrip lengths in the USAID-*Inma* alfalfa demonstration sites were determined by conducting advance tests and infiltration tests.

Frequency of irrigation is dependent on the water holding capacity of the soil, climatic factors, such as temperature, wind, humidity and day length, and the permissible soil water depletion. In the case of alfalfa, a soil water depletion level of 50 percent of the total available soil water has been used.

Based on these characteristics, irrigation

calendars were prepared for the following USAID-*Inma* alfalfa demonstration areas:

Location	Soil texture	Irrigation Frequency (days)*											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Najaf	Loamy Sand	30	25	15	12	8	7	7	7	8	12	20	30
Anbar	Clay loam	30	30	25	19	12	10	9	10	12	19	30	30
Wasit	Loamy clay	30	30	30	30	15	12	12	12	15	21	30	30
Kir - kuk	Silty Loam	30	30	30	30	20	15	15	15	20	30	30	30
Nina-wa	Silty loam	30	30	30	30	15	13	13	13	15	30	30	30

*When the irrigation frequency is 30 days it means that either rainfall is sufficient, especially in the northern provinces, or that only one irrigation immediately after cutting will be sufficient.

The water holding capacity of soil varies by soil type; sandy soils having the capacity to hold about 40 mm of moisture per meter of soil, while heavy clay soils have the capacity to hold up to about 90 mm of moisture per meter. Other soil types fall somewhere between these extremes.



A newly seeded field of alfalfa being flood irrigated Flood irrigated alfalfa in Iraq

Daily evapotranspiration rates in Iraq vary from 1 mm/day in the winter months of December and January in the northern provinces to about 11 mm/day in the heat of the summer in the southern provinces. There are crop coefficients for specific crops under varying conditions, which may increase or decrease the demand estimated per the evapotranspiration rate, but for the purpose of the alfalfa demonstration sites 0.8 has been used.

Alfalfa is moderately sensitive to soil salinity. Yield decrease related to electrical conductivity (EC_e of extraction saturated paste in dS/m) is:

EC _e Value	Percent(%) of Decreased Yield
EC _e 2.0 dS/m	0%
EC _e 3.4 dS/m	10%
EC _e 5.4 dS/m	25%
EC _e 8.8 dS/m	50%
EC _e 15.8 dS/m	100%

Seeding, Fertilizing & Germination

Seeding may be accomplished utilizing grain drills with small seed attachments, broadcast planters, Brillion seeders, aircraft, or no-till planters. Broadcast either by hand or with a simple broadcast applicator is probably the predominant method used in Iraq for seeding. Fall planting, mid-September through mid-to-late October, is recommended. Alfalfa can be planted in winter or spring, however this usually results in decreased yields. Summer planting is not recommended due to excessive heat.



Brillion Seeder

Herbicide use in young alfalfa seedling stands should be considered to eliminate competing weeds, which may reduce the stand by crowding out the young alfalfa seedlings. **Farmers should consult their Agriculture Extension Specialist for herbicide recommendations for Iraq.**

Seeding rate should correspond to the method of planting. Broadcast seeding is less efficient and therefore requires more seed.

Broadcast 22 to 27 kg / Hectare

Drilled 15 to 20 kg / Hectare

Super Phosphate should be applied before seeding and incorporated into the soil.

Broadcast seeded fields should be rolled or raked to cover the seed. Alfalfa seed should be covered to a depth of 0.6 to 1.25 cm, but never more than 1.8 cm.

There are three options to consider for providing moisture to germinate alfalfa seed:

- 1) Plant prior to anticipated rain
- 2) Plant and irrigate immediately after seeding,
- 3) Pre-irrigate and plant into moisture.

The value of each strategy will depend on the grower's tolerance for risk, soil type, reliability of rainfall, and adherence to recommended planting times.

The advantage to planting before anticipated rain is that it saves the cost of labor and water for irrigation. However, weather forecasts can be unreliable and, the likelihood of

rain during the optimum planting season is minimal in Iraq.

The advantage to planting and irrigating immediately afterward is the ability to plant during the optimum planting period even though rain is unlikely. To be successful, it is important that seeding depth be no more than 1.3 cm. If soil crusting occurs before seedling emergence, additional light irrigations are necessary to soften the surface.

The third alternative, pre-irrigating and planting into moisture, is not without challenges, especially if soil moisture is more than 1.3 cm from the surface at the time of planting. Moisture levels can be inconsistent and too-shallow placement of seed results in uneven stands because some seed germinates immediately and other seed will need additional water before germination. Seed planted too deeply may result in weak seedlings that struggle to reach the soil surface from greater depths.

Pre-irrigation is generally the best option. It fills the soil profile to field capacity, germinates weed seedlings that can then be removed by cultivation or contact herbicides, and settles the soil, allowing elimination of high or low areas in the seedbed before planting. With pre-irrigation, sufficient time must be allocated before planting for soil to be dry enough to support planting equipment. A concern, especially during fall and on clay soils, is that rainfall following pre-irrigation may prevent planting for an extended period. For these reasons, some growers choose not to pre-irrigate.

Newly immersed alfalfa seedlings



A variation of the second alternative is sprinkler irrigation to germinate the seed. Most growers see the advantage of sprinkler irrigation on newly seeded alfalfa from germination through emergence. Growers must weigh the potential yield increase with early planting and the value of current hay prices against the cost of sprinkler rentals, additional labor and management expenses, and the cost of water. Historically, the increased cost for sprinklers has been justified in view of the extra production resulting from early fall planting. If sprinklers are used only during stand establishment, a hand move system or wheel lines are recommended.



Center pivot irrigation on alfalfa—Iraq



A hand-move sprinkler system on first cutting alfalfa—Iraq

Initially, sprinklers should be run long enough to completely fill the top 15 cm of the soil profile. Subsequent shorter irrigations may be necessary only to wet the top 2.5 cm, to prevent desiccation of the germinating seeds and prevent crusting. Keeping the surface too wet may result in seedling diseases. Irrigate just frequently enough to provide moisture for the young, developing seedlings. Run times will vary, depending on residual soil moisture content following the previous crop. Irrigation runs that are too long can cause puddling, and seedlings will not survive in standing water.

Alfalfa Varieties

Non-dormant varieties, those that grow actively in the winter (Rated Fall Dormancy - FD 8 to 11) should be used in all but the northern, mountainous areas of Iraq. These varieties will provide some growth during the winter months that may be used for grazing or green chopping. The yields are greatly reduced during the cooler months

and the growth will not be adequate to make alfalfa hay. Care should be taken if grazing ruminant animals on alfalfa, as it may cause the animals to bloat.

Currently, there is one approved variety of alfalfa registered for planting in Iraq: Australia Pacific (PAC 7800 I)

Farmers in Iraq traditionally save alfalfa seed year after year or purchase unregistered 'Hamedn' from Iran. 'Hamedn' are often adulterated with wheat seed. Both saved seed and 'Hamedn' alfalfa seed is of low quality. In northern Iraq imported alfalfa seed is available, however none of the varieties on offer there are properly registered, so extreme caution should be taken in purchasing such seeds.

A program of accepting registration for recognized, regionally adapted varieties currently registered for use in Saudi Arabia, Egypt and Syria would be a step that the

Ministry of Agriculture of Iraq could take to increase the number of improved alfalfa varieties available in Iraq.

Modern alfalfa varieties are populations rather than uniform genetic strains. These populations have traits such as yield, fall dormancy, and pest and disease resistance that are significantly different from older, unimproved lines. But individual plants within a variety are not genetically identical. A trait is present in certain frequencies in the population of plants within a variety. This is pertinent, especially to the issue of pest resistance, since some susceptible plants remain in even highly resistant varieties, and some low-yielding plants remain in a high-yielding variety. Understanding the nature of alfalfa varieties as populations of many different types of plants is very important when evaluating variety performance with regard to adaptation, yield, fall dormancy, and pest and disease ratings.

Weed Control#

Weeds are serious economic pests of alfalfa. Many different weed species including annuals and perennials, warm and cool season grasses, broadleaf plants, parasitic and poisonous plants, may infest alfalfa hay grown in Iraq. Weeds in alfalfa directly compete for the same resources required for alfalfa growth and development: water, nutrients, light, and space. If weeds are left uncontrolled, they will reduce alfalfa yield and weaken or even destroy the stand, particularly if left unchecked during the seeding period. Weeds have a significant effect on forage quality. Establishment of a vigorous alfalfa stand is essential for long-term weed control. In older alfalfa fields, weeds are quick to fill in open spaces when stands decline. It is nearly impossible to control weeds in a thin or weak alfalfa stand. An understanding of the life cycle, germination, flowering, and seed formation of weeds and their method of propagation is necessary for effective weed management.

Weeds are classified into three groups according to their life cycle: annual, biennial, and perennial, and can be broadleaf or grassy weeds.

Weeds Affect Forage Quality

Weeds affect alfalfa during two distinct periods: stand establishment and in established fields. Yield is sometimes reduced, but more often yield is the same or actually higher when weeds are not controlled. However, the feeding value of the hay is usually drastically reduced. For example, in one study, protein content was as low as 9 percent in hay that contained 80 percent weeds. When weeds were controlled with herbicides, the protein content rose to more than 20 percent. Thus, an effective weed control program can more than double the nutritive value of the hay.

Weeds affect quality because most weeds are less palatable and less nutritious than alfalfa. Although some weeds make high quality

forage, they are too mature at the time alfalfa is harvested. The loss of feeding value from weed infestation can be due to physical, chemical or toxic factors. Many weeds are much lower in protein and higher in fiber than alfalfa.

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

The first step toward an effective weed-control program in alfalfa is to use farming

practices that promote a healthy, vigorous stand that will compete effectively with weeds. Weed control during stand establishment involves integrating many factors, including cultural practices and use of herbicides.

Cultural Practices to Control Weeds

When older alfalfa stands decline it is advisable to rotate out of alfalfa for 2 or 3 years to reduce disease pressure and disrupt weed and insect life cycles.

Know the weed history of a field prior to planting. Fields infested with perennial weeds are not well suited for alfalfa. Use crop rotations with annual crops such as wheat and corn that compete more aggressively with perennial weeds. An integrated approach that includes crop rotation is the key to management of perennial weeds.

Proper land leveling is an important first step for effective weed management.

If fields are not properly leveled, water collects in low spots, drowning out the alfalfa, leading to weed infestations. Non-uniform water distribution adversely affects alfalfa growth, reducing its ability to compete with weeds. A well-prepared seedbed promotes uniform germination and rapid growth of alfalfa seedlings.

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

Companion crops (also referred to as ‘nurse crops’) consist of a second species planted

along with the alfalfa during the establishment phase. Small grains (e.g., oat, wheat and barley) are commonly used as companion crops, oat being the most common. The purpose is to prevent soil erosion and suppress weeds while the alfalfa is becoming established. Most companion crops germinate and grow faster than alfalfa, provide additional competition against rapidly growing weeds.

By replacing most weeds with a desired plant species, first-harvest forage quality and yield may be improved. However, the forage quality will not be as high as a pure stand of alfalfa.

Companion crops have an additional drawback, if seeded at too high a rate the companion crop can negatively impact the seedling alfalfa in the same manner as weeds and can lower alfalfa vigor and stand density.

Chemical Weed Control

Chemical weed control is used on as much as 80 percent of the alfalfa grown in other desert production areas for seedling weed control. Herbicides are considered an integral component of a total weed-management system, and when coupled with cultural practices, weeds can be efficiently and effectively controlled. Pre-plant herbicides are applied and mixed into the soil before planting and control weeds at germination or through root uptake. Post-plant, pre-emergence herbicides are applied after planting the crop but before the weeds or the crop has emerged. Post-emergence herbicides are applied after weed and/or crop emergence.

Famers should consult their local Ministry of Agriculture Extension Specialist or herbicide dealer for herbicide recommendation to use on alfalfa plantings in Iraq.

Insects in Alfalfa

Although only a few pest species infest alfalfa, they can cause substantial yield and quality losses if present in high numbers. Most pests tend to be sporadic, causing yield losses in some years and having little effect in other years. An effective pest management program can significantly reduce the losses caused by insect pests. To implement an Integrated Pest Management (IPM) strategy to optimize economic returns in alfalfa, the following principles must be observed:

- Correct identification of pest and natural enemy species,
- Use of economic threshold values,

- including natural enemy activity,
- Careful monitoring and sampling of pest and natural enemy populations,
 - Implementation of control strategies that minimize effects to natural enemies and other non target species.

Beneficial Insects

Beneficial insects are common in alfalfa



(Lady beetle feeding on aphids)

Alfalfa supports an incredible diversity of insects, most of which have little or no impact on the plant itself. Alfalfa has been called an “insectary” since it is home to many predators and beneficial insects that move among crops and provide biological control of pests in diverse cropping systems as well as in

alfalfa itself. For example, while more than 1,000 species of arthropods have been identified in alfalfa, fewer than 20 are pests and fewer still are serious pests.

Insect Pests

Serious pests include the alfalfa weevil in the spring, a complex of caterpillar larvae (alfalfa caterpillar and army-worms) in the warmer months, and a complex of aphids, including the spotted alfalfa aphid, throughout the year. Most growers use pesticides to control these insect pests based on IPM principles. Numerous management strategies, including resistant varieties, biological control, chemical control and cultural control have been devised to mitigate pest impact on alfalfa yield and quality. **USAID regulations prohibit USAID-Inma from recommending or providing insecticides. Farmers should consult their Agriculture Extension Specialist, or pesticide dealer for recommendations for labeled insecticides for use in Iraq. Other sources of pesticide information are Agriculture**

Extension Fact Sheets and publication produced by Agriculture Universities available on the internet, for example, see <http://alfalfa.ucdavis.edu/IrrigatedAlfalfa/>

Weevil

***Hypera postica* Gyllenhal (Alfalfa Weevil)**

***Hypera punctata* (Clover Leaf Weevil)**



Description Alfalfa Weevil Larva

Alfalfa weevil adults are small (0.6 cm) brown snout beetles that have a distinctive dark, narrow stripe which extends down their back. Adult weevils insert yellow oval eggs into alfalfa stems. Following egg hatch, small legless yellowish-green larvae, each

with a white stripe along the middle of the back, emerge. A fainter white stripe is also present on each side of the more prominent central stripe. Each larva has a very conspicuous black head and is approximately 1.0 cm when mature. Transformation to the adult stage is passed in a loosely woven white cocoon, about the size of a pea, to which leaves may be attached.

The alfalfa weevil can be confused with the **Clover Leaf Weevil (*Hypera punctata*)** which is another pest of alfalfa.



However, clover leaf weevils rarely cause economic injury in alfalfa. Larvae of both these species are similar, but have distinct

differences in appearance. The clover leaf weevil is green with a white stripe down the center of its back, but the white stripe is bordered with smudges of pink or red; the head of the clover leaf weevil is tan. Adult clover leaf weevils are twice the size of the alfalfa weevil (0.8 cm). They are light brown with a wide dark brown stripe on the back.

Life Cycle- Alfalfa Weevil Alfalfa Weevil Eggs



Some initial egg laying during November may take place before the onset of cold weather. # During the winter, when temperatures permit, adults may deposit some eggs. Female weevils insert eggs in clusters of 2 to 25 inside alfalfa stems. Larvae become noticeable

in late winter and are readily observable in late spring. The green larvae feed for roughly 3 to 4 weeks depending on the quality of the alfalfa and the temperature. Larvae molt or shed their skins three times. Following the last larval instar, cocoons are spun on plants or in curled up leaves that have fallen to the ground. The pupal stage requires 1 to 2 weeks for completion. Upon their emergence from cocoons, adults feed for a week or two, and then move to sheltered areas to spend an inactive summer. It is quite likely that at any point in time during the summer, most alfalfa weevil life stages can be found. Older adult weevils may continue their egg-laying activities, while at the same time, larvae, cocoons, and newly emerged adults may also be observed. Upon the arrival of colder weather, adult weevils seek out the crowns of alfalfa plants, the protection of wooded areas or vegetation in ditch banks and fence rows to over winter.



Alfalfa Weevil Cocoon



Alfalfa Weevil Adult

Crop Damage

Both adults and larvae feed on alfalfa foliage, but the larvae cause the majority of the damage. #Larvae feed initially on the inside of terminal leaves and later move to foliage on the lower portion of the plant. Early season larval damage (first and second instars)

shows up as pinholes in leaf terminals. Leaves are skeletonized as larvae increase in size. Third and fourth instars defoliate plants by feeding between the veins, and also on the buds and growing tips. Adults generally feed on the leaf margins, which creates a feathery appearance of the foliage. Injured leaves dry very quickly giving the field a gray to white cast.

Alfalfa weevils have the ability to severely damage the first cutting of hay. In southern areas, significant egg laying may take place during the fall, predisposing some alfalfa fields to early larval damage the following spring. In contrast, alfalfa weevil damage to hay in cold, northern areas is likely only if the first harvest has been delayed. Injury to alfalfa in the northern area will most probably occur on the stubble and tender growth of the second crop.

Clover leaf weevils and alfalfa weevils feed and behave differently. Alfalfa weevils feed during the day, actively feeding on

the foliage, starting near the leaf tips. Clover leaf weevils feed at night, usually on the lower leaves. They can be found on the ground, near the crowns during the day.

Control Measures

Early harvesting is a very effective tool for the management of the alfalfa weevil. Harvesting the crop early, when alfalfa weevil populations are high, can dramatically reduce weevil densities. This helps to remove food and shelter from larvae and also increases their exposure to harmful rays from the sun. Reports indicate that harvesting can reduce pest populations by 95 to 98 percent.

Armyworms

***Spodoptera exigua* (Beet Armyworm)**

***Spodoptera praefica* (Western Yellow-striped Armyworm)**

Description

The adult Beet Armyworm is a small, mottled gray or dusky winged moth.

The moths fly mostly at night but may be seen flying up as you walk through the field. Females deposit pale greenish or pinkish, striated eggs on the upper side of the alfalfa leaves in small or large masses covered with white cottony material. The eggs hatch in a few days, and the tiny caterpillars begin feeding on the plant. Heavy feeding on the tips of plant stalks can cause flagging as terminal leaves turn white. The smooth skinned caterpillars become full grown in about 2 to 3 weeks and are about 5.7 cm long. They may be olive green to almost black in color down the middle of the back with a yellow stripe on each side of the body.



The Western **Yellowstriped Armyworm** caterpillar is usually black, with two prominent stripes and many narrow bright ones on

each side. At maturity it is approximately 3.8 to 5 cm long. Eggs are laid in clusters on the upper side of leaves and covered with a gray, cottony material. Eggs hatch in a few days and larvae reach full size in 2 to 3 weeks. Larvae pupate on or just under the soil surface. Adults are brown moths that primarily fly at night but may be encountered flying up as you walk through the field.



Armyworms are common pests from June through September. There can be at least five generations a year. The final generation may overwinter as large larvae or pupae.



Armyworm egg mass Armyworm Pupa

Crop Damage

Armyworms skeletonize foliage, leaving veins largely intact. First and second instar larvae tend to feed in clusters around the egg mass from which they hatch. This frequently causes a tattered appearance to the terminals. This whitish appearance caused by the feeding is known as "whitecaps" and is very visible across a field. As the larvae mature and move to more stems, the areas of "whitecaps" tend to come together and the entire field takes on a tattered look.

Management

Populations of armyworms are frequently

controlled by natural enemies and are more or less cyclic, occurring in large numbers only every few years. Early harvest, border harvesting, and biological control are important components in avoiding damage from armyworms.

Border harvesting involves leaving uncut strips of alfalfa at intervals across the field. These strips serve as a refuge for natural enemies of alfalfa pests. At the next harvest these strips are cut and other strips are left. At the next harvest the strips are cut half into one windrow and half into another windrow, blending old and new hay to minimize quality loss in bales.

Biological Control

Natural enemies can provide good control of armyworms in many fields. Predators include bigeyed bugs, spiders, minute pirate bugs, damsel bugs and lacewings. The parasitic wasp, *Hyposoter exiguae*, is the most important of at least 10 parasites attacking this pest. Viral diseases of armyworms are also

important natural control agents. Sprays of *Bacillus thuringiensis*, are acceptable for use on alfalfa.

Alfalfa Caterpillar *Colias eurytheme*#



#

Description

The yellowish-orange or whitish butterflies of the alfalfa caterpillar lay eggs on the short, new growth alfalfa that is less than 15 cm tall. Eggs hatch into green caterpillars in 3 to 7 days. #

#



Full grown Caterpillars are about 3.8 cm long and are distinguished from other common caterpillars on alfalfa by their velvety green bodies and white lines along their sides.

Caterpillar populations usually result from a flight of butterflies into the field when the alfalfa is less than 6 inches tall. Extremely large numbers of adults migrating between fields are often present from June to October. Factors contributing to economic populations are slow and uneven growth of the crop, lack of parasites, and hot, dry weather. There are four to seven generations a year of alfalfa caterpillar, and each generation is closely synchronized with the hay-cutting cycle so that the caterpillar pupates before cutting occurs.

Damage

Alfalfa caterpillars consume the entire leaf. The larger larvae are most destructive.

Management

The most important way to control the alfalfa caterpillar is to preserve and encourage its natural enemies by avoiding unnecessary insecticide applications for aphids or weevils in late spring or by using nonselective insecticides against caterpillar pests in summer.

Biological Control

An important parasite of the alfalfa caterpillar is *Contesia Medicaginis*, a dark brown to black wasp about 0.6 cm long. This wasp stings very small alfalfa caterpillars and lays an egg inside. The egg hatches and the wasp larva consume the body contents of the caterpillar. A parasitized caterpillar dies before it reaches 1.2 cm in length. It is recognized by being lighter than normal in color, somewhat shiny rather than velvety on the surface, and swollen toward the rear. Grasping the caterpillar at each end of the swelling and pulling it apart will expose the shiny, white parasite. It is important to determine the amount of parasitism because the economic threshold takes

parasitism into account. Sprays of *Bacillus thuringiensis*, are acceptable for use on alfalfa.

Cultural Control

Border harvesting is a useful method for preserving the natural enemies of both the alfalfa caterpillar and aphids because it helps retain parasite larvae in the field. Early harvesting of fields infested with economic levels of alfalfa caterpillars kills a large number of caterpillars, preserves crop yields, and avoids reducing the natural enemy population. Time this cutting to avoid serious damage, yet obtain satisfactory yield.

Aphids

***Acyrtosiphon kondoi* (Blue Alfalfa Aphid)**

***Acyrtosiphon pisum* (Pea Aphid)**

***Therioaphis maculate* (Spotted Alfalfa Aphid)**

There are three species of aphids that constitute the principal aphid threat to alfalfa in Iraq. The spotted alfalfa aphid, *Therioaphis*

maculata, is easily identified by the six rows of black spots on its back. The blue alfalfa aphid, *Acyrtosiphon kondoi*, and the green pea aphid, *Acyrtosiphon pisum*, are large aphids and look somewhat similar except that the blue alfalfa aphid is, blue-green in color, and lacks a dark ring on the third antennal segment and is uniformly brown. All three species can be a serious pest to alfalfa, thinning stands and reducing tonnage. Plant quality is also reduced by the black fungus that grows on the honeydew produced by the aphids.



Blue Alfalfa Aphid



Pea Aphid



Spotted Alfalfa Aphid

Description

Both the blue alfalfa aphid and the pea aphid prefer cool temperatures (optimal temperature for development of blue alfalfa aphid is 60°F) and reach damaging levels in spring, but blue alfalfa aphid is more tolerant than pea aphid of cool temperatures and appears earlier in spring.

Pea aphid often reoccurs in fall as well. Both species may be present in alfalfa fields at the same time as the alfalfa weevils. The blue alfalfa aphid prefers the plant terminals while pea aphid is usually more generally distributed. Both species prefer the stems to the leaves.

The spotted alfalfa aphid is a small, pale yellow or grayish aphid with four to six rows of spined black spots on its back. Mature females may either be wingless or have wings with smoky areas along the veins. This aphid prefers warm weather and is generally found during summer months. High populations may continue into fall and winter.

Damage

These aphids feed on alfalfa and inject a toxin that retards growth, reduces yield, and may even kill plants. Damage can also reduce the alfalfa's feed value. A black fungus, sooty mold, grows on the honeydew excreted by the aphid reduces palatability to livestock. Damage is more severe on short hay than on taller alfalfa for both species. The toxin injected by the blue alfalfa aphid is more potent than that of the pea aphid.

Management

Using resistant varieties of alfalfa and encouraging populations of natural enemies

are very important in managing aphid populations in alfalfa. It is important to distinguish these two species because blue alfalfa aphid causes more damage than pea aphid, and the two species have different treatment thresholds. Natural enemies, especially lady beetles, are monitored along with the aphids to determine the need for treatment. Aphids frequently become problems when their natural enemies are disrupted by weevil sprays. Border harvesting or strip cutting can be important for preserving natural enemies.

Resistant Varieties

Planting alfalfa varieties resistant to blue alfalfa aphid and pea aphid has been the most effective means of controlling aphids in alfalfa. Spotted aphids are constantly evolving and quickly overcome resistant varieties of alfalfa. Prolonged periods of below-normal temperatures may lower resistance to blue alfalfa aphid injury and result in some crop injury.

Biological Control

The most significant aphid predators are several species of lady beetles, including *Hippodamia convergens* and *Coccinella septempunctata* that attack and consume both of these aphid species; treatment thresholds for pea aphid are based on the number of lady beetle adults and larvae present. Green lacewings can also be important in regulating aphids and many other predators including bigeyed bugs (*Geocoris* spp.), damsel bugs (*Nabis* spp.), and syrphid fly larvae also play a role in limiting aphid populations. The major parasite of the pea aphid is *Aphidius smithi* while the parasite *A. ervi* attacks both species. Large golden-brown aphid mummies on the upper surfaces of leaves indicate parasitization. When parasites are present, be careful when treating for aphids and other insects. Parasites frequently provide adequate control. Aphids may also be controlled by a naturally occurring fungal disease, which is most prevalent during cool, rainy, or foggy weather.

Cultural Control

Use border harvesting to help maintain populations of parasites and predators within the field.

Organically Acceptable Methods

The use of resistant varieties, biological control, and cultural control are acceptable to use on an organically certified crop. Organically certified insecticides such as azadirachtin (Neemix), neem oil (Trilogy), and pyrethrin (PyGanic) are registered for use on alfalfa to control aphids. Studies, however, have shown that at best they provide some suppression of populations but do not control them.

Monitoring and Treatment Decisions

Start to monitor fields in February for aphids and lady beetles and continue monitoring through fall. If the lady beetles and other natural enemies fail to keep the aphid populations in check, an insecticide treatment may be necessary. **Consult the local**

Agriculture Extension Specialist or pesticide dealer for recommendations for aphid treatments in Iraq.

Nematodes

Root Knot Nematode

Meloidogyne hapla*, *M. incognita*, *M. javanica*, *M. thamesi*, *M. arenaria*, and *M. chitwoodi

Description

Plant parasitic nematodes are microscopic roundworms that live in soil and plant tissues and feed on plants by puncturing and sucking the cell contents with a needlelike mouthpart called a stylet. The nematode life cycle typically includes an egg stage, four larval stages, and an adult stage. The life cycle, from egg hatching to egg production, usually requires 3 to 6 weeks under optimal conditions to complete. Environmental factors, such as soil temperature, soil moisture, host status, and time of infection, can influence the number of nematode generations completed within a year. Nematodes move relatively short

distances on their own (a few centimeters per year), but they are easily spread long distances by soil movement (wind, farm equipment, etc.), irrigation water, nursery stock, seed, and debris in seed and hay.

Damage

Root knot nematodes cause substantial damage. In general, the symptoms and damage are characteristic of nematode problems but not diagnostic because they could result from other causes as well.

Infection of alfalfa by root knot, *Meloidogyne*, species may be confined to localized areas of a field or extend



throughout an entire

field. The extent of the damage in the field depends on several factors, including initial nematode population level, alfalfa variety, and soil temperature at planting time. High initial populations and relatively warm soil temperatures may cause serious injury to seedlings,

probably the most practical means of managing root knot nematodes. Unlike other crops such as tomatoes, resistant varieties of alfalfa do not help reduce nematode populations.

Depending on the root knot nematode species present in the field, crop rotation can be a useful management strategy. It is important to have the species identified. For *Meloidogyne incognita*, the following are good rotation crops: barley, oats, wheat, cole crops, corn, cotton, hops, sudangrass, cowpea and watermelon. For *M. napla*, cotton serves as a good rotation crop.

Soil fumigation before planting can be effective against the northern root knot nematode, but fumigants are expensive and generally not economically feasible on alfalfa.

Diseases

In Iraq's dry climate, diseases are generally not the most important yield-limiting factor,

but several diseases can be found. Seedling diseases often kill young seedlings on wet, heavy soils during cold periods. Root diseases can damage or kill established plants. This manual will cover four of the most significant diseases. In addition the following alfalfa diseases are also present in Iraq: Bacterial Wilt, Phytophthora Crown and Root Rot, Verticillium Wilt, Spring and Summer Black Stem and Leaf Spot, Lepto Leaf Spot, Yellow Leaf Blotch, Sclerotinia stem and crown rot, and Mosaic Viruses. More information can be found about each of these diseases at: <http://www.ipm.ucdavis.edu/PMG/selectnewpest.alfalfa-hay.html>

Fusarium Wilt

Fusarium oxysporum f. sp. Medicaginis

Symptoms

The first symptom of Fusarium wilt is wilting shoots. Bleaching of the leaf and stem color follows, and finally there may be a reddish tint to the foliage. In roots, dark reddish brown streaks occur in the stele (the center

of the root that contains the vascular tissue). In advance stages, the entire stele may be discolored. The dark discoloration caused by Fusarium wilt is in contrast to the yellow-brown discoloration of bacterial wilt.



Comments on the Disease

Fusarium wilt is favored by high soil temperatures. Planting of resistant cultivars is the best control measure.

resulting in stunting. The Northern root knot nematode (*M. hapla*) infects and parasitizes roots of alfalfa plants and causes the plant cells to enlarge into small oval galls on the roots that can be seen with the naked eye. Galls caused by root knot nematodes are accompanied by lateral root growth, unlike galls caused by the beneficial nitrogen-fixing bacteria. In a heavily infested field, young seedlings may be killed by this nematode, even though roots may not display galls. The Columbia root knot nematode (*M. chitwoodi*) produces symptoms similar to the northern root knot nematode, but it is less pathogenic to alfalfa. This nematode causes tiny galls that can easily be missed if roots are not examined carefully. Root knot nematodes may enhance the development of diseases such as bacterial wilt, *Phytophthora* root rot, and *Fusarium* wilt.

Management

The use of resistant alfalfa varieties is

Stagonospora Crown and Root Rot

Stagonospora meliloti

Symptoms

Symptoms of *Stagonospora* crown and root rot include rough and cracked bark tissue on infected roots and crowns. The presence of red flecks in diseased root tissue is a distinctive diagnostic symptom. Fine red streaks also occur in the xylem (water-conducting tissue) in the center of the root, below rotted portions of the crown. Affected crown tissue is generally firm and dry, unless secondary organisms invade the tissue. The pathogen also may infect leaves and stems, causing irregular, bleached lesions with diffuse margins. Infected leaves soon drop after lesions form.

Comments on the Disease

Stagonospora crown and root rot is a cool season crown and root rot disease. Spores of the pathogen are spread by water that splashes from infected leaves, stems, or plant

debris. The fungus enters the crown through stems and grows slowly downward into the taproot. Although the infection can take 6 months to 2 years to kill a plant and above-ground symptoms may be indistinct, the disease reduces plant vigor and yield. Leaves and stems are generally infected during spring rains, but crown infections can occur anytime. The disease is most damaging when alfalfa is not actively growing.

Management

To minimize the effects of *Stagonospora* crown and root rot, provide optimum growing conditions for the alfalfa crop. Consider rotating out of alfalfa for 2 years to eliminate the sources of inoculum within a field.

Rhizoctonia Root and Stem Canker (Rot)

Rhizoctonia solani

Symptoms

Tan, elliptical lesions on the taproot in the areas where lateral roots emerge are distinctive symptoms of Rhizoctonia-related diseases. In winter when the fungus is inactive, these sunken lesions will turn black and appear to be inactive. If roots are girdled during summer, the plant will die. If infection is not severe, new roots will emerge when temperatures are too cool for the fungus.



Comments on the Disease

Rhizoctonia root canker, also known as crown and stem rot, occurs during periods of high temperatures and high soil moisture. The fungus occurs worldwide and also cause

serious **seedling damping off**. Only certain strains of the fungus can cause the root canker form of disease. No control measures are known for these diseases.

Seedling or Damping Off Diseases

Pythium ultimum*, *P. irregulare*, *P. violae*, *Phytophthora megasperma*, and *Rhizoctonia solani

Symptoms

Damping off is a name given to a condition where seeds are killed before germination or seedlings are stunted or collapse and die. Seeds destroyed before germination are discolored and soft. After seed germination, symptoms include brown necrotic (dead) lesions along any point of the seedling. Lesions that girdle the young root or stem lead to plant death. Partially girdled plants, as well as those subject to continued root tip necrosis, may be stunted and yellowish in color to varying degrees. A discolored, constricted area near the soil surface may be seen in

older seedlings. The magnitude of the dark discoloration is dependent upon the age of the seedling as well as the duration of environmental conditions favorable for disease development.

Pythium ultimum and *P. irregulare* cause both pre and post-emergent damping off of alfalfa. *Pythium violae* causes root tip necrosis and inhibition of lateral root formation. *Rhizoctonia solani* may cause pre-emergent death of seedlings but usually causes post-emergent necrosis of the stem at or near the soil surface, which is marked by a distinct margin between infected and healthy tissue.

Phytophthora megasperma, another common soil-borne pathogen, can be particularly devastating in poorly drained soils.

Comments on the Diseases

Pythium and *Rhizoctonia* are common in most soils where they persist indefinitely. Both fungi are transported by water, contaminated soil on equipment, and movement of infected plant materials. Both have wide host ranges.

Damping-off is favored by poor growth of alfalfa seedlings resulting from unfavorable temperatures, excessive moisture, low light, or improper fertilization.

Damping off caused by *Pythium* spp. usually occurs under cool soil temperatures in fields with poor drainage.

Damage by *R. solani* is often related to the amount of organic matter that remains in the soil from the previous crop, with damage increasing as the level of organic matter increases.

Management

Planting high quality seed under environmental conditions favoring rapid germination and seedling growth reduces the chance of infection. Therefore, avoid planting in November and December. Also avoid excessive irrigation and compaction or poorly drained soils. Purchase seed treated with appropriate fungicides to protect seedlings from the damping off pathogens. Although crop rotations do not eliminate these pathogens because of

their wide host ranges, rotations with crops like small grains may help to reduce inoculum levels.

Harvest Strategies for Alfalfa

Harvest management decisions are critical to the profitability of an alfalfa crop. The timing of alfalfa harvests is the primary method by which growers can influence the nutritional quality of alfalfa hay. Additionally, harvest timing has a profound influence on forage yield and stand life as well as pest management, particularly weed infestation. It is difficult to overemphasize the importance of cutting schedules to alfalfa performance and overall profitability.



Yield–Quality Persistence Tradeoff

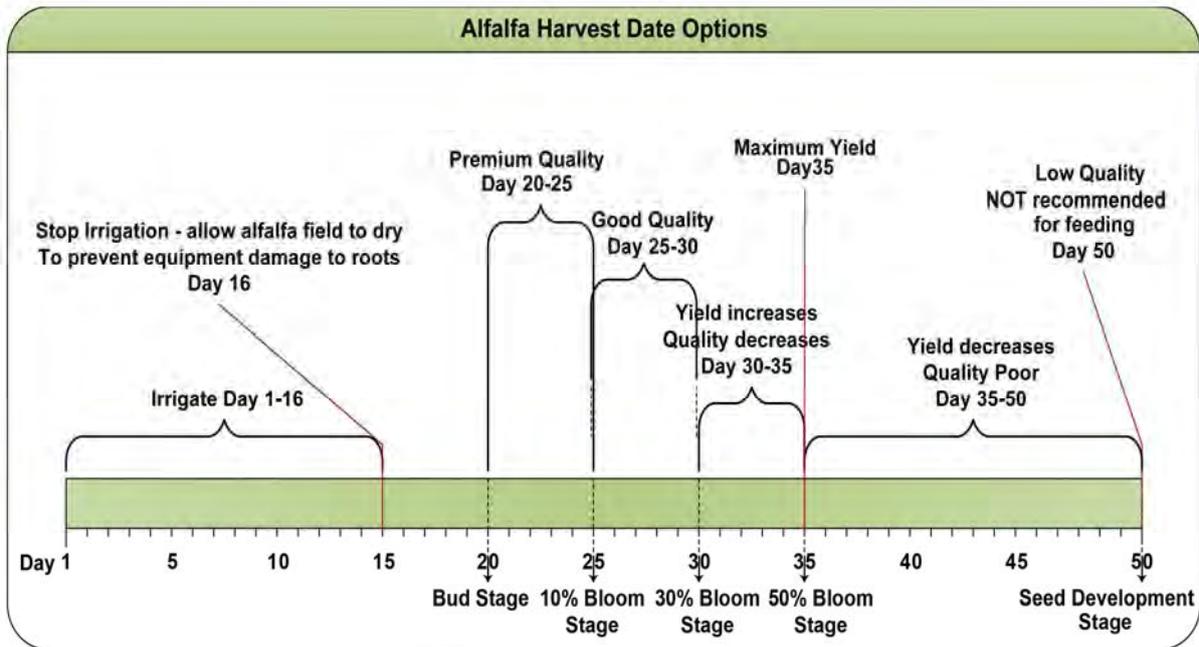
Deciding when to cut alfalfa is a difficult management decision. There are several tradeoffs involved, and no single cutting schedule fits all situations. Alfalfa yield and forage quality are almost always inversely related within a growth cycle. Alfalfa harvested at an immature growth stage (short interval between cuttings) results in relatively low yield but high forage quality. Conversely, cutting alfalfa at a mature growth stage (long interval between cuttings) results in high yield but low forage quality. This relationship of alfalfa growth and development is often termed the yield–quality tradeoff, and is fundamental to understanding the influence of cutting schedules on alfalfa performance.



In addition to the yield–quality tradeoff within a growth period, cutting schedules influence the number of harvests possible in a year, thereby influencing seasonal yield and costs. Additionally, cutting alfalfa at immature growth stages shortens stand life and increases weed invasion due to the deterioration in plant health from frequent cuttings. Alfalfa yield, per cutting, increases as plants mature during a growth period and the interval between cuttings increases. Yield can double as alfalfa goes from the pre-bud to full-bloom stage. In theory, maximum yield occurs when alfalfa reaches full bloom. However, as a result of leaf senescence and loss from lower portions of mature alfalfa plants, maximum alfalfa yield is often reached at around 50 percent bloom and may level off after this point. Most premium hay producers harvest during the late bud stage to 10 percent bloom, and well before the alfalfa exceeds 50 percent bloom. Unless there is a buyer willing to pay a substantial premium for hay made from early bloom alfalfa, it will

not be profitable in the long run. As a practical matter, in Iraqi conditions this may be about every 28 days in the cooler times of the spring and fall harvest seasons and about every 20 to 24 days in the heat of the summer.

In midsummer Iraqi conditions it is very important to coordinate harvest and irrigation schedules, so that the soil surface just has time to dry after the last irrigation prior to harvest. Irrigation will start again immediately after the harvested crop is removed otherwise the crop may undergo moisture stress, which will reduce both yield and quality.



These Options are for the Second through a possible Third Year after Alfalfa Field Establishment

Cutting Interval

More cuttings per year do not equate to higher total production per year. In fact, the opposite can be the case. Within reason, a long cutting interval (fewer harvests) will generally result in higher total seasonal production. However, the higher yield is of reduced quality, so a midpoint between high yield and high quality balance is sought.

Selection of the best cutting schedule is not an easy task, since many factors are involved. It requires the integration of all the topics mentioned above into a season-long harvest management plan, which includes market considerations as well as agronomic factors. The timing of an individual cutting should not be considered alone, but in relation to its effect on the entire production season, with consideration of stand life and economics over time. Several factors are important: the quality of the hay desired, time of year, weather conditions, desired stand life, and practical considerations, such as the irrigation schedule, harvests costs, whether the grower uses a contract harvester, and market conditions.

The growth stage at which alfalfa is cut should reflect the intended use of the hay. Alfalfa intended for use as a feed for beef cows or sheep can be of much lower quality than that sold to dairies for high-producing milking cows, or for feeding young calves or lambs.

Alfalfa hay intended for the dairy market must be cut early (late-bud stage at the latest) for the necessary quality that most dairy buyers require. Conversely, hay intended for beef cattle or sheep can be cut later, at 10- to 30-percent bloom, to maximize yields with acceptable quality for these classes of livestock.

Weather conditions alter the growth rate and forage quality of alfalfa. Therefore, a cutting schedule should adapt to changes in weather. In addition, rain or extremely poor curing conditions can reduce the forage quality of alfalfa hay after harvest. If preserving alfalfa as hay, it is best to avoid cutting when very poor curing conditions or rain are anticipated.



Economic Considerations

Deciding when to harvest is largely an economic decision. Given the existence of the yield–quality tradeoff, the decision is not easy. Early harvest results in low yield but high forage quality and price, whereas delayed harvest results in increased yield but forage quality and price decline.

The optimal time to cut alfalfa depends on the cutting schedule that generates the highest revenue. To determine the most profitable approach, take into account the rate of change in yield and quality for that season and the current price differential between the different quality market classes for alfalfa hay.

For example, in the summer of 2011 green cut alfalfa was selling for \$85 to \$90 per ton from the field while high quality, dry, early bud alfalfa hay with excellent leaf retention was selling for \$200 per ton and late cut,

full bloom, stem laden alfalfa sold for \$100 per ton. Another factor for consideration in Iraq is the livestock producers' recognition of the value of premium feed and their willingness to pay a premium for the highest quality. It may be that a farmer who intends to sell his alfalfa crop may tend to favor quantity over quality, while a dairyman producing for his own use may recognize the overall value of producing a premium feed.

Pest management decisions may also impact cutting schedules. The decision to harvest early to control an insect pest without resorting to spraying is an option for weevil control in spring and worm control in summer. Additionally, allowing longer growth periods at least a few times during the year may enable an alfalfa crop to compete more vigorously with weeds.

Common Cutting Schedule Strategies

Calendar Strategy

Alfalfa fields are frequently harvested on a calendar basis, using a predetermined fixed interval and fixed number of cuttings per season. The advantage of this method is that it facilitates planning. It allows advance scheduling of irrigation, cutting of other fields, and bale pickup. Cutting fields on a calendar basis is common when a contract harvester is employed to harvest fields. Contract harvesters often harvest fields on a predetermined interval, typically every 26 to 28 days, to schedule the harvest of other clients' fields.

The problem with harvesting alfalfa on a calendar basis is that it does not account for variable weather conditions, different rates of growth due to dormancy of the variety, temperature, season, or differences in growth between fields. For example, 28-day alfalfa during a hot August period will likely be very different than 28-day alfalfa during a

cool May. Weather in most Mediterranean, arid climates is relatively constant during the summer months but can still fluctuate enough even during the summer to affect yield and quality at a constant cutting interval. Spring and fall weather is more variable than summer, and there should be enough flexibility in the cutting schedule to allow for adjusting to weather changes. The dormancy of a variety also influences its rate of development. In general, a less dormant variety will be more mature on a given date than a more dormant variety. Scheduling harvests using the calendar fails to account for the stage of growth of the crop at each harvest.

Growth Stage Strategy

Another method of scheduling alfalfa harvests uses the growth stage of alfalfa to indicate the appropriate time to cut and thus the number of cuttings per season. The grower selects a specific alfalfa growth stage (such as pre-bud, bud, 10-percent bloom) at which harvest will begin. This method takes into account the effects of environmental and varietal differences and results in more consistent, predictable forage yield and quality than when harvesting on a calendar basis. Generally, the alfalfa growth stage at harvest is based on the appearance of bud or bloom; however, re-growth from crown buds is also used to indicate the proper time to cut.



harvest.

Cutting Height

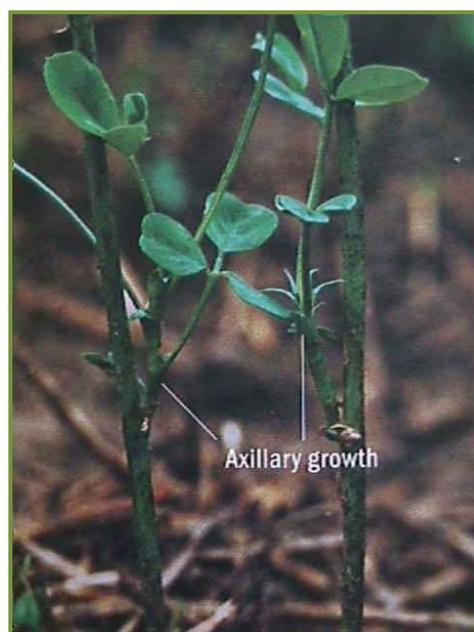
Occasionally, questions arise regarding the appropriate cutting height for alfalfa. The bottom of the stem is the least nutritious part of the alfalfa plant. Perhaps raising the cutting height could improve the nutritional quality of the alfalfa. Studies from the central and northern United States have shown that average annual yields of dry matter, protein, and digestible dry matter decrease as cutting height increases from 8 to 23 cm. Data shows that cutting above 5 cm results in a yield reduction of 1 per 2.5 cm of additional cutting height. Raising the cutting height did increase forage quality, but it resulted in a significant decrease in yield.##

#

When alfalfa is cut very short (1.5 cm or less) most of the auxiliary buds are removed and new shoots must come from the crown buds. Stems originating from auxiliary buds contribute less to the yield of alfalfa than

stems originating from crown buds. Therefore, leaving a stubble height of no more than 5 to 10 cm is recommended when cutting alfalfa. Leaving tall stubble appears only to be beneficial if the plant is under stress and does not have root reserves to initiate stem re-growth.

New stems emerging from axillary buds after harvest



Fall and Winter Harvest Management

The timing of the last harvest in the fall is an important consideration. Weather conditions may dictate when to make the last hay harvest. However, green-chop, silage, or grazing with sheep may be feasible later in the season when hay harvest is not possible. Weather conditions are not the only factors to consider.

Keep in mind the effect of fall harvest management on stand life and vigor. The timing of the last harvest is even more important in northern Iraq where winter conditions are harsher than in Mediterranean or desert regions of Iraq.

Late fall or winter harvesting can have a negative effect on yield the following year, and can shorten stand life, can increase opportunity for weed infiltration. Just as too frequent cutting during the normal production season can excessively deplete root reserves, so to can frequent or late season harvesting decrease overwintering capability of alfalfa crowns.

Research in the Imperial Valley of California, which has a climate very similar to Iraq, showed no reduction in yield, vigor, or stand density with one or two late fall to winter harvests, provided there was a rest period of at least 45 days between harvests made from December through mid-

February. Winter grazing of alfalfa in these desert environments may be advantageous, since haymaking is difficult. A sufficient rest period is also advised between grazing periods, because grazing, like cutting, can excessively deplete root reserves.

Caution should be used to avoid animal traffic damage to crowns if the soil is wet.

Curing and Preservation of Alfalfa

Significant yield and quality losses result when alfalfa is not properly cured, preserved and stored. Growers invest considerable time, inputs and money into producing a high yielding, high quality alfalfa crop. The goals of harvesting are to cut alfalfa at the growth stage that provides the optimum combination of yield and quality. The goals of curing and preserving alfalfa are to maintain quality and minimize losses through proper preservation methods. All of the efforts that **Alfalfa Hay** go into producing high-quality alfalfa can be nullified if the crop

New stems emerging from crown buds

The primary drawback to cutting based on growth stage rather than a calendar basis is that it is more management intensive and requires the ability to make labor and schedule adjustments. Additionally, the 'stage' of development does not always correspond to known values of quality and yield across different environments. For example, a full-bloom alfalfa in desert conditions may be higher in quality than a full-bloom alfalfa in a cooler environment. That is because flowering under desert conditions often occurs very early (sometimes within 10 days) and actually produces a higher-quality plant (lower stem percentage) than a full-bloom alfalfa growing in a cooler environment (higher stem percentage).

Frequent cutting of alfalfa at very early maturity stages often depletes root carbohydrate reserves. When carbohydrate reserves are low, energy for stem re-growth is low and results in poor plant recovery after

is not harvested, cured and stored properly.

Alfalfa offers tremendous flexibility in providing forage for livestock nutrition. Growers may opt to cut and feed alfalfa directly to dairy cows (green chop), or ensile the alfalfa in large plastic bags, covered piles, or pits. Packaging alfalfa into cubes and pellets has been practiced, but is not currently a popular preservation method. Pelletizing may be of interest to some alfalfa farmers in Iraq as there is an export market for alfalfa pellets in Saudi Arabia.



Alfalfa Cube



Alfalfa Pellets

The main difference between the various preserved alfalfa products is moisture content. Proper moisture content is the critical factor affecting the successful preservation of hay and silage. Green-chop has the highest moisture content, followed by silage, and lastly hay pellets and cubes. Each harvest strategy has advantages and disadvantages, since each harvest and storage option has potential risks of dry matter and quality losses. The alfalfa preservation strategy of choice depends on several factors: whether the alfalfa is sold or fed on-farm, distance to market, weather conditions, equipment available, and market demand for different alfalfa products. A description of the different alfalfa products and their production methods are listed below.

Forage Harvest Method	Green Chop	Silage (Haylage)	Hay
Moisture	75- 80 %	60-70%	Small 2 tie bales <20% Medium 3 tie bales <17% Big round bales (0.5-1 T) < 14%
Advantages	Overall yield increases 10-12%	Overall yield increase is possible	
	High quality feed	Minimal loss of leaves More control to harvest at optimal maturity stage Storage results in constant nutrient value (easier to balance rations) Highly palatable & digestible Well suited to add to TMRs (total mixed ration)	High quality feed Good quality hay leads to desirable dry matter intake by livestock Hay can be feed to all classes of livestock Simple to feed, highly adaptable to TMRs
	Field traffic lowest- 1 pass Least soil compaction Least crown damage	Field traffic medium- 2 passes	
	Rain does not restrict harvest	Minimal weather risk factor Cut and wilt complete in 1-2 days	
	Irrigation can immediately follow Cutting (same day)	Irrigation can follow cutting (next day)	
	Minimal storage required	Short time between cutting and storage	Best storage method for off season feeding Can be stored for feeding when forage is dormant Relatively low transport costs (as most moisture has been removed) Can easily be marketed
	Must be harvested daily		
Disadvantages			Hay making requires optimum weather conditions
			Field traffic results in soil compaction, reduced water penetration
			Difficulty with maintaining leaves
	Must be fed quickly – 1 day	Silo management is difficult Once open, front face (2.5-5 cm) must be used daily to minimize spoilage	Hay does not keep indefinitely but will maintain quality if properly stored for a year
	Day to day variability in nutrition Early season harvest can cause bloat Can cause loose stool in livestock		For certain classes of livestock the energy value of hay may be too low- requiring supplementation
		Dry matter loss during fermentation can be higher than hay	
		Poor bunk management can result in high losses during feeding	Wastage can be high (30%) if proper feeding facilities are not provided
		Nutrient loss during storage – possible	
	Silage bags require large storage space Silo and pits require special construction and space	Covered, dry storage required to maintain quality	

Green-Chop Alfalfa

Green-chopping is a harvest technique that involves cutting and chopping alfalfa into a feed wagon. The fresh forage is then delivered directly to the animals. Green-



chopping alfalfa is common practice for the first cutting in the spring and late cuttings in the fall when making hay is risky due to weather conditions, and when fields are in close proximity to animals. However, there are operators that green-chop a portion of their alfalfa throughout the year.

Advantages of Green-Chop

If all cuttings in a growing season are green-chopped for direct feeding or silage, an overall yield increase of 10 to 12 percent is expected. Several factors contribute to the yield increase.## Handling the forage when it has high moisture content avoids leaf loss that occurs during raking and baling for hay

production. Retained leaves contribute to higher feed quality. Field traffic from tractors and equipment used in raking, baling, hauling and stacking is reduced in a green-chop system because the forage is harvested and removed in a single pass.

There are two distinct advantages to reducing traffic in the field, which lead to improved yield and stand longevity. Heavy field traffic can result in soil compaction, which can limit future production. Field traffic also damages the crowns and injures newly emerging shoots. This may contribute to disease problems and delayed re-growth. Field traffic has a much greater effect on re-growing stems several days after harvest (during raking and baling), and a negligible affect during cutting.

Removing the forage from the field immediately (Green-Chop) or soon after cutting (Silage) has many advantages. Irrigation can follow shortly after harvest, resulting in less

stress to the alfalfa. Reducing traffic damage and preventing stress from delayed irrigation allow for the crop to come back more quickly following the harvest, often allowing for an additional cutting each growing season.

Green-chop systems can avoid quality damage due to rainy weather. This is especially true in the spring and fall when field



drying times are longer and the weather is more unpredictable in Mediterranean climates.

Disadvantages of Green-Chop

Green-chopping is only practical when the field and the animals to be fed are in close proximity. Green-chop is a high-moisture feed (75 to 80 percent water). Hauling that amount of water long distances is not economical.

A disadvantage to green-chop from the dairy perspective is the day-to-day variability of the feed. The forage must be fed quickly, so the grower only cuts as much feed as can be used that day. The alfalfa remaining in the field declines in quality as plants continue to mature. Variability is even greater if more than one field is being green-chopped to supply the fresh forage. Another disadvantage is that equipment must be taken to the field on a daily basis to harvest a supply of forage.

Exercise caution when green-chop is first fed, or when it is fed at the end of the season when moisture content is higher, because bloat can occur. The potential for bloat also exists if the alfalfa is very immature when green-chopped. Additionally, green-chop systems can cause excessive looseness in the stool when fed at high rates. In some cases, nutritionists would recommend feeding dry feeds in combination with green-chop, or feeding green-chop

incorporated with a Total Mixed Ration (TMR).

Alfalfa Silage (Haylage)

Alfalfa can be stored for a long period by ensiling it. Silage is a preserved feed that retains much of its nutrient value when handled properly. To make alfalfa silage (haylage), the alfalfa is cut and left in the field to wilt until it reaches 60 to 70 percent moisture content.

Depending on the weather, the alfalfa may remain in the windrow from a half day to a full day to reach the desired moisture



content. Uniformity in moisture content is important. Moisture should be tested throughout the harvest to keep it within the desired range.

If too much moisture remains in the forage at the time of ensiling, nutrients are leached from the pile or pit and run off causing nutrient loss and creating an environmental pollution problem. Fermentation may also be negatively affected. On the other hand, if the forage is too dry (greater than 50 percent moisture content); it is difficult to pack tightly in the pile, pit, or bag. If packed too loosely proper preservation may not be achieved.

Heat damage or mold formation may result when forage is too dry. Quality and digestibility are both reduced by browning reactions associated with heating.

Once the alfalfa has reached the target moisture content, windrows are raked together. A forage harvester chops the forage from the windrow and blows it into a silage truck or wagon. Alfalfa should be chopped to an approximate length of 1.9 to 2.5 cm. If the chop is longer than this, the forage is difficult to pack tightly, especially if it is on the dry side of the recommended range.

If the chop is too short, feeding the forage may lead to metabolic problems in the animals consuming the haylage.



Silage trucks or wagons transport the chopped forage to its final destination and dump it into a pile or pit, or pack it into a bag. Upright silos are rarely used for haylage in desert areas.

Working quickly to tightly pack the forage with the tractor and covering it to eliminate and exclude oxygen are critically important to the silage-making process.



A polyethylene sheet or tarp is placed over the pile or bunker and weighted down with discarded tires or other weights. If silage is left uncovered, losses of 50 percent in the top 1.2 m can be expected; overall losses of 32 percent or more have been recorded. Inspect covers or bags routinely for - punctures or tears. Preventing oxygen from leaking into the system can greatly reduce storage losses.

The Fermentation Process

The main objective in silage preservation is

to exclude oxygen as quickly as possible from the silage mass and reduce pH rapidly through bacterial fermentation. There are four phases to the fermentation process: *aerobic, lag, fermentation, and stable.*

In the *aerobic* phase, plant respiration and aerobic microorganisms consume oxygen trapped in air spaces in the silage mass. Once oxygen is depleted, the system becomes anaerobic. The transition from an aerobic to an anaerobic environment happens quickly, within a few hours under optimum conditions

Once the system becomes anaerobic, the *lag* phase begins. During this phase, cell membranes break down and anaerobic bacteria begin to grow and multiply rapidly, using the plant sugars as a substrate.

During the *fermentation* phase, bacteria convert sugars to acetic and lactic acids, resulting in a low pH and high concentration of

lactic acid (at least 70 percent) in the ensiled forage. Lactic acid is the most efficient fermentation acid and will quickly drop the pH of the silage. The faster fermentation is completed, the more nutrients will be retained in the silage. Well-fermented alfalfa silage should have a pH from 4 to 5. At this pH range, the bacteria die out and the silage enters the *stable* phase, where it remains until feeding begins. The anaerobic (oxygen-free) environment also prevents mold and yeast growth.

Inoculating Silage Crops

Alfalfa can be difficult to ensile because of low sugar content and low bacterial activity compared to corn or other grasses. Some growers apply silage additives (inoculants) to the forage to aid in the fermentation and preservation process. Most silage additives are designed to improve fermentation by providing bacteria and enzymes.##Additives add to the population or enhance the growth of lactic acid bacteria, increasing

their production of organic acids that reduce pH. Other types of additives, categorized as inhibitors, slow down various processes in silage preservation and are either aerobic or anaerobic. They include materials like propionates (aerobic inhibitors) or lactic acid (anaerobic inhibitor). Silage additives may improve recovery of silage dry matter by reducing the loss of dry matter during the ensiling process and/or at feeding. Finally, they may improve digestibility, intake, and animal performance.

It is best to wait at least 3 to 4 weeks to allow for maximum fermentation before the alfalfa haylage is fed. This will result in better aerobic stability. The rate at which the silage is fed must be sufficient to prevent the exposed silage from heating and spoiling. Good management of the feeding face of an open silage pit is critical to prevent spoilage. A minimum rate of 2.5 to 5.1 cm silage removal from the face per day is recommended, taking care to remove silage from

the entire exposed face. It is important to limit the disturbance of the packed silage to avoid piles of loose haylage. Estimates of storage losses in haylage range from 2 to 12 percent from surface spoilage and fermentation. Losses are often greater in a pile or pit than in bags, where there is less surface area exposed at any one time.





Advantages of Silage

The yield and quality advantages listed earlier for green-chop apply to an alfalfa silage (haylage) system as well. #

There are more nutrients preserved per acre because of reduced leaf losses, and weather damage is much easier to avoid, compared with haymaking. Although the forage is allowed to wilt in the field, it typically requires only 2 to 6 hours mid-season, and from 15 to 20 hours during spring and fall, to achieve the proper moisture content for haylage. It is still a high-moisture feed, and traffic is reduced, compared to a haymaking system. There are benefits associated with feeding haylage to cows. The wetter ration is more palatable and digestible, and is preferred by cows, especially during the hot summer months. It is better suited than green chop as an ingredient in Total Mixed Rations (TMRs).

Disadvantages of Silage

Although field losses are minimal with silage systems, dry matter losses during fermentation can be much higher than in stored hay, often equaling or exceeding the potential field losses observed in haymaking.

Additionally there is frequently a loss in digestibility in alfalfa silage compared with fresh or preserved hay. Since silage is higher in moisture than hay, silage production is limited to those areas in close proximity to the location where the silage will be utilized. Competition for a limited number of custom operators (e.g., baggers) can be an issue. When using bags, a large space to store the product is required because silage bags are typically 3 m wide and 75 m long, and they cannot be stacked. Silage bags need to be on a firm surface. Bags can be easily punctured or torn, so vigilance is required to monitor the condition of the bags and make necessary repairs. Once the feed is used, disposal of the plastic bags can be a problem. When haylage is stored in piles or pits, the space requirement is also significant, but not as large as that required for bagged haylage. When silage is exposed to air, yeast and mold growth cause deterioration resulting from changes in chemical composition, pH, and temperature.

Deteriorated forage is usually white due to mold growth, but can be various other colors, depending on mold species. Mold may contain toxins, which are poisonous at certain levels of intake. Aerobic spoilage occurs to some degree in virtually all sealed silos until fermentation is complete and again once the silage face is opened. Poor bunker management and poor feeding management can result in very high losses.

Another disadvantage of ensiling alfalfa is protein availability. Through the ensiling process, some of the protein of alfalfa is converted into non-protein nitrogen (NPN). This may be a problem because this protein is made available too rapidly in the rumen, and can be simply excreted as urea. Alfalfa protein from hay is more slowly metabolized by rumen microbes, and thereby is more available to the animals.

The Spontaneous Combustion in Silage and Hay

This process of forage heating up and then burning is typically called spontaneous combustion. Spontaneous combustion for hay usually occurs within the first two months of storage. In silos, forage can dry down if air enters the silo through leaks in walls or covers; this results in the potential for fires throughout the whole year.

Spontaneous heating and combustion occurs when sufficient moisture (above 25 percent in hay and below 45 percent in silage), oxygen (air) and organic matter are present together to support the growth of bacteria and molds.

Hay storage barn after spontaneous combustion fire



This growth results in an initial temperature peak of 54°C to 65°C. When the forage reaches this temperature range, a chemical process called the Maillard Reaction may occur, causing additional heat generation. This reaction can be self-sustaining and does not require oxygen (air) to continue. The gases produced will ignite if they have reached a high enough temperature and are exposed to oxygen (air).

Cause of Fires:

- Hay that is too wet will heat (above 25 percent moisture content) and then enter the spontaneous combustion cycle.
- Silage and haylage that is too dry will heat (below 40 percent moisture content) and then enter the spontaneous combustion cycle.
- A large mass of forage which allows the heat to build up.
- A slow trickle of air moving into the material.

- Old silage (2 years) in silo drying down to critical level.

The Alfalfa Haymaking Process

Haymaking is a four-step process. (1) It begins with cutting, which is usually done with a 3.6-, 4.3-, or 4.9 m swather or with a mower. The next day, the partially cured hay is raked to turn the windrow, and usually two windrows are combined or laid side by side.

This procedure hastens the curing process and improves the efficiency of the baling operation. This is sometimes repeat-



ed if curing conditions are poor or when it rains. (3) After the hay has dried sufficiently, it is baled. (4) Bales are hauled to the edge of the field (road-sided) and stored until they are transported, sold, or fed.

#

Small square bales are best loaded onto transport and hauled to covered storage. One of the most critical aspects of harvesting is drying the cut alfalfa to a point where it can be safely baled. The drying process and factors that influence drying rate are discussed below.

Hay Curing

Even though desert areas are blessed with generally good curing conditions, there are times when weather conditions make hay harvesting a challenge. Rapid, uniform curing is important to minimize quality losses caused by bleaching, respiration, leaf loss, and rain damage. It also improves subsequent yields by lessening traffic damage to the re-growth, and allowing timely irrigation after cutting.

The moisture content of alfalfa growing in the field is generally from 75 to 83 percent. The drying rate of cut alfalfa depends on environmental variables, including solar

radiation, temperature, relative humidity, soil moisture and wind velocity. Research indicates that solar radiation is by far the most significant environmental factor influencing drying rate.

The objective of the hay producer is to use management practices that accelerate the drying rate, considering weather and other factors. To determine which management practices would be most effective, it is helpful to understand the alfalfa drying process, which takes place in two phases. The first phase, or rapid-drying phase, accounts for approximately 75 percent of the moisture that is lost during the curing process and requires only 20 percent of the total drying time. The stomata (leaf pores) are wide open, and moisture is lost from leaves through these openings and from water transfer from the stems through the leaves. Some water also departs through the cut ends of stems and through bruised tissue. The main limiting factor to drying during

the first phase is caused by the boundary layer of still, moist air around the plant. Wind moving over and through the wind-row can accelerate drying by replacing the moist air in with drier air. The first phase is usually complete before the end of the first day after cutting. The second phase, the slow-drying phase, commences at about 40 percent moisture content when the stomata close. Moisture loss is extremely slow in the slow-drying phase; the drying rate in this phase is 1/100 of the initial drying rate. There are large differences between leaf and stem tissue in rates of drying, with stems being much slower.

Mechanical Conditioning

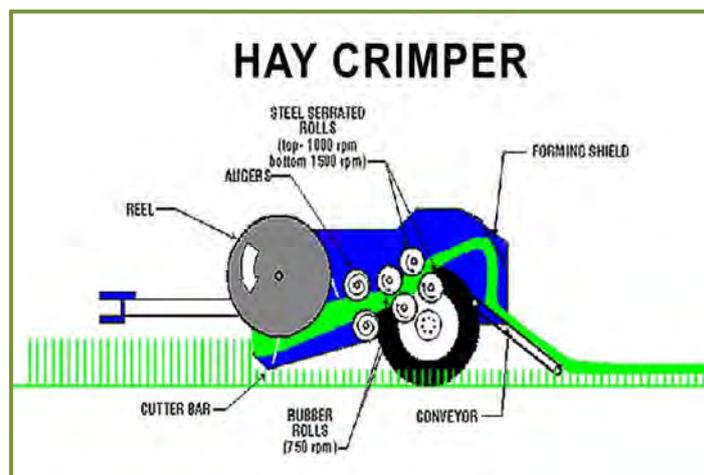
To accelerate curing, many growers mechanically condition or crimp the alfalfa as they cut it.### Mechanical conditioning has become a widely accepted practice. Most conditioners lightly crush the forage between intermeshing rollers located behind the header of the swather. A number of designs

are used, depending on the swather manufacturer. The intermeshing rollers are made of rubber or steel and crush or break the stems. The aggressiveness of crimping and the frequency of the crushing along the stem depend on the crimper design. The primary rationale for crimping is to facilitate water loss from the stems, bringing the drying rate of stems more in line with that of leaves. In theory, more aggressive crimping will have a greater benefit, but if the mechanical conditioning is too severe, shredded leaves may be lost, and the drying rate can slow if air movement is restricted in a dense mat of forage.



Hay Swather— Conditioner in Iraq

Mechanical conditioning affects both phases of the drying process. It accelerates the rapid phase by crushing stems, and it accelerates the slower phase by breaking the cuticle. Sometimes growers question the effectiveness of mechanical conditioning and wonder if the cutting operation could be simplified if the conditioning rollers were removed. Research has shown that mechanical conditioning hastens the drying process by as much as 30 percent. Drying time saved by mechanical conditioning can vary considerably depending on weather and alfalfa yield. **Conditioners should be set so that stems are cracked and crushed but not cut or shredded.** Consult the owner's manual for proper conditioner adjustment.



Swath Management

Wide windrows dry more rapidly than narrow windrows. The extent of the advantage that wide windrows offer depends on the geographic area, time of year, and yield level. In general, wide windrows are most beneficial in late spring or early summer, when yields are high and day length is long (solar radiation is greater than in late summer or fall). Wide windrows often dry one day faster than narrow windrows because the forage is spread out and more of the alfalfa is exposed to radiant solar energy. Also, boundary-layer resistance is less with wide windrows, so they do not inhibit moisture movement to the degree narrow ones do. Wide windrows improve the uniformity of drying, which affects how soon after cutting alfalfa can be raked and baled. When a grower can safely rake and bale is determined, not by the average windrow moisture content, but by the moisture content of the wettest portion of the windrow. Therefore, since the moisture content of wide

windrows is relatively uniform, they can be raked and baled earlier. If wide windrows are not raked earlier, their advantage is lost.

Wide windrows must be raked before baling. Alfalfa generally cannot be baled directly from the swath. Windrow width should not be greater than that which can be easily managed with the available rake. There must be sufficient area between the windrows so that a tractor can pass through without running over the edge of either windrow. The windrows should not be so wide that the rake cannot combine the two windrows in a single pass. In addition, the windrow should not be so wide that it becomes thin and patchy, which can cause excessive leaf loss during raking.

Raking

The purpose of raking is to expedite the drying process by transferring the alfalfa to drier soil and inverting the windrow.##Inversion exposes high-moisture alfalfa from the

bottom of the windrow to better drying conditions, increased solar radiation, and the effects of wind. Also, raking usually combines two windrows into one, improving the efficiency of baling and road-siding. Raking is very effective in improving the drying rate, but it must be done at the proper moisture content; otherwise, excessive yield and quality losses will result. Many growers make the mistake of raking alfalfa when it is too dry, leading to excessive leaf loss.



Hay raking in Iraq

The optimum moisture content for raking is 35 to 40 percent. At this moisture content, a significant increase in drying rate is

achieved, while severe leaf loss is avoided. Raking at too high a moisture content may twist rather than invert the hay and can actually slow the drying rate by restricting air movement within the windrow.

Baling and Storage

Alfalfa must be baled within a relatively narrow range of moisture content to avoid losses in yield and quality. Whenever possible, refrain from baling hay that is below 12 percent moisture because leaf shatter (leaf material that is detached from the stem yet captured in the bale) and leaf loss (lost to the ground) will be excessive. Hay baled at too high a moisture content is subject to problems with mold, discoloration and spontaneous combustion. The maximum moisture content for baling depends on bale size and density. In general, bale small two-tie bales at less than 20 percent moisture, larger and denser three-tie bales at less than 17 percent, and large bales at less than 14 percent.



Baling alfalfa hay in Iraq

The source of moisture within the bale affects the upper moisture limit for safe baling. Hay can be baled at higher moisture content when the moisture source is free moisture (dew) than when it is moisture trapped inside the stem (stem moisture). Free moisture is more readily dissipated than is stem moisture. How the hay is stacked after harvest also influences the moisture content at which alfalfa can be safely baled. Slightly higher moisture content at baling is sometimes safe, provided the alfalfa is stacked with an air gap between loads. The air gap facilitates more rapid dissipation of moisture from the bale. This is especially important

for large bales, which weigh 0.5 to 1 ton.

Moisture Content Estimates

A simple and practical method to determine if alfalfa hay can be safely baled is to grab a handful of alfalfa with both hands and twist it by rotating your wrists in opposite directions. If the stems crack and break, the hay is usually dry enough to bale. This practice is not very precise, and it takes experience to develop proficiency.

Twist test for dryness

The thumbnail test is a better method. Scrape an alfalfa stem with your thumbnail. If the epidermis, or outside layer, cannot be peeled back, the hay has dried sufficiently.

Thumbnail scrape test for dryness

#



A moisture meter is also a valuable tool to evaluate the moisture content of hay. Resistance-type moisture meters are used as hand probes or mounted in the baler chamber for on-the-go moisture monitoring. Meters often indicate a moisture content that is slightly higher than the actual content, and should be used to predict general trends, not precise moisture. They measure stem moisture less accurately than they measure dew moisture. Although moisture meters do not provide a precise assessment of the true moisture content of hay, with enough experience, moisture meters are very useful tools for assessing whether it is safe to bale hay.



Moisture meter

Using Dew to Improve Baling Conditions

After alfalfa is fully cured, dew or high relative humidity is needed to soften the leaves. Otherwise, there will be excessive leaf loss (shatter) during baling. Dew or higher humidity in the mid summer months occur in the night or early morning hours in the desert, if it occurs at all. Hay should be baled early in the morning in the summer in Iraq. In the summer avoid baling hay after mid morning to late evening in order to maximize leaf retention. Delaying the baling operation for several days to wait for dew is undesirable; yield declines and leaf loss increases the longer hay is left in the wind-row. In addition, waiting for dew postpones other necessary operations, such as irrigation, that are critical after cutting. Additionally, when baling is delayed, alfalfa re-growth occurs, and the degree of traffic damage to re-growth increases accordingly.

Safe Hay Storage



The maximum moisture content for safe hay storage is influenced by the uniformity of moisture within bales, climatic conditions during storage, and ventilation at the storage site. The moisture content of bales can be reduced somewhat by allowing high-moisture bales to remain in the field until late afternoon, or even for several days if no rain is expected, to reduce their moisture

content; then roadside them. Another way to reduce moisture content is to position bale-wagon loads outside, with a gap between the stacks before storing the bales in a barn. Unfortunately, these methods are only partially effective; neither method can rapidly dissipate moisture deep within the bales.

Significant yield and quality losses can occur during storage. Studies have indicated dry matter losses of one percentage point for each percentage of moisture above 10 percent. Quality losses can take several forms. Molds may develop in hay stored at moisture content greater than 20 percent. Molds can produce toxins that reduce palatability and are hazardous to livestock. Mold respiration causes heating, and, when hay temperatures exceed 38°C, browning reactions begin. Reactions that occur during browning, coupled with heating from mold growth, can cause temperatures to increase

further. Heating may reduce the protein and energy available for livestock.



When bale temperatures exceed 66°C , spontaneous combustion can result. This is most likely in hay with a moisture content more than 30 percent and most often occurs with large 0.5 to 1 ton bales.

Heating during the first month actually helps to dry hay (often termed the ‘sweat’). After the first month, hay has usually dried to a moisture content where it is stable and can be stored safely. Therefore, any problems that result from storing hay with excessive moisture are most likely to occur during the

first month of storage. Although the majority of dry matter losses during storage take place in the first month, researchers have found that losses continue at a rate of about 0.5 percent per month for the remainder of the storage period.



Tips for Storage

- Storage losses can be reduced by two-thirds with indoor storage and by one-half with good covering outside. Main areas of concern are weathering on the tops and sides of the bales but also where the bales contact the ground. Moisture will move from the ground up into the bale through a "wicking" action.
- All storage sites regardless of the type of storage should be well drained. A firm

base of course rock - preferably not gravel or concrete, should be used to minimize moisture movement from the ground up into the bales. Avoid areas where moisture and/or snow can accumulate or where drying is impaired.

- Temporary storage options can be effective and include low-cost frame structures with plastic covers, reusable tarps or bale sleeves.#
- Permanent covered storage should be considered in a long-term forage production system. Weather-tight facilities will maintain forage quality the best of all storage options. To be effective they must be structurally sound, well designed to allow easy access by bale handling equipment and be properly sized to store a year's supply of hay.



Alfalfa Cubes and Pellets

Alfalfa hay can be processed into cubes. Cubes have never been as popular as baled hay and, over time, their popularity has dwindled. Except for the actual cubing operation itself, most of the processes and procedures described above for baled hay also apply to cubes. The alfalfa crop is cut with a swather and raked to turn and combine windrows. The alfalfa windrows are dry chopped and transported off the field to be processed at a feed mill or with a stationary on-farm cuber.

The coarsely chopped alfalfa is compressed through mechanical dyes with approximately 3.18 cm² dimensions. The cubes can be pro-

cessed into varied lengths. Most cubes are more rectangular in shape. One main advantage of cubing is that proper humidity for leaf retention is not a critical factor as it is in baling—dry conditions are preferred. Therefore, cubing works well in desert environments like Iraq where there is insufficient dew for baling. Water is added during the cubing process. Therefore, there is often less dust with cubes than with baled hay. A dust-free product can be especially important for horses. Care must be taken not to cube alfalfa contaminated with toxic weeds. Animals consume the whole cube and are unable to segregate the toxic weeds as they do when eating hay.



Alfalfa hay can also be processed into pellets. Many feed mills in Iraq now operate pelletizing equipment. Several trials have been conducted to process alfalfa into pellets and it has been found that the pellets have the best quality when mixed with bran or wheat flour before being formed into pellets.

Conclusion

Considerable investment planning and effort is involved in producing a high-quality, high-yielding alfalfa crop. While harvesting, curing and storing are the last steps in the production process, these steps have a significant impact on the ultimate feeding value of the forage. Whether preserving alfalfa as silage (haylage), hay, cubes or pellets the production practices outlined in this paper should be followed to avoid significant losses. Key silage-making practices exclude as much oxygen as possible with proper packing and sealing to minimize spoilage and making sure the forage is at the proper

moisture content for ensiling. Key hay-making practices include rigorous conditioning, proper swath management to promote rapid curing, raking at the proper moisture content to accelerate homogeneous drying of the windrow with minimal leaf loss, and baling the alfalfa at the optimum moisture content—high enough moisture for leaf retention while still low enough for safe storage, with little risk of mold or heating problems. Employing these practices helps retain the potential feeding quality of the alfalfa while minimizing losses.

References

Much of this material was adapted from: <http://alfalfa.ucdavis.edu/IrrigatedAlfalfa/>

“Information about the herb Alfalfa”, http://www.globalherbalsupplies.com/herb_information/alfalfa.htm

Integrated Pest Management, Crop Nutrient Deficiencies and Toxicities, Plant Protection Programs, College of Agriculture Food and Natural Resources, MU Extension, University of Missouri, Columbia, MO, IPM1016, 2002, <http://www.scribd.com/doc/15085476/CROP-NUTRIENT-DEFICIENCIES-TOXICITIES>

“Introduction to Silage Making”, Dairy Updates, Feeding No. 502, Author, Dr. Michael Warrioux, The Babcock Institute, University of Wisconsin, http://babcock.cals.wisc.edu/sites/default/files/documents/productdownload/du_502.en_.pdf#

“Silo and Hay Mow Fires on Your Farm”, Fact Sheet No. 93-025, Author, Stephen

Clarke, The Ontario Ministry of Agriculture, Food and Rural Affairs, <http://www.omafra.gov.on.ca/english/engineer/facts/93-025.htm>

IPM: Field Crops: Alfalfa Weevil (*Hypera postica* Gyllenhal), Authors Kelly A. Cook, Susan T. Ratcliffe, Michael E. Gray, Kevin L. Steffey, University of Illinois Extension at Urbana-Champaign 2004, http://ipm.illinois.edu/fieldcrops/insects/alfalfa_weevil

Photo Credits

http://extension.entm.purdue.edu/radicalbugs/default.php?page=pests/alfalfa_weevil

<http://entomology.wsu.edu/insectoftheweek/WesternYellowStripedArmyWormonAlfafla.html>
<http://kentagextension.blogspot.com/2009/07/beet-armyworms.html>

http://entnemdept.ufl.edu/creatures/veg/leaf/beet_armyworm_adult.htm
http://www.utextension.utk.edu/fieldcrops/cotton/cotton_insects/Pests/fallarmyworm.htm

<http://ipm.illinois.edu/fieldcrops/insects/armyworm>

Bryan Jensen, UW-Madison, <http://ipcm.wisc.edu/WCMNews/tabid/53/EntryId/1023/-Yellow-Sulphur-Butterflies-in-Alfalfa.aspx>

<http://www.simplykitchengarden.com/vegetablepests/200.html>

<http://www.entomology.ksu.edu/p.aspx?tabindex=163&tabid=505>

http://www.ca.uky.edu/agcollege/plantpathology/ext_files/PPFShtml/PPFS-AG-F-6.pdf

U.S. Agency for International Development

1300 Pennsylvania Avenue, NW

Washington, DC 20523

Tel: (202) 712-0000

Fax: (202) 216-3524

www.usaid.gov