Alfalfa Seed Production - Southern Great Plains

Agricultural Experiment Station
Division of Agriculture
Oklahoma State University

Bulletin B-776
September 1985

TABLE OF CONTENTS

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Alfalfa Seed Production-Southern Great Plains[1]

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INTRODUCTION

Many areas throughout the western-half of Oklahoma are well suited to alfalfa seed production. State seed yields are historically low (157 kg seed ha^{-1}) however, great potential exists for increasing yields. The state average production of seed varies considerably among years, 95 to 224 kg ha^{-1} (Oklahoma Agricultural Statistics 1972-1981), although individual growers have reported occasional yields in excess of 1000 kg ha^{-1}.

Seed produced in the state is generally the by-product of the alfalfa hay industry (7, 8), i.e., dryland hay stands on which one to two hay cuts are taken and the second or third cut is allowed to mature seed. The cut allowed to mature seed is unlikely to produce a good hay cutting and usually occurs during the hottest and driest period of the growing season. Such seed production is a hay producer-weather compromise, a system that takes what it can get but is not conducive to obtaining high seed yields.

Because of the dual crop (hay then seed) production practice, the acreage harvested for seed in the state averages about 35,000 acres (14,175 ha) annually. Approximately, 12,000 acres (4,860 ha) were harvested in 1975 and 55,000 acres (22,275 ha) in 1978 and 1980. Total seed produced in the state varies, but averages about 5 million pounds a year. Acreage in alfalfa hay production varied from 350 thousand acres (142,000 ha) in 1975, to 560 thousand (227,000 ha), in 1972, but the average is about 431 thousand acrea (175,000 ha) annually (1972-81 Oklahoma Agricultural Statistics). Assuming 20% of the alfalfa acreage in the state is rotated with other crops each year and a like amount of acreage reestablished to alfalfa. Oklahoma produces about 66% more seed than it needs to meet its own annual requirements. The majority of it is sold in commercial seed channels as 'common' alfalfa at relatively low prices in comparison to seed of improved cultivars.

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Most alfalfa seed of improved public and proprietary cultivars is produced in the Pacific west and north-west. Highly specialized seed production technology, consisting of pest control (3, 12), introduced pollinators (4, 11, 13, 18) and pollination management, cultural, and irrigation practices (1, 5, 6, 9, 10, 14, 19, 22, 23, 26,) has been developed to attain maximum yields in these areas. However, grower production costs and the low price received for seed is marginal for many seed producers. Any additional costs to sustain seed yield levels or poor weather in conjunction with no upward movement in seed prices can trigger a series of events leading to a major decline in available seed supplies of improved alfalfa cultivars.

Alfalfa seed producers in Oklahoma, northwest Texas, Kansas and other states in the southern and central Great Plains area have the potential to become more competitive in the alfalfa seed industry because of: a) favorable climate, i.e., seasonal fall and early spring moisture patterns, dry and often hot weather during crop maturity, b) deep fertile soils, c) abundance in some areas of wild bee pollinators, d) being able to grow alfalfa cultivars adapted throughout much of the United States, e) lower production costs, and f) being centrally located to the major alfalfa seed consuming areas.

There are many uncertainties in using a highly specialized alfalfa seed production system, similar to that employed in the Pacific northwest and west (16). Erratic climatic conditions, high day-night temperatures during flowering and crop pollination, lack of suitable pollinators, pollinator management (both wild and domesticated bees), and the negative impact of seed pests on yields (2) are some of the problems affecting seed production in the southern Great Plains.

When studies on alfalfa seed production were initiated in Oklahoma and Texas in 1978 it was a consensus that localized studies were needed to develop the best practices for the production of seed for a given area. Planting methods and seeding rates were regarded as primary problems as well as seed pests, pollination, and pollinator management.

Relatively little information (17, 24, 25) was available on the value of thin row-spaced stands in developing cropping techniques in the area. Understanding the production practices required to maximize alfalfa seed production are fundamental to establishing efficient seed production systems. This bulletin summarizes research findings from El Reno, Woodward, Guymon, and Tipton, Oklahoma, and Bushland, Texas, on a subject matter basis, i.e., stand establishment methods and requirements, stand densities, seed pests, pollination, effects of various cultural and management practices, and seed harvesting. Suggestions are made as to the best production practices that are compatible with southern Great Plains soils and climate.

STAND ESTABLISHMENT

Establishment of alfalfa for seed production should be on well drained, fertile soils having favorable pH values (6.5-7.5). Plantings should be made in early fall (late August thru September) or early spring (April thru mid May). Early fall establishment will permit first year seed yields equivalent to a mature stand, whereas stand establishment in the spring will not. Regardless of whether growers plant in fall or spring, the critical decisions and actions affecting establishment occur prior to planting and during seed germination and seedling growth.

Preparation for Planting

A complete soil analysis for essential nutrients (nitrogen, phosphorus, potassium, boron, zinc, iron, manganese, copper, and sulphur), organic matter, cation exchange capacity, and pH is needed. Soil tests must be representative of the field in question. Soil samples from different soil types should not be mixed. Nutrient and lime deficiencies should be corrected prior to the establishment of alfalfa. Soil survey maps help locate different soil types on individual farms and are available at local USDA Soil Conservation Service Offices.

Uniformity of seedbed preparation is essential. A firm, weed-free seedbed with just enough loose surface soil to provide for uniform depth of seed cover must be properly prepared in advance of the date of planting. A preplant herbicide, such as, 'Eptam' (S-ethyl depropylthiocarbamate), or 'Balan' (N-butyl-N-ethyl-α,α,α-trifluoro-2, 6-dinitro-p-toluidine), applied at recommended label rates should be incorporated at the time of seedbed preparation. Another promising herbicide is 'Prowl', [pendimethalin [N-(1-ethylpropyl)-3,4-dimethyl-2, 6-dinitrobenzenamine], however, at the present time it is not labeled for preemerge application on alfalfa.

Seeding

For uniform stand emergence, *Rhizobium* inoculated, viable seeds are planted at a depth of ¼ (heavy soils) to ½ (light soils) inch (0.5 to 1.2 cm). Small discrepancies in depth of planting in heavy soils may result in stand failures. Plantings should be made when soil moisture is favorable and temperatures (20 to 30 °C) are conducive to optimum germination and seedling emergence.

Seeding rates are dependent on row spacing and quality of seed. A pound of pure-live alfalfa seed contains between 220,000 to 250,000 seeds. The number of seed in a fixed weight varies among years and source of seed due to climatic or field conditions during pod-set and seed maturation.

Planting methods we evaluated include 24, 36, 42, and 48 inch (61, 91, 106, and 122 cm) row-spacings and broadcast seedings established at 4 to 16 pounds/acre (4.4 to 18 kg seed/ha).

If row planting equipment is not available or timeliness in obtaining equipment is a problem, growers can use alternative methods, i.e., using a 'Brillion' seeder with a 6'' spacing between hopper outlets, set to plant 8 pounds seed/acre. This setting is equivalent to 2.0 pounds/acre when tapping-off unneeded outlets to obtain a 24-inch row spacing. A spout extending from the selected spaced outlets to just above the soil surface between the planter rollers is needed to place seed in a narrow 1-inch band. Similar modification can be made on other broadcast type planters used to establish alfalfa.

Causes of Stand Failures

1. Undesirable soil pH.
2. Poor seedbed.
3. Improper planting depth.
4. Drought.
5. Weed competition.
6. Improper rates of preplant herbicides.
7. Poor quality uninoculated seed.
8. Crusted soil surfaces following heavy rains. A rotary-hoe can be used to aid emergence if the seed zone is below the crust.

WEED CONTROL IN ESTABLISHED SEED FIELDS

Spring Clean-up

The timely implementation of weed control practices (Table 1) is the key to clean weed-free seed fields. Spring clean-up should start in early March while alfalfa is dormant. Seed fields should be raked-clean of previous crop residue, sprayed (Figure 1) with an effective long lasting preemerge herbicide, and power-harrowed or cultivated to:

1. Destroy volunteer alfalfa and winter weeds between and within rows.
2. Incorporate surface residue of the previous crop year.
3. Aid in the control of seed pests such as the alfalfa seed chalcid.
4. Incorporate herbicides.

Pre-and-Post Emerge Herbicide Usage

Herbicides such as 'Sinbar' [terbacil (3-tert-butyl-5-choloro-6-methyluracil)] controls weeds without incorporation in the soil. 'Treflan', [trifluralin (α,α,α-2,6-dinitro-N,N-dipropyl-p-toluidine)], however, must be incorporated. Power-harrowing and/or cultivating to incorporate field residue and the herbicide application can be accomplished in one operation. We have used Sinbar and Treflan at label rates with excellent results through August. No additional herbicides need to be applied for fall seed harvests. The applica-

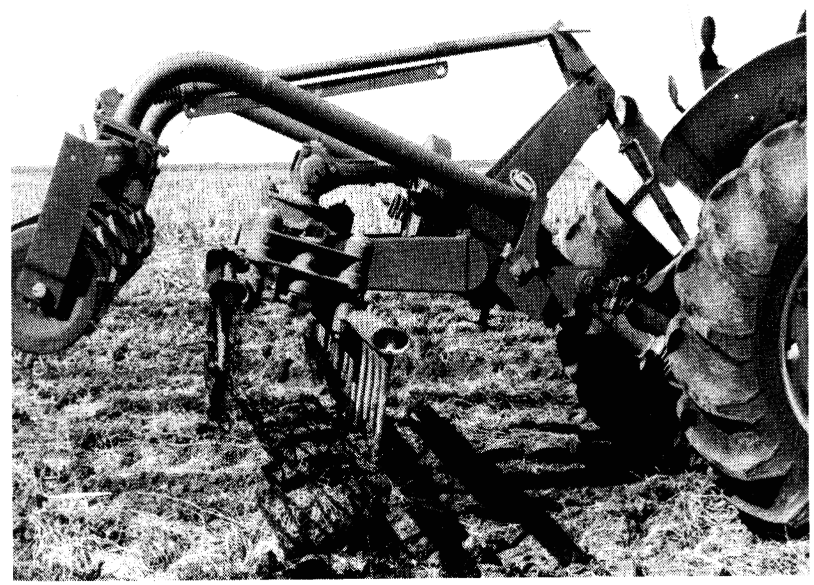

Figure 1. (A) Application of preemergence herbicide, (B) power harrowing to destroy volunteer alfalfa, winter weeds, and incorporate surface residue and herbicide, and (C) a close-up view of the 'Vicon' power harrow used.

Table 1. Herbicides for weed control in Alfalfa seed fields.

Treatment	Herbicide	Common Name	Product Rate/Acre	Lbs. Ai/Acre	Remarks
Preplant Incorporated	Balan	Benefin	3-4 qt.	1.2-1.5	Eptam controls mustard but should not be used on sandy soils. Balan doesn't control mustard but usually controls henbit. Good on most other weeds.
	Eptam 7E	EPTC	2.3-4.6 pt.	2.0-4.0	
Seedling or Established Stands	Butyrac	2,4-DB*	1.5-3 qt.	0.75-1.5	Low volatile ester formulations will give more effective weed control during winter months than Amine formulations. Alfalfa seedlings must be in the 3rd trifoliolate leaf stage and weeds less than three inches tall for broadleaf weed control.
	Butoxone	2,4-DB*	1.5-3 qt.	0.75-1.5	
Dormant, Established	Dinitro*	Dinoseb, Dow General, etc.	1.9-3.8 lbs.	1.5-3.0	Stands must be at least one year old. Kerb is excellent for control of many weedy winter annual grasses if used preemergence or early post emerge. Read label carefully for proper application of preemergence chemicals. Most control both grasses and broad-broadweeds.
	Furloe CIPC	Chlorproham	2.0-3.0 qts.	2.0-3.0	
	Karmex	Diuron*	2.0-3.9 lbs.(80W)	1.5-3.0	
	Kerb	Pronamide	1.5-3.0 lbs.(50W)	0.75-1.5	
	Sencor	Metribuzon*	0.8-1.6 lbs.(50W)	0.4-0.8	
	Sinbar	Terbicil	0.5-1.5 lbs.(80W)	0.4-1.2	
	Treflan	Trifluralin	1.5-2 pts.	0.75-1.0	

*Choice of several formulations.

tion of 'Paraquat' or 'Dow General' to dessicate the fall crop prior to seed harvest destroys a high percentage of fall volunteer alfalfa and weed seedlings. When a single seed crop (August seed harvest) is harvested and a second (fall) one is not feasible because of the short season, a late fall cultivation is needed to destroy weeds and volunteer alfalfa seedlings between rows. Volunteer alfalfa seedlings are considered weeds in seed production fields.

Growers should survey approved herbicides for similarities and differences in order to select the best-suited chemical(s) for their situation. Herbicides cleared for use on alfalfa may have similar characteristics, such as the weed species controlled, longevity of soil activity, and recommended rates for effective control, but may differ in cost and ease of application.

Weeds Frequently Encountered in the Production of Alfalfa Seed

1 . Johnsongrass [*Sorghum halepense* (L.) Pers.]
* 2 . Dodder (*Cuscuta* spp.)
3 . Mustards (*Brassica spp.*)
4 . Pigweed (*Amaranthus* spp.)
4 . Red sorrel (*Rumex acetosella* L.)
6 . Henbit (*Lamium* amplexicaule L.)
7 . Annual bromes (*Bromus spp.*)
* 8 . Curley dock (*Rumex crispus* L.)
9 . Russian thistle (*Salsola* kali L.)
10 . Horseweed (Mares-tail) (*Erigeron canadensis* L.)
* 11 . Field bindweed (*Convolvulus arvensis* L.)

*Noxious weeds are not allowed in alfalfa seed offered for sale and should be eliminated prior to seed harvest.

Effect of Weeds

1. Reduce stands.
2. Reduce yield.
3. Harbor harmful insects (e.g., *Lygus*).
4. Slow harvest
5. Increase cost of seed cleaning.

FERTILIZATION

Fertilization of Established Stands

Fertilization of established stands has not increased seed yields. Foliar application of plant nutrients, with the possible exception of Boron, has usually failed to increase seed yields (20). Alfalfa seed fields established in rows and thinned for maximum seed production require less nutrients than hay fields where several cuttings are removed each year. Therefore, seed production stands can remain productive longer at nutrients levels lower than those required for maximum hay yields.

POLLINATION

Pollination

Wild bees, [such as *Megachile* (Sayapsis) *policaris* Say, *M.* (Litomegachile) *brevis* Say (two native leaf cutter bee species), *Agapostemon splendens* (Lep.), *A. angelicus* (Ckll.), *A. texanus* (Cresson), *Melitoma* spp. *Bombus pennsylvanicus* (Degeer), *Svastra obliqua* Say, *Manthophora walshii* Cr., and *Diadasia enavata* Cr.] and certain wasps e.g. *Campsomeris quadrimauilata* (fab.), play a vital role in pollination of alfalfa depending on the time of crop bloom in the southern Great Plains. However, reliance on wild bees of the area to effect pollination is not a good practice because:

1. Populations are not sufficiently high to achieve maximum pollination efficiency in early (May-June) flowering crops.
2. Chemicals used to control insect pests in other crops on adjoining fields or fields removed by some distance may adversely affect wild bee populations, their survival, and reproductive capacity throughout the season.
3. Lack of knowledge on:
   a) wild bee habitat,
   b) creating and locating artificial habitat,
   c) attracting wild bees to habitat, and
   d) protection of habitats.

Leaf Cutter Bees

The leaf-cutter bee, *Megachile rotundata* (F), is one of the few species of wild bee man has learned to manage (4) and use for alfalfa pollination. This bee and the Alkali bee, *Nomia melanderi* Ckll., (11), are highly efficient pollinator of alfalfa in the Pacific northwest.

With the exception of some early work with the honey bee, *Apis mellifera* L., this study used alfalfa leaf-cutter bees exclusively at Woodward and Guymon locations to pollinate summer seed crops and the wild native, and local honey bees for pollination of fall seed crops. Incubated leaf-cutter bee cells were used at a rate of 1 gallon of live cells/acre approximately 6 days after initial field bloom.

The leaf-cutter bees, bee cells and nesting materials, can be purchased from a number of sources. The use of this bee has certain disadvantages and problems.

1. Growers must provide shelter and nesting materials (since these are reusable this is considered a one-time cost).
2. Even when carefully managed it is difficult under Oklahoma conditions to maintain, much less generate leaf-cutter bee population increases during the year. Until the management problems are solved related to maintaining leaf-cutter bee populations, recurring yearly purchase costs of bees can be expected.

Figure 2. The small highly active alfalfa leaf cutter bee, *Megachile rotundata,* half the size of a honey bee, prefers alfalfa pollen as a food source and effectively polinates 98 percent of the visited flowers.

3. Leaf-cutting bees are inactive when field temperatures reach or exceed 35 °C (95 °F).
4. Inadequate shelter design and nesting materials—bees desert shelters.
5. Lack of flowering alfalfa and/or other adjacent crops for bees to forage on throughout the growing season requires removal of shelters containing bees to new locations;
6. High day-time temperatures—Depending on cutting sequence, flowering of the alfalfa seed crop may occur during the hottest and driest part of the season. Daytime temperatures during July and August frequently exceed 37.7 °C (100 °F).
7. Sudden gusts of high wind—leaf-cutter bees are weak fliers and if blown too far (¼ mile) from nesting sites become disoriented and lost.
8. High shelter temperatures—temperatures often exceed 32 °C (90 °F) inside shelter. Plastic nesting materials may have superior insulation qualities but appear to require a long time to cool down, thus, high mortality of developing larvae is suspected.
9. Varying periods of high relative humidity (40-80%).
10. Diseases, -chalkbrood, etc.
11. Parasites.
12. Pesticides—lack of proper selection of pesticides during bloom to control forage and seed pests, i.e., *Lygus.* Although applications are made in late evening with precautions taken to protect pollinators, residual toxicity often results in bee kills.

Honey Bees

The use of pesticides, the kind of pesticide, and residual toxicity are also problems with honey bees. The honey bee, however, is easily managed and can be moved in great numbers when needed. Work with honey bees in this study has been to determine if higher visitation and pollination efficiency is governed by the demand or needs of the hive, and the influence on seed yields of available alfalfa flowers at these demand periods. Honey bees have been inefficient pollinators of alfalfa from Mid-June, July, thru August. The purpose of utilizing the honey bee was to find an efficient pollinator for early season pollination in cropping sequence (early, mid summer, late summer, and fall crops) studies. Although a strikingly less efficient pollinator of alfalfa than either the leaf cutter or native bumble bee, honey bees appear to be more effective in pollinating alfalfa during late spring (May) and early fall (September).

Crop Bloom

Alfalfa flowers over a period of approximately 7 weeks and if pollination occurs seed pods are set throughout that period.

Crop Maturity

Prior to seed harvest, at each location, seed pods were collected according to pod color, i.e., black, dark brown, light brown, and green. The pod colors reflect maturity (2) and time of podset. Early set pods are dark whereas late season pods are green. These pod maturity classes were used to determine total seed-set/pod and numbers of sound seeds, seeds parasitized by chalcid, and seed lost due to other agents (*Lygus,* diseased, etc.). A large random number of mature alfalfa racemes collected were by treatment and location.

Under the climatic conditions at El Reno, the average seed-set/mature pod (3.5) and beneficial effects of pollination, pod-set, are off-set by heavy infestation of pods by seed chalcid fly (43-72%, early to late set pods respectively) losses. The flowering period June through mid July which produces early August seed crops at this location, occur when seed chalcid fly populations are extremely high. Only 21 to 55% of the total seeds set, depending on the time of crop maturity, contribute (Figure 3) to yield (sound seed). Seed damage or losses, i.e., lightweight, shriveled, brown, partially germinated, or scalded seeds (caused primarily by lodging thus higher pod humidity and heat), and diseases due to climatic conditions and other seed pest, such as, *Lygus* spp. are occasionally high in the area.

Several years of study at Tipton and Woodward, Oklahoma in the western one-third of Oklahoma, show chalcid parasitisium increases from 10 to 27% of the total seeds set as the growing season progresses. Other seed losses are attributed to the time of pod maturity and irrigation requirements or amounts applied to maintain proper growth and bloom. Sprinkler irrigations

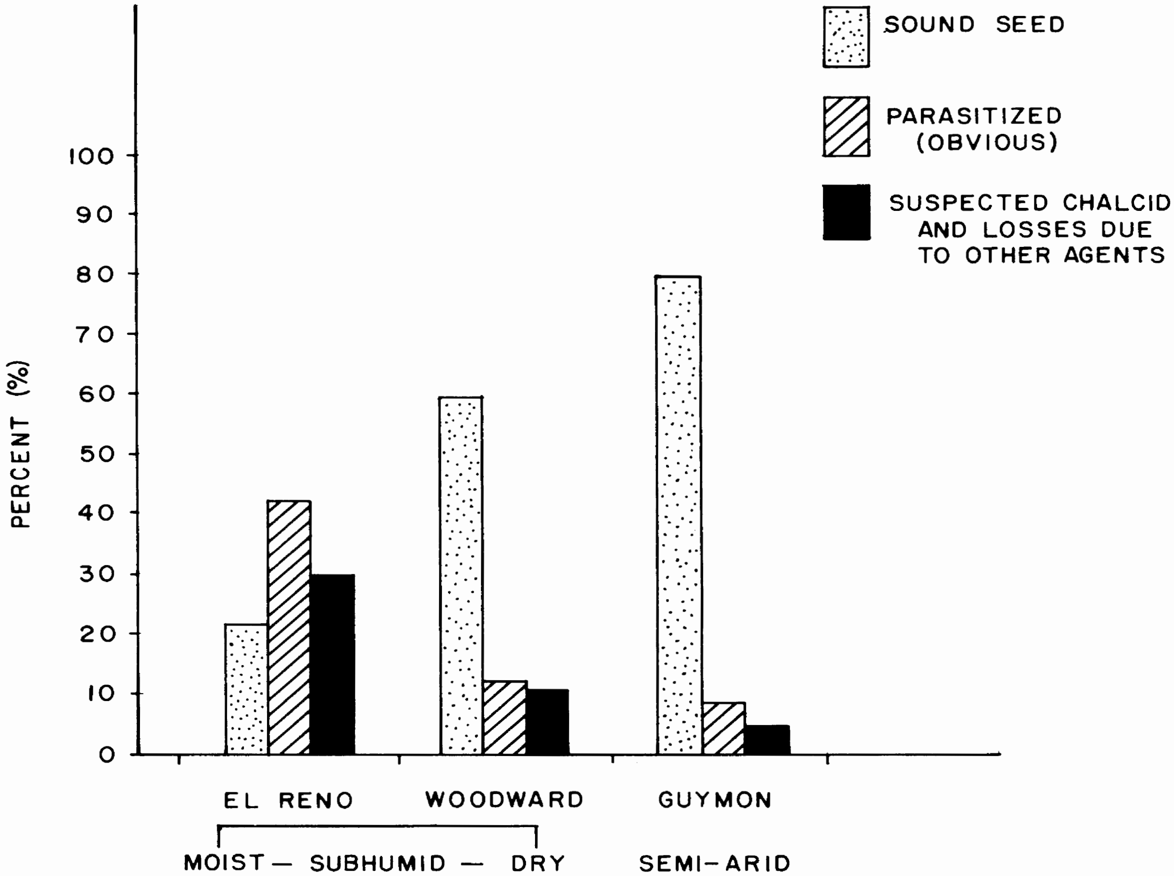

Figure 3. Mean percentage of sound alfalfa seed versus seed losses by location due to chalcid fly parasitisum and other agents prior to an early August seed harvest.

used during crop flowering and pod maturity increased seed losses due to lodging and shattering. The lowest seed losses, whether due to chalcid fly (5 to 12%) or other agents, occurred in the semi-arid environment at the Guymon location. This area of the state, with its predictable dry climate with warm days and cool nights, has the greatest single crop potential for alfalfa seed production in Oklahoma. However, the area lacks a high population of well adapted crop pollinating insects.

Only small differences were found in the average number of seeds set/mature pod, 3.5 to 4.6, among locations. The average number of sound seeds/mature pod were lowest at El Reno (0.7) and highest at Guymon (3.6) and Bushland, TX (3.1). This may not appear important, but if the following factors are true, small differences are significant: a) an acre of alfalfa contains as many as 2 billion flowers (25); b) percentages of flowers capable of forming pods (18), range from 5.7 to 57.0% under field conditions; c) percentage of flowers capable of forming pods are only 46.7% under controlled conditions

(21); and d) an average of only 200 million flowers/acre according to Lesins (15), are capable of forming pods (which is 10% of 2 billion flowers and within the range stated by Menke (18) above). A gain or loss of one seed per pod could increase or reduce yield, respectively, by as much as ± 815 lbs of seed/acre [200-million pods/acre divided by 235,000 (No. seeds/lb of well filled alfalfa seed)]. To attain near maximum seed yield in the area crop pollination efficiency must approach 60% of all flowers capable of setting a pod.

Yield Components

Alfalfa yield components include stems/unit area, racemes/stems, pod-set/stem, number sound seed set/stem, and seed size (fill). Where total number of racemes/stem are divided by actual pods set/stem a relatively low number of pods set/stem are obtained in August seed crops (Table 2). This has been true for all locations and reflects the lack of adequate full season crop pollination. Pod set on racemes may be nil in early-season, partial in mid-season, and near complete in late season, or the reverse occurs.

Stem numbers/unit area, racemes/stem and number of pods set/stem are dependent on row spacing and broadcast stand densities. Pollinators favor the more open thinned and unthinned row spacings as evidenced by the higher average number of pods set/stem. High, plant densities have greater numbers of stems/unit area but fewer racemes/stem thus fewer flowers capable of forming pods. Estimated pollination efficiency among years has been consistently higher for solid row and spaced row than for broadcast stands.

Seed Yields

Although the actual 4-year average yields from broadcast stands (360 lbs/ac) for August seed crops at Woodward are high, researchers feel growers cannot expect consistent high yields from broadcast stands and costly pollinators for the following reasons:

1. Fewer flower/unit area capable of forming pods because of the lack of bees.
2. Less pollinator activity in dense stands.
3. Heavy plant canopies, thus, higher canopy humidity and high seed losses due to shatter, and discolored and partially germinated seeds.
4. A great tendency for maturing stands to lodge, resulting in harvest difficulties and seed losses.

Pollination percentages are consistently higher for thin spaced row stands. Yields are higher and more consistent than with broadcast stands, provided pollinator number and pollinator field activity are adequate.

Studies of alfalfa seed production involved row spacings, stand densities, and timing of crop bloom, *via* cutting treatments under both irrigated and dryland conditions. Treatments were: a) cutting May 1 to 15, blooming would

Table 2. Three-year averages for three seed yield components, three row spacings and one broadcast establishment treatment by harvest date.

	July				Aug.				Oct.			
		Ave/Stem		Est %		Ave/Stem		Est %		Ave/Stem		Est %
	Stems/ft^2	Racemes	Pods	Pollination*	Stems/ft^2	Racemes	Pods	Pollination*	Stems/ft^2	Racemes	Pods	Pollination*
24" rows												
Unthinned	23.0	47.4	83.0	26.8	19.7	55.6	88.0	24.2	18.1	33.9	56.1	25.3
Thinned	21.3	61.8	97.8	24.2	20.7	31.0	72.0	35.5	21.0	22.5	39.5	26.9
36" rows												
Unthinned	16.3	52.8	86.5	25.1	15.0	36.7	80.0	33.3	16.1	27.0	68.3	38.6
Thinned	17.0	65.3	104.7	24.5	15.0	40.8	93.8	35.2	18.7	26.1	45.5	26.6
42" rows												
Unthinned	18.8	52.1	96.1	28.2	17.3	35.0	69.3	30.3	24.7	23.0	50.3	33.4
Thinned	15.0	67.6	121.9	27.6	14.0	44.8	98.8	33.7	20.3	32.9	72.6	33.7
Broadcast												
8 lbs/Ac.	41.9	61.5	73.9	18.4	52.7	25.0	39.0	23.8	88.6	19.2	31.5	25.0

*Estimated % pollination efficiency = [A ÷ B] x 100, where:

A = Stems/Acre (43,560 x Stems/ft^2) x Av. No. Pods/Stem (estimate of pods set/ac.)

B = Stems/Acre x Av. No. Racemes/Stem x 14 x 0.467 (estimate of number flowers capable of pod set)

Where: 14 = Mean No. Flowers/Raceme

46.7 = Estimated percentage flowers capable of forming pods (Pedersen, et al., 1956) begin mid to late June and b) leaving plots uncut so plants started blooming in early to mid May. Seed harvest of treatments varied with cut date and location. After each summer seed harvest, fields were cleaned up, (including tailings) and irrigated (except on dryland studies) to stimulate regrowth. Regrowth at all locations was allowed to mature a fall seed crop if possible. The average total seed yields is shown in Table 3.

INSECT PESTS

Forage

Major forage pests on alfalfa grown for hay or seed in the southern Great Plains are the alfalfa weevil, *Hypera postica* (Gullenhal), aphids, pea *Acyrthosiphon pisum* (Harris), spotted alfalfa *Therioaphis maculata* (Buckton), and blue alfalfa *A. kondoi* Shinji; varigated cutworm, *Peridroma sucia* (Hubner); alfalfa caterpillar *Colias eurytheme,* Boisduval; and the fall armyworm *Spodoptora furgiperda* (J.E. Smith). Most forage insect pests commonly occur in the spring but some, e.g., the spotted alfalfa aphid, alfalfa caterpiller, corn earworm *Heliothis zea* (Boddie), and armyworms can be a problem throughout the summer months. Occasionally, late-summer and fall infestations of loopers, *Caenurgina erechtea* (Cramer), grasshoppers *Melanoplis bivittatus* (Say), *M. differentialis* (Thomas), and blister beetles, *Epicauta* sp., are serious.

Seed Pests

Major seed pests are plant bugs, *Lygus spp.,* and alfalfa seed chalcid, *Bruchophagus roddi* (Gussakovsky). Potentially damaging to seed production are high thrip, *Chirothrips spp.,* populations and web worms, *Achyra rantalis* (Guenee). The most damaging seed pest, *Lygus* or alfalfa seed chalcid to alfalfa seed production in the area depends on the growers seed production system and time of crop bloom and maturity. Alfalfa seed pest problems are magnified in Oklahoma and surrounding states because of:

1. Climate-dryland haying of one or two cuts during favorable weather and leaving the second or third cut for seed. Most seed production in the area is from dryland hay stands and there is never a uniform (maturity) time when all growers harvest seed. Few or no control practices, either cultural or chemical, are used to minimize the yearly impact of seed pests.
2. Crop diversification in the area and infestation of alfalfa from these crop sources through migration.
3. Volunteer alfalfa plants growing along roadsides and elsewhere serve as pest reservoirs.
4. Numerous host plants (weeds) in fence rows and surrounding areas.

Occasionally, seed chalcids in some areas of Oklahoma, have destroyed 78% of the total seed crop. Fluctuating yearly chalcid infestation levels, where

Table 3. Average alfalfa seed yields in pounds seed/acre as influenced by row spacing and stand density by location and years.

Row spacing (inches)	Plant spacing	Guymon				El Reno				Tipton				Woodward					Bushland, TX**			
		79	80	81	Av.	79	80	81	Av.	79*	81	82	Av.	79*	80*	81*	82	Ave.	80	81	82	Ave.
12	solid	55	334	157	182	-	-	-	-	314	366	131	270	-	-	-	-	-	-	-	-	-
18	solid	73	325	75	159	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
24	solid	-	-	-	-	49	563	141	255	-	-	-	-	234	524	589	388	433	-	-	-	-
24	12"	-	-	-	-	-	-	-	-	-	-	-	-	264	459	548	472	435	-	-	-	-
24	24"	-	-	-	-	-	-	-	-	-	-	-	-	231	549	561	482	455	-	-	-	-
28	solid	64	360	115	180	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
(30)	solid	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	187	45	295	175
36	solid	-	-	-	-	60	364	96	173	-	-	-	-	219	482	497	402	400	-	-	-	-
36	12"	-	-	-	-	-	-	-	-	-	-	-	-	247	520	572	383	430	-	-	-	-
36	24"	-	-	-	-	-	-	-	-	-	-	-	-	217	525	487	382	402	-	-	-	-
42	solid	-	-	-	-	49	334	108	164	305	350	105	253	213	455	468	376	378	-	-	-	-
42	12"	-	-	-	-	-	-	-	-	-	-	-	-	226	485	501	352	391	-	-	-	-
42	24"	-	-	-	-	-	-	-	-	-	-	-	-	227	508	528	308	392	-	-	-	-
Broadcast (lb/A)																						
4 (4.5 kg/ha)		84	398	72	184	55	331	139	175	343	361	130	278	196	455	509	309	367	-	-	-	-
8 (9 kg/ha)		42	356	53	150	-	-	-	-	315	374	122	270	174	409	473	363	354	161	26	279	155
16 (18kg/ha)		53	314	34	134	-	-	-	-	269	342	143	251	-	-	-	-	-	-	-	-	-

*Combined summer plus fall crop yields for 1979, 80, and 81.

**Non-irrigated, study established on the level bench of a conservation bench terrace system that received storm runoff from watershed twice as large as the level bench.

cultural controls are not employed, appear to be related to dormant season moisture and temperature. Growing seasons following rather mild and moist winter weather appear to have less chalcid infestation than those following severe winters. No effective control for chalcid is available other than timing crop maturity to avoid seasonal peak populations of the pests (chalcid fly populations peak during July and Aug.) and through incorporating the previous year's crop residue 1-2'' deep by power-harrowing or cultivating in early spring (Mar. 1-15) will significantly reduce chalcid emergence. An emerging chalcid that is buried at a depth of 1-2'' will usually perish before reaching the soil surface.

Lygus can be effectively controlled with pre-and-post bloom chemical applications (Table 4). Caution must be exerised when spraying during bloom to avoid destroying beneficial pollinating insects. Some precautions when spraying during bloom are, cover all pollinator hives or shelters, spray during early morning or late evening when pollinators are in shelters or nests, and use pesticides with a short residue and relatively non-toxic to bees. Growers with ground spray rigs can track their field during the day based on boom spray width and spray at night following these tracks.

Table 4. Insecticides frequently used to control harmful pests in alfalfa seed fields.

Name		Toxicity		
Common	Trade	Residue on Bees*	Advantages	Disadvantages
carbofuran	Furadan[r]	7 to 14+ days	Long residual control of pests. Controls alfalfa weevil, pea aphids, grasshoppers, and lygus.	Longevity of residual toxic to bees and beneficial predators.
ahlopyrifos	Lorbsban	4 to 7 days	Gives good control of most aphids, alfalfa weevil, cutworms, armyworms, and grasshoppers.	Longevity of residual toxicity to bees, and injury to beneficial predators. Some phytoxic symptoms may occur on young rapidly growing alfalfa.
dimethoate	Cygon/ De-Fend	2 to 3 days	Good control on most aphids, lygus bugs, and grasshoppers.	Requires warm temperature and lush growth for good action. Injurious to beneficial predators.

methomyl	Lannate[r] L. Nudrin[r] 1.8	2 to 15 hours	Controls fall armyworms, alfalfa weevil larvae, lygus, cutworms, and aphids.	May require several applications to control severe pest infestation in seed fields.
methyl parathion	Methyl-Parathion[r]	4 to 6 days	Good control of lygus, aphids and alfalfa weevil. Not greatly affected by cool temperatures	Longevity of residual toxicity to bees and beneficial predators sometimes causes injury to alfalfa.
parathion	Parathion[r]	4 to 6 days	Good control of lygus, pea and blue alfalfa aphids, and alfalfa weevil.	Effectiveness sometimes influenced by cool temperatures. Residual toxicity to bees and beneficial predators.
endosulfan	Thiodan	1 to 3 days	Controls aphids, lygus, and stink bugs.	Toxic to beneficial predators. May need repeat applications to maintain control in seed fields.
trichlorfon	Dylox	2 to 6 hours	Less injury to beneficial predators	Poor control on resistant lygus and no effect on aphids. Requires cool acidified spray water. Should be used immediately after mixing.
demeton	Systox 6[r]	2 hours	Controls most aphids	Not effective on alfalfa weevil, grasshoppers, cutworms, and armyworms. Gives poor control of lygus bugs and mites in seed fields.

[r] = Restricted use insecticide. Can be applied only by certified applicators or persons under their direct supervision.

* Ref: Johansen, Carl. "Bloom treatments" Alfalfa seed pest management news. May 1984. Coop. Ext. Serv. Washington State University.

______________"Prebloom treatments", Alfalfa seed pest management news. April 1984. Coop. Ext. Serv. Washington State University.

A growers insect control program depends largely on timing and management. If the primary growth is allowed to flower and mature seed, pests may be a problem only late in the season. Other pests such as alfalfa weevil, aphids, armyworms, grasshoppers, etc., need to be controlled if populations reach economic numbers.

The insecticides listed are a diverse group of chemicals. Applicators should be aware of potential health hazards involved in application and use. Read all labels carefully before using any pesticide and then follow those instructions. Consult your State Agricultural Experiment Station or Extension Service personnel for specific use information consistent with label directions and cautions.

IRRIGATION

When and how much to irrigate are questions frequently asked by seed producers. No sound basis for formulating irrigation practices for alfalfa seed production have been established. The ''rule of thumb'' is to maintain alfalfa bloom in a good growth situation without stimulating crown regrowth. Both over-head (sprinkler) and furrow irrigation systems are used. Sprinkler irrigation, like rainfall, can cause lodging and high seed losses, i.e., brown partially germinated or scalded seeds and shattering, and should not be used after crop bloom. Furrow irrigation gives more latitude since water is applied under the plant canopy and large amounts can be applied in single applications. Soil texture, fall-spring rainfall amounts, grower cropping sequence, and row spacing or stand density are extremely important in determining irrigation needs. Soil moisture levels near field capacity at crop bloom are sufficient to mature excellent seed crops.

Cropping System and Irrigation Needs

Although Sorensen, et. al. (24), recommended the second crop, or an August seed crop, as the best in the central plains area, our highest yields were obtained from the primary spring growth of row spaced (24'' to 36'') stands that matured seed in July. Usually the accumlated fall and winter soil moisture and early spring and summer rainfall distribution was sufficient to produce a good to excellent July seed crop without irrigation. Primary alfalfa spring growth will initiate bloom during May (1-15) and continue blooming through mid-to late June. Rainfall during crop bloom may reduce flower nectar quality and quantity, damage the flowers, thus reduce pollinator acceptance and field activity. Rainfall through the 3rd week of bloom and pod set is not damaging to the existing seed yield unless it occurs in excessive amounts. Rains occurring later when seed pods are mature causes pods to absorb moisture and swell. When they dry a high percentage of pods may split shattering its seed contents.

A summer seed crop can be harvested in mid to late July, about 3 to 5 weeks after bloom. Harvesting a July seed crop followed by baling crop residue and irrigating (3 to 5 inches) to stimulate regrowth allows sufficient time to produce a fall seed crop in all areas of Oklahoma except the extreme NW part of the state. This cropping practice has been successful (3 out of 4 years) in the western one-third of Oklahoma and on the Texas High Plains (Bushland, TX) where only a late July or early August seed crop is harvested without benefit of irrigation.

Allowing the primary spring growth versus the May-cut regrowth to mature seed has both its advantages and disadvantages.

Advantages:

1. A short crop development season (July seed harvest).
2. Early attainment of peak water use associated with early canopy and flowering under near stress free conditions.
3. Peak populations of pests are avoided (*Lygus,* Chalcid and grasshopper infestations).
4. A lower percentage of pods set/raceme are attained but this appears to be off-set by a higher number of sound seeds-set/pod.
5. In most areas of Oklahoma there is sufficient time to mature a fall seed crop. Where irrigation water is available, one and sometimes two good irrigations (3-5 inches) about 15-20 days apart may be needed to maintain the fall crop.
6. A higher yield potential.
7. Pollination activity (efficiency) by honey bees appears to be greater during May and September blooms.
8. A September (fall) bloom occurs at population peaks for many valuable wild pollinators, especially the Bumble bee, *Bombus spp.*
9. A good single seed crop (July production system under dryland conditions).

Disadvantages:

1. The cost of introducing pollinators, i.e., leaf-cutter bees, honey bees, etc.
2. Forage feeding insects occur most often during April and May, e.g., alfalfa weevils, must be carefully controlled prior to crop bloom.
3. Fewer pods per raceme in comparison to June and July pollinated crops.
4. Diseases, especially rust *Uromyces striatus* Schroet. var *medicaginis,* may be severe in isolated fields with moderate to high plant densities about or during bloom and pod setting of the primary growth. Where alfalfa seed fields are irrigated by flooding or are planted on level bench terraces as in the Texas High Plains, severe stand losses can result from *Phytophtora* root rot. Planting on beds is one way to reduce flooding effects thus, severity of loss to root-rot *Phytophthora megasperma* Drechs.

5. Lodging can be severe in fields having high plant densities or rank spring growth. Too much moisture promotes lodging, new crown growth, increases the number of brown or scalded seeds in pods set prior to lodging, and decreases flower accessibility to pollinating insects.
6. Late fall rainfall may interfere with harvesting plans and reduce yield.

Effects of Cutting

When the primary spring growth is cut-back (May 10-15) for hay, in either bud or other bloom stages, the seed crop will mature in August. From this practice only one good seed crop can be obtained and the likelihood of additional irrigation needs are increased. Summer seed yields, however, are similar whether the primary crop growth is uncut and managed for a July seed crop or cut and managed for an August crop (Table 5). The August seed crop may require a single irrigation immediately after the May cut date, during the bud stage prior to bloom, or both.

Disadvantage of August seed crops are:

1. Except for the Southwest quarter of the state, only one seed crop can be obtained with certainty per season. Attempts to produce a fall seed crop following an August seed harvest in the central and N.W. parts of Oklahoma are usually terminated by frost during bloom.
2. Crop bloom and pod set in June through July occur during peak field populations of alfalfa seed chalcid fly and *Lygus* spp.
3. Even when pollination efficiency is good, the increased yield potential is often off-set by seed pests to a much greater extent than the July harvest.

DRYLAND

The best strategy for optimizing yield under dryland conditions depends on the established long-time rainfall distribution patterns of the area and planting in rows at very low seeding rates. The grower need not estimate or predict precipitation to determine the best row spacing. In these studies, the 24 to 36 inch row spacing (61-91 cm) established at 2 lbs. pure-live-seed/acre had the highest yields, regardless of thinning rate within row and whether the stand was irrigated or dryland. This has been true every year without exception. The key to maximizing yields is the efficient use of moisture. It is best for the grower in areas of low winter and early spring precipitation to be somewhat pessimistic and use lower plant populations, i.e., 36 inch row spacings, thus manipulating available moisture for maximum use; and making flowers accessible to pollinators.

The strategy under dryland conditions in the western one-third of Oklahoma and the Texas High Plains should be to allow the primary spring growth

Table 5. Mean yields in pounds alfalfa seed per acre as influenced by time of crop maturity and row spacing, at Woodward, OK.

	Uncut*						Cut (May)**					
	1983			1984			1983			1984		
Treatments	July	Oct	Total	July	Oct	Total	Aug	Oct	Total	Aug	Oct	Total
	pounds/Acre											
Rows (inches)												
24	351	173	524	370	282	652	307	-	307	372	23	396
36	276	174	542	338	259	596	289	-	289	354	22	376
42	286	148	434	330	240	570	274	-	274	311	27	338
Broadcast												
4 (lbs/acre)	291	157	448	278	248	526	324	-	324	345	20	365
8	289	136	425	254	252	506	299	-	299	372	13	385
Mean	298	157	475	314	256	570	298		289	351	21	372

*Irrigated twice, once after the July seed harvest and residue removal and again just prior to late August bloom.

**Irrigated twice, once ofter the May cut and again after the August seed harvest and residue removal.

to mature seed. This strategy dictates the introduction of crop pollinators, (honey bees or leaf cutter bees), into the fields. A grower *can not* rely on wild bee populations during this period.

FALL SEED CROPS

The production of a fall seed crop in western Oklahoma and the Texas high plains is possible, but depends to a great extent on the soil moisture reserve following the July seed harvest. If sufficient moisture remains for the regrowth to proceed into the hot-dry month of August, a rain occurring before or during early bloom can result in a good fall seed harvest. A fall seed crop is more dependable with wide row spacings (36-40 inches). Where plants were thinned within the row and intermittent moisture stresses occur under dryland conditions, the lowest plant densities increase the chances of producing good fall seed crops. Where thick stand densities go into drought induced dormancy, thin stands persist with less branching in the axils of main stem leaves and by shedding a high percentage of their leaves. Shedding of leaves reduces evapotranspiration demand and maintains a favorable moisture balance in the stem and flowering parts of the plant.

The relationship between the duration and intensity of water stress during August (regrowth) and the occurance of precipitation during September bloom on pod-set is not well understood. Our observations suggest that improved fall seed yields follow drought stress conditions, if precipitation occurs shortly before or after bloom.

CENTRAL AND EASTERN, OKLAHOMA PRODUCTION

Spring and early summer months are characterized by high intensity rains which provide up to 78% of the 30 plus inches (76 + cm) of the annual precipitation. Rank growth and lodging plus high chalcid populations are major deterrents to developing an efficient seed production system. Crops grown for seed from solid or row-spaced stands have a severe alfalfa seed chalcid infestation problem throughout the growing season.

The production of acceptable July or August seed yields, regardless of stand density is unlikely because of seed pests. The problem with the alfalfa seed chalcid, however, is less severe (although high) in the fall (late August to frost). The dual system of hay then seed production from hay stands, presently used by growers in these areas, has considerable merit. Under these climatic conditions the dual hay (2-3 cuts) then seed is effective management.

SEED HARVESTING

Alfalfa seed fields are harvested by swathing, curing, and combine threshing using a pickup attachment on the header, or by chemical desiccation of the field followed by direct combining.

The two harvest methods growers commonly use are summarized as follows:

1. Swath the field and allow the windrow to cure to a uniform dryness (c. 14% w/w moisture) and combine thresh using a pickup attachment.
2. Spray-apply a drying agent (desiccant), such as, Dow general (Dinitro), paraquat, or diquat, at recommended rates to bring the standing vegetation to a uniform acceptable dryness; then combine harvest.

Windrow Curing

Seed fields should be swathed when the majority (80% or more) of the seed pods are dark (light brown to dark brown) and late set pods have turned from green to ''lemon-yellow'' in color. Swathing should be done during late evening or early morning hours when humidity is highest to reduce pod shatter losses. Cutter bar losses usually will not exceed 5 kg seed/ha (4.5 lbs/acre) under good conditions. However, windrow losses can be extremely high when strong winds scatter the crop before threshing or rains occur after swathing and windrows are turned to facilitate drying. Windrowing the crop is preferred to chemical curing when fields are weedy or harvested prior to frosts.

Chemical Curing

A July or August seed crop can attain the proper dryness for direct combining in 3 to 4 days following desiccation. Direct combining avoids the problem of winds disturbing windrows. If rain occurs before harvesting but after desiccation, fields dry out quick and can be harvested sooner than a swathed field. Chemical desiccation also allows growers to delay harvest until nearly all pods are ripe. However, long delays in harvesting may result in high shatter losses. A field should be desiccated when the vast majority of the seed pods in the field are ''lemon-yellow'' or darker in color, (usually 3 to 5 weeks after terminal bloom). Immature green pods lower seed quality since they do not ripen after desiccation.

Alfalfa seed crops maturing in July or August are easily cured by the use of a chemical mix of 'Dinoseb' (2-sec-butyl-4, 6-dinitrophenol) 2 quarts/acre (4.7 liters/ha), plus 4 quarts diesel oil (9.3 liters/ha), and 100 ml (247 ml/ha) Ortho-x-77 spreader in 30 gal (280 1/ha) of water; or the substitution of 'Diquat' (6,7-dihydrodipyrido (1, 2-a:2',-1-c) pyrpazinediium ion for dinoseb at 1 qt./acre (2.3 1/ha) in the mix.

Although the above mixes bring the summer seed crops to an excellent standing cure, they do not work well when curing a late October seed crop. Eight to 10 times more diesel oil is needed in the fall because of the short days and cool weather. Chemical desiccation of fall seed crops is not cost effective for growers in the area. In addition, fall seed harvested from a spray-cured field usually has a higher moisture content than a windrowed crop. Unless drying facilities are available, growers should swath their fall seed crops and combine harvest using a pick-up attachment.

Combining Seed

Most standard combines can be modified to harvest alfalfa seed. For harvesting from swathed fields or windrows the combine header should be equipped with a belt-type pick-up attachment. A varied assortment of pick-up attachments, ground driven or driven off the reel sprocket or a separate detachable pick-up header (the platform auger header is removed and the pick-up header attached in its place) are used. These are operated at speeds slightly faster than the combine's ground speed.

Chemical-cured alfalfa seed fields are harvested by direct combining. To avoid shatter losses (stripping pods from stems) a vertical cutter-bar should be attached to one end of the platform to cut through foliage. Lifter guards (such as the Richardson guard) should be used in row-planted stands. The header reel is usually not needed but used when harvesting very light seed crops. Combines having rasp-bar type cylinders are commonly used for alfalfa seed.

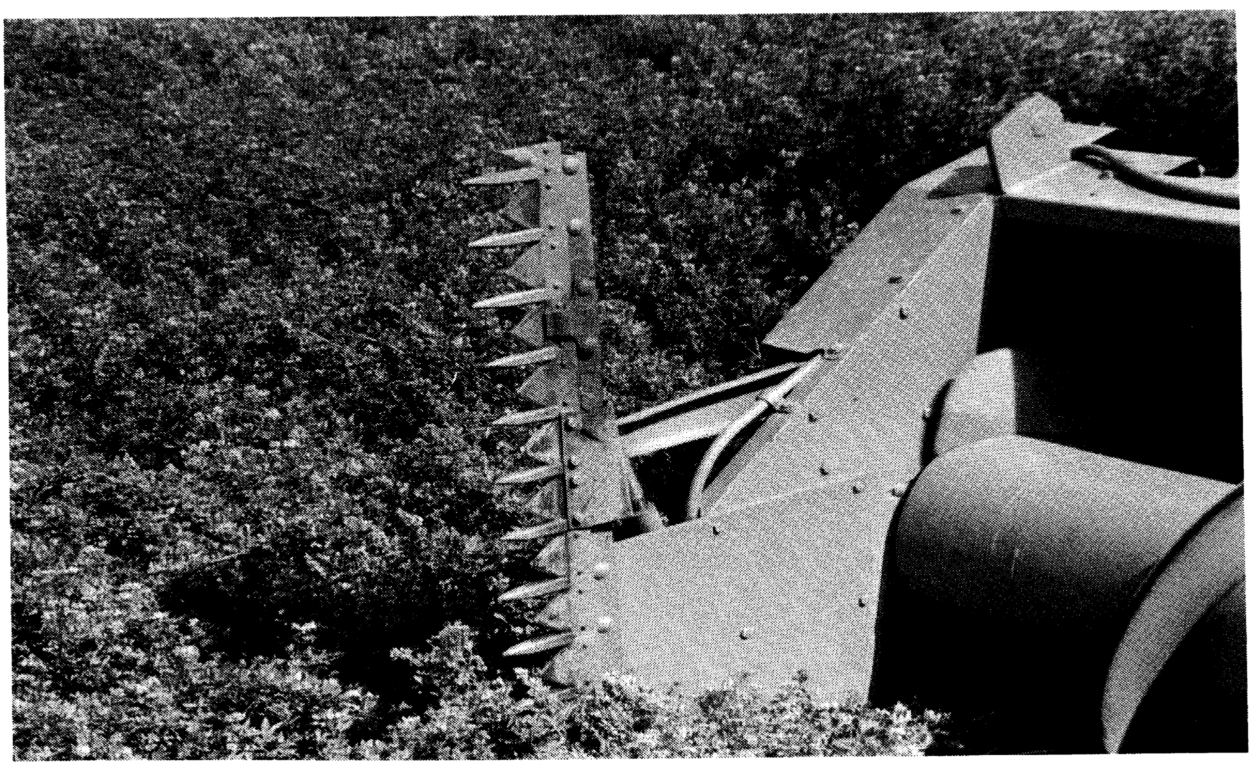

Figure 4. A combine header with a vertical cutter-bar fixed to one end of the platform to facilitate direct combining of alfalfa seed crops following chemical desiccation.

When direct combining cured stands or windrowed crops, the grower should:

1. Adjust combine cylinder (18'' dia.) speed between 800 and 900 RPM (3,770 and 4,241 ft./minute or 1,148 to 1,292 m/minute). Cylinder speeds in excess of 4,000 ft./minute may damage seed and overload cleaning shoe with excessive amounts of small broken plant material. Calculate the circumference of a cylinder by the formula.
   $c = 2\pi r$ or $c = \pi d$; $\pi = .31416$, $d =$ diameter in inches
   Thus: 3.1416 x 18'' = 56.5488'' ÷ 12 = 4.7 feet
   RPM x 4.7 = feet per minute.
2. Set clearance between cylinder bar and concave between 1/8 to 3/8 inch (3.2 to 9.5 mm).
3. Adjust fan for just enough air to stratify the material for good separation.
4. Adjust the forward or combine ground speed, 2 to 3 m/hr, to cut-width (swath) so as to keep the machine evenly loaded. Excessive feed rates will increase seed losses.

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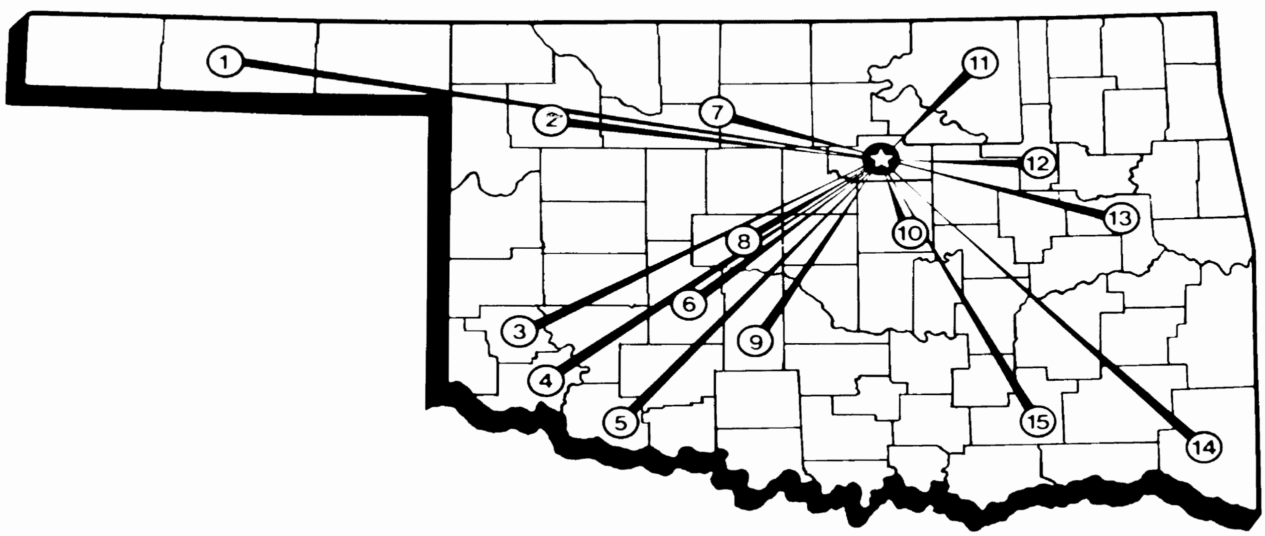

★ Main Station—*Stillwater, Perkins and Lake Carl Blackwell*

1. Panhandle Research Station — *Goodwell*
2. Southern Great Plains Field Station — *Woodward*
3. Sandyland Research Station — *Mangum*
4. Irrigation Research Station — *Altus*
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