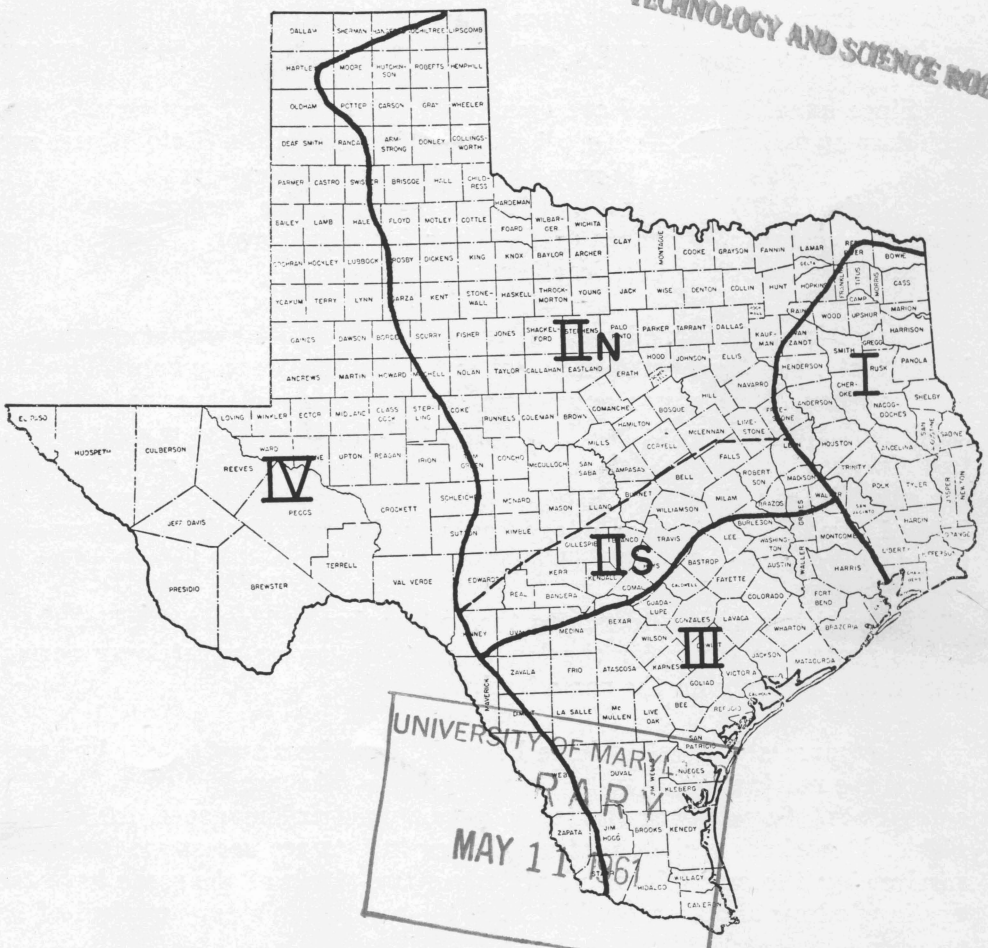
Bulletin 79

Sweetclover in Texas



Areas of adaptation of sweetclover in Texas. Area I—not generally recommended. Area II—biennial white, biennial yellow, annual white (Hubam); Area II-N—spring planted; Area II-S—may be fall planted. Area III—annual white, annual yellow. Area IV—not recommended except under irrigation.

January 195

TEXAS AGRICULTURAL EXPERIMENT STATION

R. D. LEWIS, DIRECTOR, COLLEGE STATION, TEXAS

DIGEST

Sweetclover was among the first legumes tested by the Texas Agricultural Experiment Station. Four species, two biennials and two annuals, are now grown in Texas. The important varieties among these species are Madrid, Evergreen, Hubam and annual yellow-flowered sweetclover. The cover picture shows the areas of adaptation.

Biennial sweetclover was found to be well adapted on the limestone soils in the State before 1900. Agricultural research workers recognized its value as a soil-conditioning crop and recommended it for this purpose. Research at the Angleton station in 1915 showed that it was necessary to inoculate sweetclover. Studies were conducted at Chillicothe to determine the most effective date of planting, rate of seeding, row width and the influence of seed scarification on forage yields. Good yields were obtained from plantings made from January 1 to April 1. Better stand survival was obtained at Chillicothe when sweetclover was seeded in 32-inch rows than when close-sown in 8-inch rows.

Since sweetclover seed are small, 260,000 to 350,000 per pound, they should be planted one-half inch deep on a firm clod-free seedbed. Location within the State determines whether sweetclover should be spring or fall-seeded. It may be planted alone or with small grains. At least 40 pounds of phosphoric acid (P_2O_5) per acre usually are necessary for good results. Soils should be tested to determine the kinds and amounts of fertilizer for sweetclover. Band application of phosphate fertilizer has proved superior to broadcasting.

Sweetclover is a good pasture crop and provides abundant grazing. Because of its characteristic bitter taste, the first reaction of cattle to sweetclover may be unfavorable, but they graze sweetclover readily when they become accustomed to it. On sweetclover-oat pasture at Temple, steers gained as much as 2.1 pounds per day. The quality of the forage, as measured by protein and phosphorus content, is excellent. Sweetclover grows well with perennial grasses, especially Johnsongrass. When grown with oats, it is one of the best pasture combinations. Sweetclover makes good hay and silage. Spoiled sweetclover hay or silage contains dicoumarol which injures the fine capillaries and reduces the clotting power of the blood of animals. Such spoiled hay or silage should not be fed to livestock.

Sweetclover adds nitrogen to the soil, makes soil more friable, thereby increasing aeration, and offers protective cover for the land. Crops following sweetclover normally produce more than crops grown continuously on the same land.

Maximum soil benefits have been obtained from sweetclover by harvesting a seed crop and returning all the residue to the soil. On many farms, the production and sale of sweetclover seed are paying enterprises. Sweetclover planted in pure stands and managed for seed production gives highest seed yields. Experiments show that pollinating insects are necessary for good seed production. Cutting and windrowing the sweetclover plants when two-thirds of the seeds have turned brown, allowing them to dry in windrow and then combining, is the most satisfactory method of harvesting the seed.

Although a number of insects attack sweetclover, there is only one at present that is specific to sweetclover. This is the sweetclover root borer, for which there is no known control. Among the more important diseases of sweetclover are cotton root rot, blackstem and anthracnose, for which there are no known controls.

ACKNOWLEDGMENTS

Much of the research reported in this bulletin was conducted at the various substations. Special recognition is given to J. Roy Quinby and J. C. Stephens of the Chillicothe station for the early research on seeding sweetclover. The early work of Paul B. Dunkle (deceased) at the Denton station has been a major factor in the wide distribution and use of Madrid sweetclover in North-central Texas. The Blackland station at Temple also has contributed much information through grazing studies with sweetclover and small grain.

The section on Diseases of Sweetclover was contributed by Marvin H. Whitehead, formerly professor, Department of Plant Physiology and Pathology.

Sweetclover In Texas

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Department of Agronomy

SWEETCLOVER IS MORE WIDELY ADAPTED IN TEXAS than any other cultivated legume. Where sweetclover grows well, the roots penetrate the soil, opening it up so that water intake is rapid. The physical condition of the soil is improved and the land is easier to till. When sweetclover roots are well nodulated, large amounts of atmospheric nitrogen are fixed and are available for succeeding crops. It is a good pasture and hay crop. Some farms make a good business of the sale of seed.

Sweetclover was among the first legumes tested by the Texas Agricultural Experiment Station. The performance of *Melilotus alba,* a biennial white-flowered sweetclover, is reported in Bulletin 34 of the Texas Station, published in 1895 (3). At McKinney, spring-planted *M. alba* grew to a height of 4 feet by August 1. In October, the taproots were 18 to 24 inches long with a diameter at the crown of one-half to three-fourths inch. At College Station, *M. alba,* planted on April 20, 1894, grew to a height of 15 to 20 inches by midsummer. In summarizing this work the authors stated that "it is prized as a renovating crop for enriching worn lands" and is one of the most promising spring-planted clovers. In a Texas Station bulletin (14), published in 1898, sweetclover was recommended as "a restorative crop on poor loams and lime land," and the authors stated that "sweetclover thrives on lime washes and dry prairies where many crops fail." Reports from farmers, given in a Texas Station bulletin in 1901 (5), show the wide adaptation of sweetclover: Waco—"planted on fertile sand, it grew splendidly and kept down all weed growth"; Dublin—"grew 3 to 5 feet tall, roots very large and could not be pulled up; stood drouth very well"; Harris county — "planted on heavy black clay, stood 90 days without rain, lived through dry season and made some growth."

TABLE 1. SPECIES AND VARIETIES OF SWEETCLOVER ADAPTED TO TEXAS

Common names	Species	Varieties
Biennial white-flowered	Melilotus alba	Evergreen Spanish Common white
Biennial yellow-flowered	Melilotus officinalis	Madrid Common yellow
Annual white-flowered	Melilotus alba annua	Hubam Floranna
Annual yellow-flowered	Melilotus indica	Annual yellow-flowered (Sour) or (M. indica)

DESCRIPTION OF SPECIES

There are several known species of sweetclover, but only four are important to the Texas farmer. Table 1 gives the species and varieties of sweetclover adapted to Texas.

The sweetclover plant is erect with slender, somewhat angular stems which become woody at maturity. The central stem often is not conspicuous as 5 to 10 stems may come from the crown of the plant. Stems on biennial sweetclover may reach a height of 4 feet the first season, while the second year they will be taller and more vigorous.

Figure 1 shows some characteristics of the sweetclover plant. The leaves are trifoliate and the leaflets are borne on a petiole about the length of the leaves. The leaflets are one-half to three-fourths inch in length, broadly oblong, rounded

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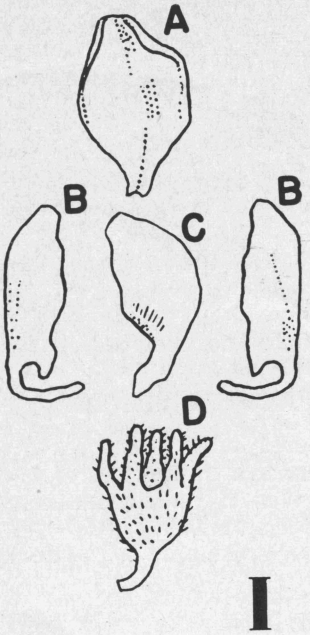

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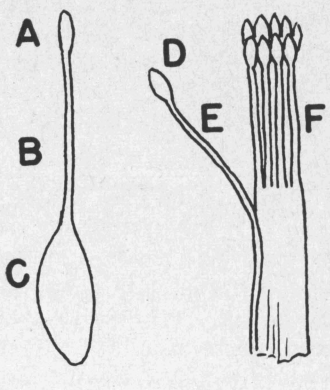

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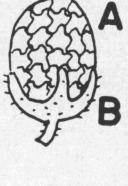

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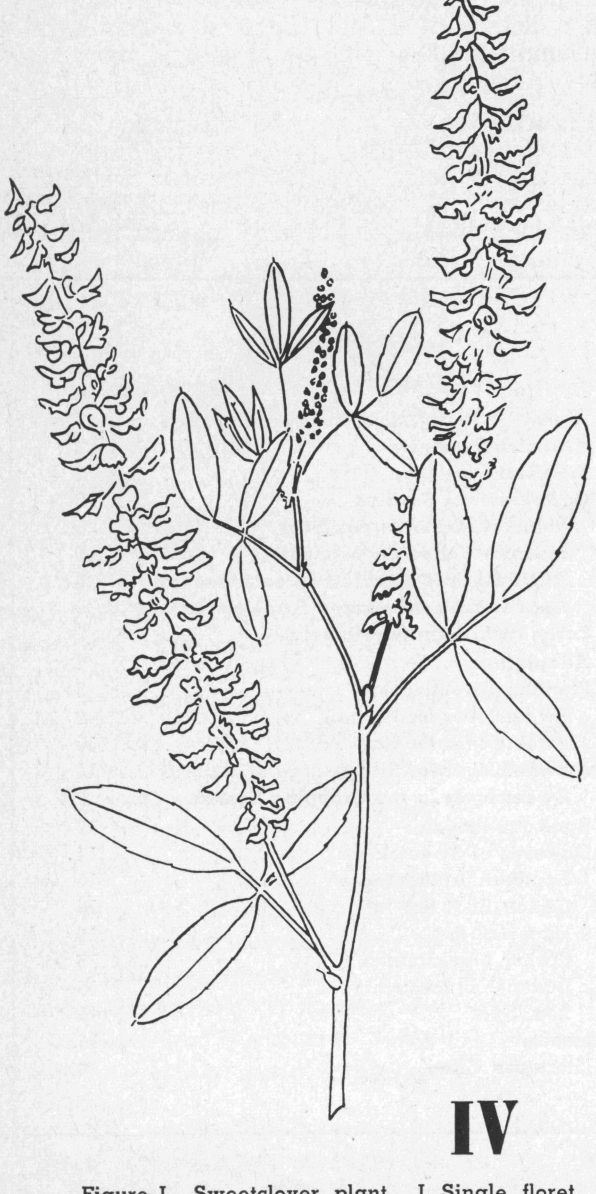

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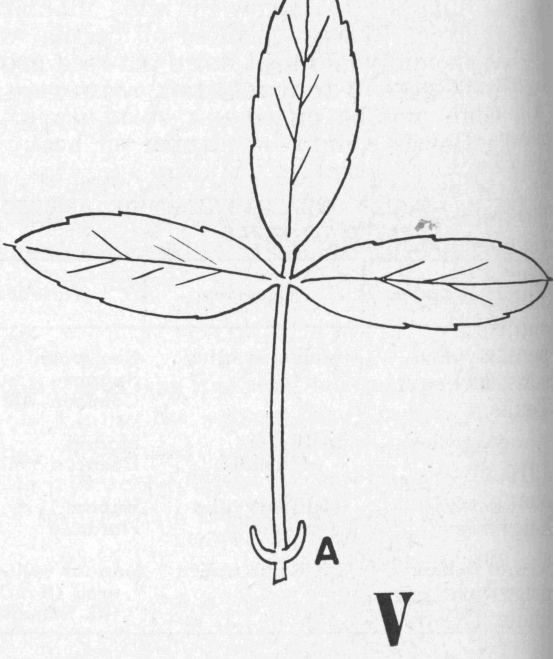

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Figure I. Sweetclover plant. I. Single floret (A) Standard (B) Wings (C) Keel (D) Calyx. II. Sexual parts (A) Stigma (B) Style (C) Ovary (D) Anther (E) Stamen (F) United stamens. III. Mature ovary (A) Pod (B) Calyx. IV. Flowering branch. V. Leaf showing (A) Stipules.

and notched at the tip and serrated on the margins. The stipules, small leaf-like bracts at the base of the leaf petiole, are one of the basic means of distinguishing sweetclovers from alfalfa and certain other legumes.

The flowers are small and are borne in slender racemes. The calyx is green, smooth or slightly pubescent, and the calyx teeth are short and nearly equal. The corolla is made up of two wing petals, a keel and a standard petal. The standard is larger than the wings. The wings have narrow claws at the base and are somewhat longer than the keel petal. There are 10 stamens, 9 are united at the base and 1 is on a single filament. All stamens produce fertile anthers but do not develop at the same time, thus pollen may be shed within a given flower for several days. The number of ovules that develop per flower vary from one to four, one being the most common. It is generally accepted that sweetclover is cross pollinated but seed may be produced by self-pollination.

The pod is indehiscent, short, one-eighth to three-sixteenths inch in length and wrinkled. The seed are covered with a thin cuticle which is not permeable to water. The number of seed per pound varies from 260,000 to 350,000, depending on the species.

Sweetclover has a taproot system. Its extent and vigor varies with the species. The root system of the biennial sweetclover enlarges greatly the first year, storing large amounts of carbohydrates for use during the second growing season. As the first-year plants become older, the upper part of the root system becomes woody. Dormant buds develop at the crown of the plant. In the early spring of the second year, these dormant buds develop into the second year's growth. The root system of the annual types is less vigorous and reaches full development at the time of flowering.

Biennial White Sweetclover

This species, *Melilotus alba,* is distinguished by its biennial habit of growth and white flowers. Although several varieties have been developed, Evergreen shows the most promise for Texas conditions. Developed by the Ohio Experiment Station, it was released in 1924. It is tall-growing, late-maturing and higher in forage production than other varieties. The flowering period occurs over a period of 6 to 8 weeks, therefore, it is possible to obtain only a small amount of seed at any one time. This characteristic has made seed expensive and difficult to obtain. For these reasons, Evergreen has not been generally planted in Texas.

Spanish, a variety introduced from Spain in 1910, shows some promise in Texas. It has vigorous growth, is leafy, upright and of medium height and maturity.

White-flowered biennial types of unknown origin are sometimes grown, and the seed are sold under the name of common white.

Biennial Yellow Sweetclover

This species, *Melilotus officinalis,* has a similar growth habit to the white biennial, the main difference being its yellow flowers. Minor differences are that white sweetclover may reach a height of 6 to 8 feet but the yellow rarely exceeds 4 to 5 feet; the variety Madrid is finer-stemmed with more leaves than common white. Taproots are well developed, but branch more than the white biennial form. The stems of the first season's growth are inclined to be decumbent. Madrid, the most important variety, was introduced in 1910 by the U. S. Department of Agriculture from the Madrid Botanical Gardens of Madrid, Spain. Its vegetative characteristics are similar to the biennial white-flowered types. Early and uniform ripening of seed make this variety the best of the yellow-flowered varieties for seed production. It has finer stems and more leaves than other varieties of sweetclover. It has good seedling vigor and is able to compete with weeds. It is more dependable in the drier areas than common white because it is 2 weeks earlier in flowering, thus escaping the midsummer drouth.

Common yellow consists of types of unknown origin grown for a number of years in the Great Plains States. It is lower-growing and more prostrate with less leaf surface than the white-flowered types. Because of its ability to withstand adverse soil and climatic conditions, common yellow often is planted in the Great Plains region. No attempt has been made in Texas to isolate varieties from the common yellow. In general, yield and performance of common has been inferior to the Madrid variety.

Annual White-flowered Sweetclover

Among the annual white-flowered sweetclovers, Hubam, *Melilotus alba annua,* is the most important in Texas. It was selected in Iowa from seed obtained in Alabama in 1916. It grows from 3 to 7 feet tall and has a good taproot system. It makes all its growth in one season, usually producing one main stem from which many branches arise and these are terminated by flowers. Hubam may be planted in the spring or fall in areas II-S and III, front cover, but should be spring-planted in area II-N. On soils where cotton root rot is a problem, Hubam fits into a cropping system better than the biennials. Although subject to cotton root rot, Hubam usually matures before the disease can kill the plants.

Floranna is a variety of annual white-flowered sweetclover released by the Florida Agricultural Experiment Station in the fall of 1951. Preliminary tests show that from College Station southward, it produces more forage than Hubam, is about 2 weeks earlier and makes more rapid regrowth after being grazed. Elsewhere in the State, it has shown no superiority.

Annual Yellow-flowered Sweetclover

This species, *Melilotus indica,* is sometimes called sour clover. It is the only sweetclover that

Figure 2. Biennial white-flowered sweetclover. Picture taken June 23, 1917 at the Denton station.

will grow on a soil low in lime. Annual yellow seldom reaches a height of more than 3 feet and the root system is weaker and shallower than the other sweetclovers. This species is the most rapid growing and the earliest maturing among the sweetclovers. It usually is not winter-hardy north of an east-west line through Robertson, Madison, Trinity and Bell counties. Annual yellow sweetclover has escaped from cultivation and is found growing along roadsides, wasteland and in pastures throughout South Texas.

EARLY TESTS WITH SWEETCLOVER

Tests were conducted with sweetclover by many of the substations soon after they were established (1, 4, 7, 9, 10, 19). In 1915, the Angleton station determined that it was necessary to inoculate sweetclover for good growth. Figure 2 shows a field of biennial sweetclover on the Denton station in 1917. Early work at Denton compared seeding rates in 30-inch rows (Table 2). In 1918, broadcast plantings of sweetclover at Denton were reduced as much as 40 percent by drouth; no killing was observed in clover planted in 30-inch rows.

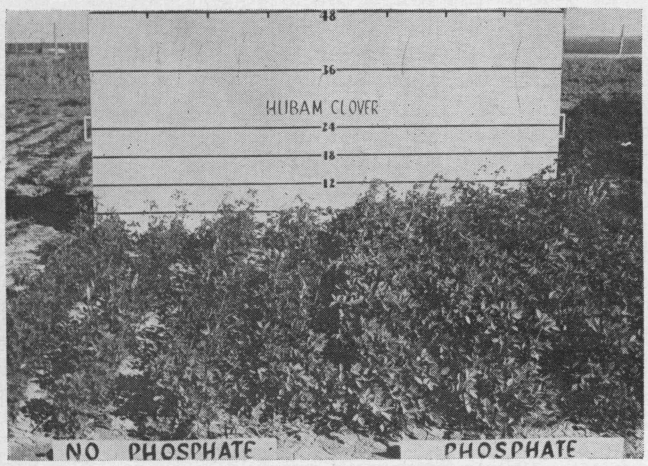

Figure 3. A comparison of the growth of Hubam clover receiving phosphorus with no phosphorus at the Temple station.

The Chillicothe station initiated tests in 1928 to determine the influence of planting date, width of rows and scarified versus unhulled seed on yield, along with a variety test. Table 3 summarizes the results of date-of-planting and scarification experiments. Good yields were obtained from all dates of planting from January 1 to April 1. From these tests it was determined that unhulled seed gave better results than hulled seed when planted in December and January. The station superintendent in reporting on these experiments stated, "the advantage of unhulled seed . . . is that several stands of unhulled seed will frequently emerge and a stand may be obtained after one emergence has been killed by freezing." The Chillicothe results show that sweetclover seed planted after February 1 should be scarified.

Table 4 shows that on the average there was no difference in forage yield from sweetclover planted in 32-inch and 8-inch rows at Chillicothe. However, differences occurred among planting dates within years. Where weeds are a problem, row plantings may be cultivated to control them.

ADAPTATION

Many variety tests with sweetclover have been conducted in Texas. Varieties released by experiment stations, the USDA and private producers have been tested under various environmental conditions. Varieties and species adapted to different areas of the State are given in Table 1. Results of sweetclover yield tests at several locations are shown in Table 5. The general areas of adaptation of these varieties are given on the front cover.

TABLE 2. INFLUENCE OF RATE OF SEEDING BIENNIAL SWEETCLOVER IN 30-INCH ROWS ON YIELD OF AIR-DRY FORAGE, DENTON

Rate of seeding, pounds per acre	Yield, pounds per acre		
	First year	Second year	Total
3	3530	2600	6130
6	3480	2970	6450
9	2920	3170	6080

TABLE 3. POUNDS PER ACRE OF AIR-DRY FORAGE FROM BIENNIAL SWEETCLOVER PLANTED ON DIFFERENT DATES, *CHILLICOTHE*

Date planted	Date harvested					
	Scarified seed			Unhulled seed		
	Nov. 26, 1929	May 28, 1930	Total	Nov. 26, 1929	May 28, 1930	Total
12-5-28	0	0		4,500	9,820	14,320
12-15-28	2,480	3,860	6,340	6,120	6,900	13,020
1-2-29	3,300	5,880	9,280	4,940	7,800	12,740
1-16-29	3,940	6,060	10,000	4,380	6,920	11,300
2-11-29	3,280	5,720	9,000	3,460	6,000	9,460
2-14-29	2,780	5,520	8,300	3,240	6,200	9,440
3-4-29	2,360	5,370	7,730	2,580	—	—
3-15-29	3,640	6,440	10,180	2,380	5,700	8,080
4-1-29	2,500	6,140	8,640	2,220	5,000	7,220
4-15-29	3,040	6,760	9,800	2,860	6,780	9,640
5-7-29	2,580	8,540	11,120	1,780	5,080	6,860
	Dec. 2, 1931	June 23, 1932		Dec. 2, 1931	June 23, 1932	
11-20-30	2,500	5,760	8,260	2,680	5,980	8,660
12-1-30	2,320	5,840	8,160	2,540	6,640	9,180
12-17-30	2,980	7,940	10,920	2,300	6,300	8,600
1-1-31	2,680	8,060	10,740	2,640	7,940	10,580
1-14-31	2,560	7,420	9,980	2,380	7,680	10,060
2-2-31	2,720	8,540	11,260	2,500	7,920	10,420
2-19-31	2,320	7,060	9,380	2,340	7,020	9,360
3-10-31	2,600	8,200	10,800	1,500	6,460	7,960
3-16-31	2,460	7,720	10,180	2,540	11,160	13,700
4-3-31	2,100	8,460	10,560	1,600	6,560	8,160
4-16-31	1,940	6,980	8,920	1,480	6,820	8,300
5-4-31	2,240	9,840	12,080	820	5,080	5,900
5-15-31	1,940	9,560	11,500	—	1,120	1,120
6-2-31	960	9,180	10,140			
8-5-31		3,980	3,980		4,000[1]	4,000
9-11-31		4,300	4,300		3,400[1]	3,400
10-6-31		3,940	3,940		3,200[1]	3,200
1-2-31		1,580	1,580		500[1]	500
	Oct. 28, 1933	June 24, 1934		Oct. 28, 1933	June 24, 1934	
1-4-33	960	1,920	2,880	1,140	2,380	3,520
1-7-33	1,020	2,080	3,100	1,120	2,320	3,440
2-6-33	1,180	2,600	3,780	1,180	2,460	3,640
2-24-33	1,120	2,260	3,380	1,140	2,420	3,560
3-6-33	840	3,280	4,120	1,620	2,720	4,340

[1] Plants bloomed in spring of 1932.

Because of poor internal drainage in the soil, low pH and a deficiency of phosphorus and potash, sweetclovers generally are not recommended in area I. Sweetclover will grow on some soils of this area if lime and proper fertilizers are applied.

The sweetclovers, both the annual Hubam and the biennial varieties, are well adapted to area II. In much of the region, phosphorus is the only fertilizer needed. Figure 3 shows the influence of phosphorus on the growth of sweetclover in area II. The soil should be tested to determine the fertilizer needs for sweetclover. In the western part of area II, the tight, hard soils are too drouthy for growing sweetclover. Its growth is limited in this area to sandy soils, creek and river bottoms and land under irrigation. As water becomes a limiting factor, seeding in regular width rows with some cultivation is recommended.

TABLE 4. POUNDS PER ACRE OF AIR-DRY FORAGE FROM TWO DIFFERENT ROW SPACINGS OF BIENNIAL SWEETCLOVER, CHILLICOTHE, 1929-32[1]

Date planted	Date harvested					
	32-inch rows			8-inch rows		
	Nov. 26, 1929	May 28, 1930	Total	Nov. 26, 1929	May 28, 1930	Total
12-15-28	6,120	6,900	13,020	3,980	5,980	9,960
1-16-29	4,380	6,860	11,240	2,860	5,540	8,400
2-14-29	3,240	6,200	8,440	2,440	5,700	8,140
3-15-29	2,380	5,700	8,080	2,360	5,020	7,380
Average	4,030	6,420	10,190	2,910	5,560	8,470
	Dec. 2, 1931	June 23, 1932	Total	Dec. 2, 1931	June 23, 1932	Total
12-17-30	2,300	6,300	8,600	2,620	7,200	9,820
1-14-31	2,380	7,680	10,060	2,660	7,820	10,480
2-19-31	2,340	7,020	9,360	2,440	7,280	10,720
3-10-31	1,500	6,460	7,960	2,340	7,940	10,280
4-16-31	1,480	6,820	7,300	1,800	10,360	12,160
Average	2,000	6,860	8,660	2,370	8,120	10,690

[1] Unhulled M. alba planted.

TABLE 5. YIELDS OF SWEETCLOVER VARIETIES AT VARIOUS LOCATIONS

Location	Madrid yellow		Common white		Evergreen	Common yellow		Hubam	Annual yellow
	First year	Second year	First year	Second year	First year	First year	Second year		
Iowa Park								3,000	
Denton[1]	3,160	3,100	2,980	2,940				2,420	
Chillicothe[2]	2,190	2,670	2,980	5,360		1,060	2,170		
Angleton	5,040				6,710			3,200[3]	1,280[3]
College Station, Brazos Valley Lab.	7,590[4]				6,340[4]			5,430[4]	
Raymondville	1,440				870			2,240	1,810
San Benito	3,040				1,260			4,070	1,910
Winter Haven								4,410	
Beaumont[4]			3,780					3,760	800
Temple			3,680[4]					4,170[4]	1,840[4]

[1] 5-year average. [2] 2-year average. [3] 8-year average. [4] 3-year average.

In area III, sweetclover is fall-planted. In the western part of the area, planting of sweetclover is hazardous. However, there is less evaporation from the soil during the fall and winter and more water is available for use by the plant. If good soil moisture is present when the seed germinate, a crop may be expected on the more productive soils. In the eastern half of area III, on calcareous soils, the annual sweetclovers will make abundant growth, provided phosphate is applied according to the needs of the soil. Acid soils require applications of lime for best results for all varieties except *M. indica.*

In area III, usually the biennial sweetclovers do not live through the summer. Hubam makes earlier and more rapid growth, but the biennials extend later into the summer. Drouth and diseases, or a combination of the two, usually kill most of the biennial plants by August. When planted in the early fall, many plants bloom in June but produce few seed.

Moisture is the limiting factor for sweetclover growth in the western part of the State, area IV. Sweetclover will grow in years when moisture is above average. In area IV, sweetclover should be planted in regular width rows to take advantage of all moisture. In general, sweetclover is not recommended for this area.

PLANTING SWEETCLOVER

Because of the small size, sweetclover seed should not be planted more than three-fourths of an inch deep. Best stands are obtained when the seed are planted one-fourth to one-half inch deep on a firm, clod-free seedbed. Seeding rates recommended are influenced by climate, row width, companion crop and use that is to be made of the clover. In regular width, 36 to 42-inch rows, plant 2 to 3 pounds per acre; in 14 to 16-inch rows, 4 to 5 pounds; overseeded on small grains, 8 to 10 pounds; and drilled alone 12 to 15 pounds.

Sweetclover often is interplanted with one of the small grains. In areas II-S and III, front cover, the sweetclovers may be seeded in the fall at the same time winter small grains are planted. Several methods have been used successfully. Where grain drills with small seed attachments are available, the down spout from the small seed box may be attached to the rear of the disk boot and the seed allowed to fall behind the disk and then covered with the chain drag. Figure 4 shows the equipment used in planting sweetclover in this manner and Figure 5 shows the stand obtained. In area II-N, sweetclover normally is seeded in February or March. However, the biennial sweet-

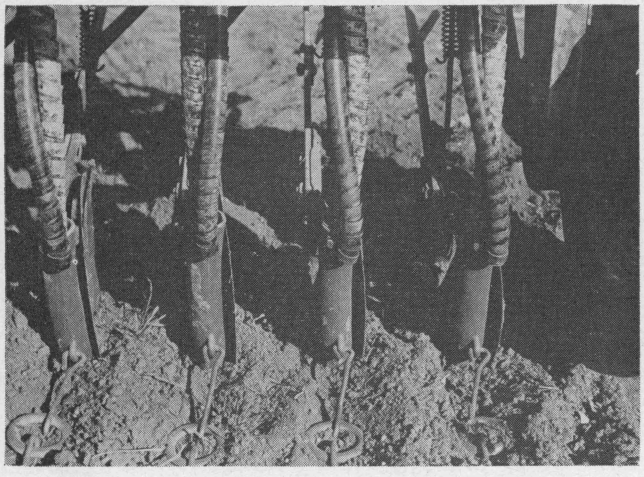

Figure 4. Rear view of drill used for planting small grain and sweetclover in one operation.

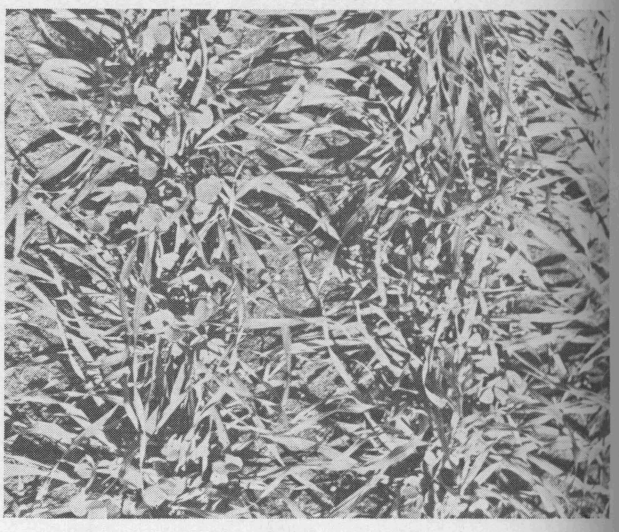

Figure 5. Fall-seeded oats and sweetclover planted above a band of phosphate fertilizer.

TABLE 6. INFLUENCE OF PHOSPHATE AND PHOSPHATE PLACEMENT ON GROWTH AND NITROGEN AND PHOSPHATE CONTENT OF EVERGREEN SWEETCLOVER TOPS AND ROOTS, TEMPLE

Phosphate treatment	Plant part	Dry-matter production[1]	Nitrogen		Phosphorus	
		Pounds per acre	%	Pounds per acre	%	Pounds per acre
None	Tops	1930	2.4	47.0	0.12	2.4
Broadcast[2]	Tops	3680	2.5	91.0	0.15	5.7
Banded[2]	Tops	4750	2.5	117.0	0.18	8.5
None	Roots[3]	1680	2.0	35.0	0.09	1.6
Broadcast[2]	Roots[3]	2030	2.1	43.0	0.15	3.2
Banded[2]	Roots[3]	2520	2.2	55.0	0.20	5.1

[1]Harvested 116 days after planting. [2]Sixty pounds of phosphoric acid per acre. [3]Root obtained from 0-18-inch depth.

clovers may be planted in late summer or early fall under irrigation. The yield of spring-seeded sweetclover in fall-seeded small grain often is low because of the competition offered by the small grain and the subsequent dry weather after small grains are harvested. If a good stand survives, growth may be expected during the fall and spring from the biennial types.

In planting sweetclover on calcareous soils, best results have been obtained when the phosphorus was placed in bands 2 inches below the seed. Table 6 shows that banding 60 pounds of phosphorus acid per acre produced 4,750 pounds of tops and 2,520 pounds of roots on a dry-matter basis per acre, whereas the broadcast application produced 3,680 pounds of tops and 2,030 pounds of roots per acre. The forage and tops from the banded application contained 172 pounds of nitrogen and 13.6 pounds of phosphorus in comparison with broadcast production of 134 pounds of nitrogen and 8.9 pounds of phosphorus (8).

In the 20 to 25-inch rainfall area, sweetclover should be planted in pure stands on a firm seedbed in regular width rows and cultivated to control weeds.

The use of sweetclover with small grains planted in the regular manner is limited to areas of more than 30 inches annual rainfall. When sweetclover is to be used with small grain in areas of 25 to 30 inches rainfall, the small grain should be planted in wider rows, 14 to 42 inches. Figure 6 shows Madrid sweetclover planted in regular width rows with oats in the fall at Beeville. The clover was still green in May, after the oats were matured. This mixture was grazed during the winter and spring.

It often is possible to obtain volunteer stands of the sweetclovers if they are allowed to produce a seed crop. In area III, stands of Hubam and annual yellow have been maintained for several years in a perennial grass stand such as Johnsongrass.

Sweetclover for Pasture

Sweetclover is a good pasture crop and with proper management will furnish abundant grazing for some time. Frequently cattle will not graze sweetclover well when it is grown with a small grain as long as the small grain furnishes abundant grazing; but as they become accustomed to the sweetclover they usually will make good use of it. Figure 7 shows cattle grazing Hubam clover. After they become accustomed to its characteristic bitter taste, they relish it.

Young sweetclover is high in moisture and protein. Mature cows utilize the early growth of sweetclover better than young stock. When grazing new growth of sweetclover, young stock frequently do not obtain enough dry matter to meet requirements for fast gains, but mature cows with greater stomach capacity do well. For proper utilization, sweetclover should be kept to a uniform height of 8 to 12 inches.

Longtime cattle-grazing studies at Temple show that oats and sweetclover will average 127 days of grazing with a variation from 80 days during dry years to 160 days in favorable years. Steers have gained from 1.3 to 2.1 pounds per day during the grazing season. Steer gains per acre have been 168 to 304 pounds, with an average acre gain of 218 pounds (16).

Table 7 shows the phosphoric acid, protein and lime content of sweetclover harvested in South Texas in the prebloom stage. The protein content is above 20 percent in all cases and the

Figure 6. Sweetclover planted in alternate rows with oats.

Figure 7. Cattle grazing sweetclover.

phosphorus content is high. In these tests, irrigation did not influence the quality of the forage but did influence the yield. The biennial sweetclovers were higher in protein than the annuals but were lower in total yield (17).

Good results have been obtained by seeding small grain and sweetclover in an established stand of Johnsongrass. A good practice is to graze this combination during the winter and spring, then remove the livestock to allow the Johnsongrass and annual sweetclover to mature. Such management also gives the first-year biennials a chance to build up root reserves. After the sweetclover and Johnsongrass mature, the pasture may be grazed as needed. Once a good seed crop has been produced, it will not be necessary to plant the sweetclover the following year. With first-year biennial sweetclover, a small grain may be seeded in the fall, Figure 8. If the ground is packed, it may be necessary to use a deep-furrow drill or special planting equipment for placing the small grain seed 2 inches in the soil. A regular seedbed for seeding small grains may be prepared for annual sweetclover in combination with small grain.

Sweetclover for Hay

Sweetclover makes good hay in areas where it can be cured properly, Figure 9. Annual sweetclover should be harvested when the first blooms appear. If cut too early, the moisture content is so high that the hay is difficult to cure. If cutting is delayed until full bloom, there may be a great loss of leaves and the hay will be coarse and stemmy.

First-year hay crops from spring-seeded biennial sweetclover should be harvested in late summer or early fall after the plants have built up root reserves. Biennial sweetclovers that are fall-planted may be harvested more than once. It is possible to graze until April 15 and get a hay crop in late June when weather conditions are more favorable for hay making. Second-year sweetclover should be cut in the early bloom stage. If a high stubble is left, it is possible to obtain two cuttings for hay or one cutting for hay and a seed crop.

Harvesting of sweetclover for hay should be done when conditions are favorable for curing. Improper curing may result in spoilage. Spoiled sweetclover hay contains a substance called dicoumarol which injures the fine capillaries and reduces the clotting power of the blood and the animals may bleed to death from slight wounds or internal hemorrhages. Hay containing dicoumarol does not always show signs of spoilage. By observing the animals being fed sweetclover hay, the bleeding disease usually can be detected and the animals taken off such hay in time to prevent losses. As a precautionary measure, it is best not to feed cows a full diet of sweetclover hay just before or a short time after calving or dehorning.

Sweetclover for Silage

Sweetclover for silage is equivalent to other legumes when the crop is harvested at the proper stage of growth. Spring growth of sweetclover may be used more economically as silage than as hay because of the difficulty of curing hay in the

TABLE 7. POUNDS OF HAY AND PROTEIN PRODUCED PER ACRE, AND THE AVERAGE PERCENT LIME, PHOSPHORIC ACID AND PROTEIN IN SWEETCLOVER FORAGE AT TWO LOCATIONS, WITH IRRIGATION

Variety	Location	Hay yield, pounds	% lime	% phosphoric acid	% protein	Pounds protein
Hubam	Raymondville	6030	2.36	.70	21.62	1300
	San Benito	4900	2.44	.69	21.21	1040
Annual yellow	Raymondville	2160	1.88	.69	21.40	460
	San Benito	2110	2.30	.63	21.56	450
Madrid	Raymondville	4640	2.63	.70	24.20	1120
	San Benito	3870	2.94	.69	23.17	900
Evergreen	Raymondville	3140	3.17	.74	24.72	780
	San Benito	2210	3.00	.76	24.46	540

spring. Since prebloom sweetclover has a high moisture content, the crop should be allowed to *wilt slightly* before ensiling. When sweetclover alone is to be used for silage, 80 to 100 pounds of molasses or 150 to 200 pounds of ground corn should be added for each ton of green material. If oats or barley are growing with the sweetclover, the mixture should be cut when the grain is in the dough stage and no preservative will be necessary; in most cases this mixture need not be wilted. Because of the possibility of dicoumarol being formed, it is especially important that sweetclover be firmly packed as it goes in the silo. The same precautions should be observed in feeding sweetclover silage as in feeding hay.

Sweetclover in the Cropping System

Sweetclovers are excellent soil-improving crops. By their proper use, a farmer can go a long way toward maintaining the productivity of his soil. There are many ways that sweetclover may be fitted into a cropping system. Sweetclover may be made to pay its way by using it for grazing, hay, silage or seed. Best results for soil improvement may be obtained by returning most of the residue to the soil. Maximum benefits may be obtained from sweetclover by harvesting a seed crop and returning all the residue to the soil.

In an experiment at Temple, Table 6, Evergreen sweetclover harvested 116 days after seeding contained 117 pounds of nitrogen in the tops and 55 pounds in the roots, or a total of 172 pounds of nitrogen per acre. The nitrogen content of sweetclover tops on a dry-matter basis just prior to blooming is 2.5 to 3.0 percent (8). The roots of sweetclover contain about 2 percent nitrogen. A yield of 3 tons of tops and roots is common where sweetclover is adapted. With the exception of annual yellow, sweetclover has a deep root system and will improve the physical condition of soils. It improves the friability of the soil and makes it easier to work. Good root penetration permits a greater and faster absorption of water and roots also improve aeration and drainage. Sweetclovers provide a protective cover for the land against runoff and reduce soil losses.

The effects of growing sweetclover in rotation with other crops have been determined by the Texas Station at several locations. On alluvial Brazos Valley soil, corn following 1 year of Madrid sweetclover produced an average yield of 72 bushels. At the same time, corn following corn produced only 35 bushels (15). In this test, all of the sweetclover residue was returned to the soil, Figure 10. At the Denton station, continuous corn produced an average of 35 bushels per acre, while corn following Hubam clover for seed produced 41 bushels, Figure 11. At Denton, in 1951, sweetclover produced adequate nitrogen for corn following it on the same land. Yields from corn receiving 60 pounds of nitrogen were 30 bushels, as compared with 29 bushels for corn following sweetclover (13). A comparison of the yield and quality of continuous corn with corn following Madrid clover is given in Figure 12. The yield of continuous cotton compared with cotton following sweetclover at two locations is shown in Figure 13. The use of sweetclover in the rotation materially increased cotton yields (2). Sweetclover also can be grown for a cash crop. Hubam grown for seed in the rotation at Temple averaged 352 pounds of seed per acre (6). The rotation where the Hubam was used for hay and green manure averaged 3,240 pounds of hay per acre.

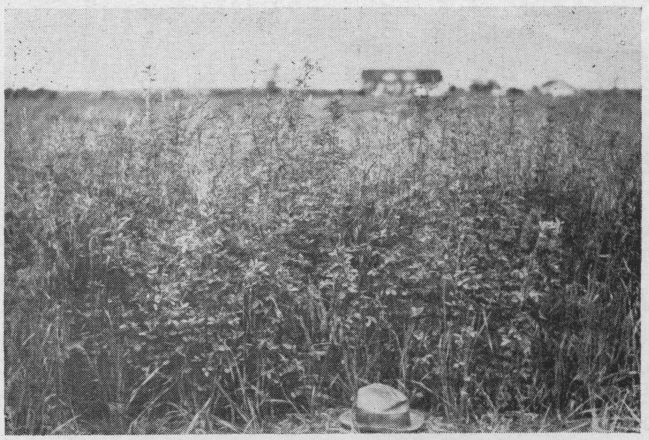

Figure 8. Oats in second-year Madrid sweetclover.

Studies were conducted at the Temple station on the control of cotton root rot by the use of sweetclover, Figure 14. In summarizing this work the authors state: "Delay and marked reduction in cotton root rot and the highest yield of cotton were found in the plots in which Hubam had been grown to maturity the previous year." Hubam clover usually matures in the early summer before cotton root rot becomes severe, therefore, the benefits from a soil-improving standpoint have already been obtained (11).

Sweetclover may be seeded with small grains. If the sweetclover makes enough growth to interfere with combining of the small grain, it is

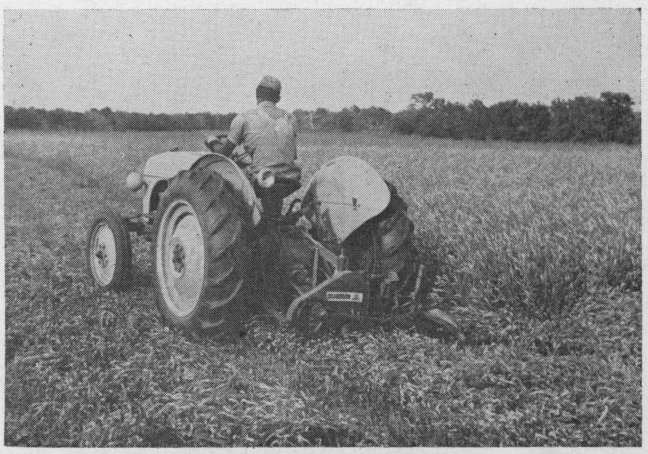

Figure 9. Cutting Hubam clover for hay.

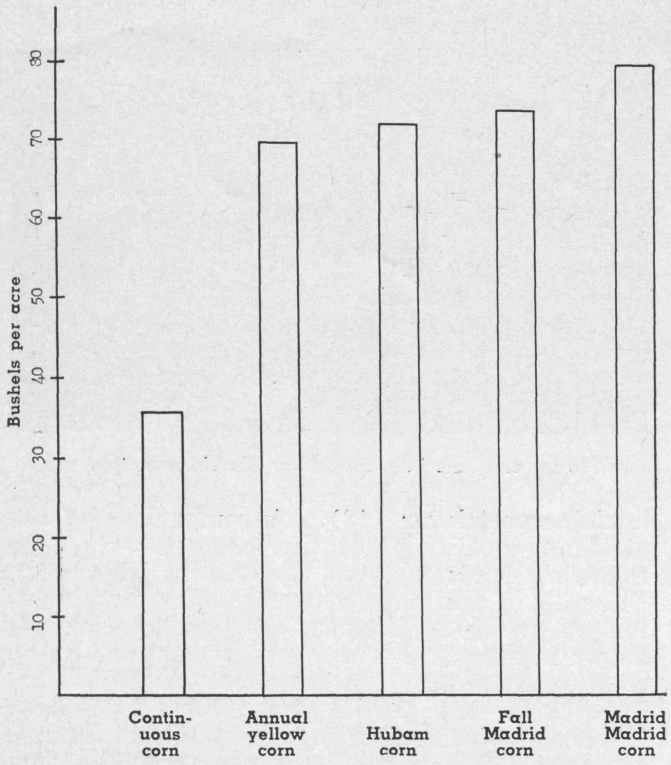

Figure 10. Influence of sweetclover on subsequent yields of corn at the Brazos River Valley Laboratory near College Station.

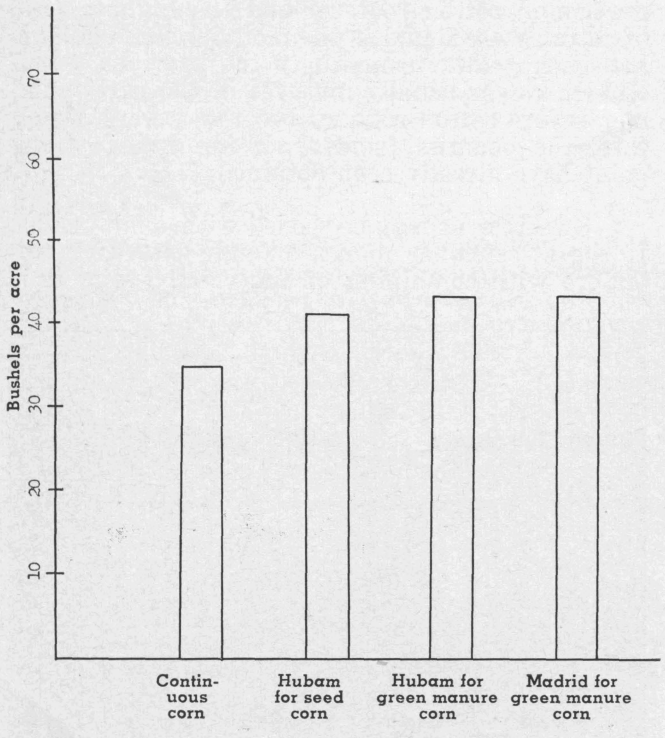

Figure 11. A comparison of continuous corn with corn following 1 year of sweetclover at Denton. Average of 2 years, 1950-51.

necessary to cut and windrow the crop to allow the sweetclover and small grain to dry before combining. After the small grains have been harvested, the second growth of sweetclover may be used for grazing, hay or seed. Biennial sweetclover will not produce seed the first year and only hay or grazing may be obtained.

Using sweetclover as a mixture with small grains in the cropping system offers the best possible means of soil maintenance on a short-term basis. Subsurface tillage should be used on the small grain-sweetclover stubble in preparing a seedbed for cotton or corn to follow. As soon as the Hubam has completed growth in the summer, if cotton is to follow, the land should be tilled and kept free of weeds that might harbor the root-rot organism. If the biennial sweetclovers are to be used as annuals in the rotation ahead of cotton, the land should be tilled in late July or early August. If corn is to follow, the biennial clovers may be allowed to grow until the regular time for seedbed preparation for corn.

SEED PRODUCTION

Sweetclover seed production in Texas for 1950-53 averaged 11,060,000 pounds annually. Most of it was produced in the Blackland and Grand Prairie regions. Harvested yields averaged 150 to 300 pounds of seed per acre.

Only about 60 percent of the sweetclover seed produced by the plant is harvested. Weather hazards, which cause shattering, and improper harvesting methods account for most of the loss. Seed production often is the by-product of a grazing program. Livestock sometimes are allowed to remain on the sweetclover too long in the spring and they graze the clover too closely for highest seed production. Proper grazing management will aid in obtaining a better harvest. Sweetclover sometimes grows too rank for most efficient harvesting if the plants are not grazed or clipped.

The highest yields of seed are obtained when the sweetclover is planted on good soil that has

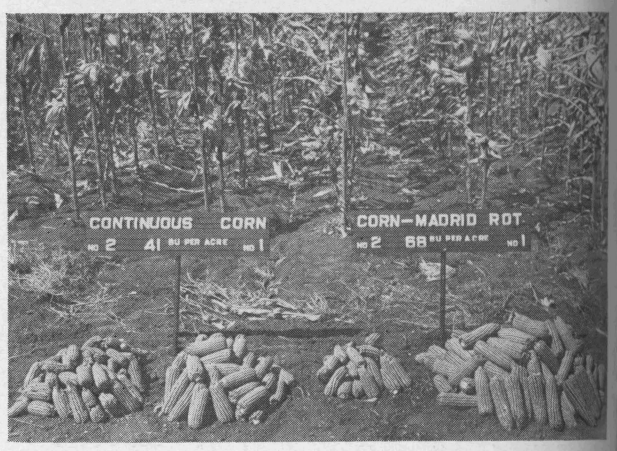

Figure 12. A comparison of the yield and quality of continuous corn with that of corn following Madrid clover at the Temple station.

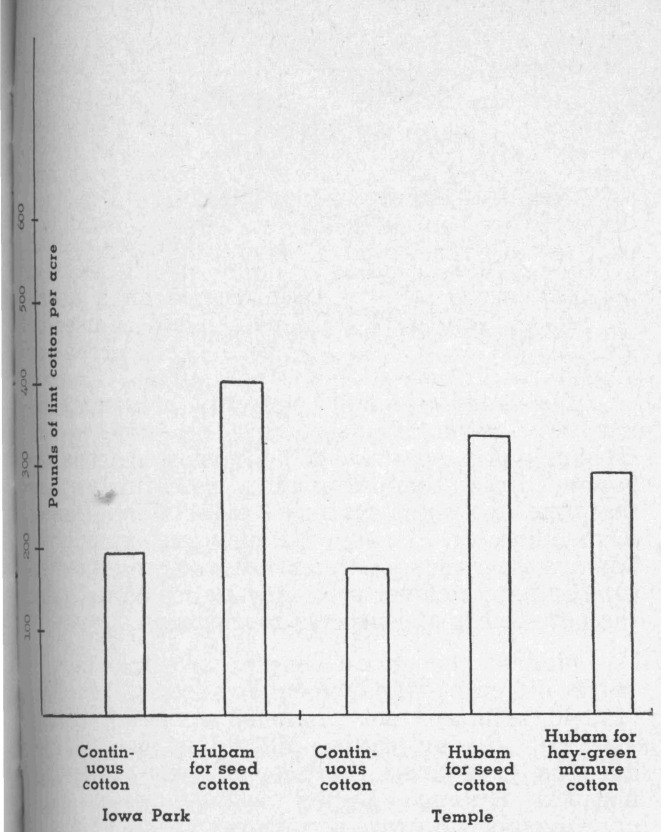

Figure 13. A comparison of the yield of continuous cotton with cotton following 1 year of Hubam clover.

been properly fertilized. In areas of above 30 inches rainfall, sweetclover for seed usually is planted broadcast or close drilled. In lower rainfall areas, it should be planted in regular width rows for best seed production. When seeding broadcast or with a drill, plant 12 to 15 pounds per acre; in regular width rows, plant 2 to 3 pounds per acre.

Hubam is the most important sweetclover for seed production in Texas. In areas III and II-S, it usually is seeded between October 1 and November 15, and in area II-N, in February or March. A smooth, firm seedbed is needed and the seed should not be covered more than one-half inch deep. Hubam should be inoculated at the time of planting. For best results, it usually is necessary to apply fertilizer. The soil should be tested to determine the kind and amount of fertilizer to use. Where phosphorus alone is applied, banding 2 inches below the seed gives best results. When Hubam makes good growth it should be clipped or grazed in the winter to remove the excessive vegetative growth. The clover should not be grazed or clipped lower than 6 inches. For maximum seed yields, cattle should be removed and plants not clipped for at least 70 days before the normal time Hubam matures.

Recent experiments show the necessity of pollinating insects for good seed production. Where all bees were excluded, seed yields were only 16 pounds per acre, but when the area was left open to natural pollinating insects, seed yields were 130 pounds. When the bees were caged in, the yield was 157 pounds per acre. Sweetclover flowers wilt soon after pollination. A field of sweetclover in bloom that has flower stalks with many fresh open blossoms indicates an inadequate number of pollinating insects present (18).

Harvesting of Hubam seed begins during June in South Texas and continues through August in North Texas.

The two general methods of harvesting Hubam clover in Texas are windrowing before threshing and combining the standing crop. In the windrowing operation, the plants are cut when about two-thirds of the seed have turned brown. Figure 15 shows Hubam being cut and windrowed with a converted grain binder. The operations necessary to change a grain binder to permit windrowing are relatively simple. The binder attachment and the bundle carrier should be removed and the binder deck covered with smooth sheet iron. A factory-made platform

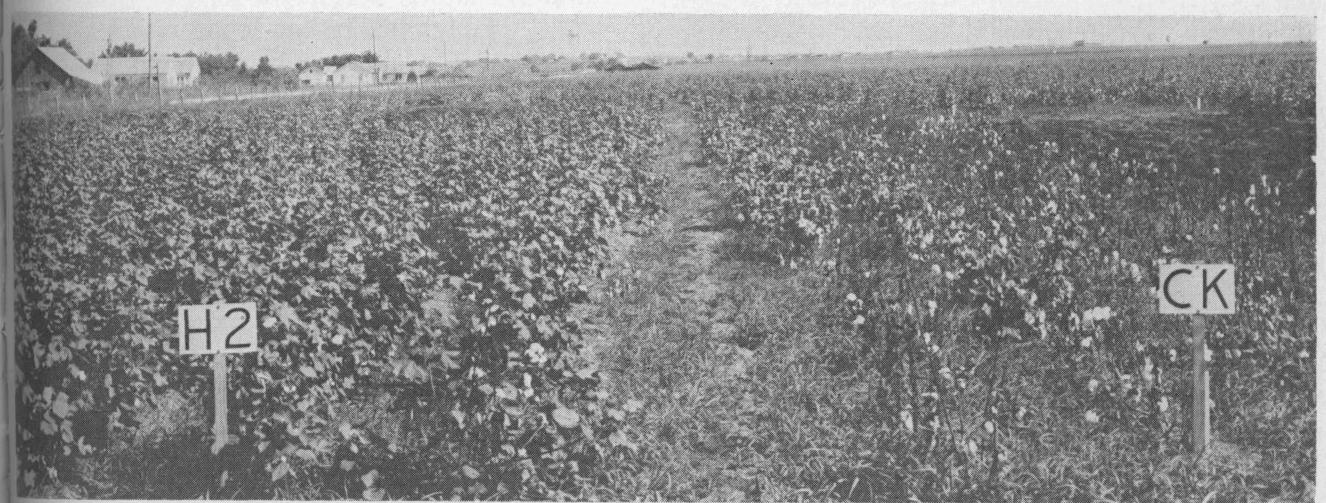

Figure 14. Influence of Hubam clover is a 2-year rotation on cotton root rot. Right, continuous cotton. Left, cotton following Hubam.

Figure 15. Windrowing Hubam clover with a converted grain binder.

swather also may be used for windrowing. Other methods of windrowing may be used but there is greater loss from shattering. The clover should be cut 12 to 18 inches high. In thick stands, the stubble holds the cut material off the ground and allows more rapid drying.

When possible, windrowing should be done early in the morning or at night when the stems are tough and there is enough moisture present to prevent shattering. The width of the swath should not exceed the width of the combine by more than 2 feet. It usually takes 4 or 5 sunny days to dry the clover for best combining. Figure 16 shows Hubam clover being combined that was windrowed with a converted grain binder.

Combining the standing plants is the second method used. To eliminate as many green stems and seed as possible, most of the pods and seed should be dead ripe, therefore, there always is a loss from shattering. Seed combined from the windrow may be sacked and stored but seed harvested from standing plants contain green pods and stems and should be dried before storing.

Figure 16. Combining seed from a windrow of sweetclover.

Standard grain-drying equipment may be used provided the temperatures are held below 130° F. The seed also may be spread 4 to 6 inches deep on wooden floors and stirred at 3 or 4-hour intervals until dry.

Chemical drying through defoliants reduces the moisture content of the standing sweetclover. Satisfactory results have been obtained from the use of several drying materials. One pint of dinitro in 10 gallons of diesel fuel can be used when approximately half the seed pods are brown. Combining normally should follow within 3 days (20).

The production and harvesting of annual yellow sweetclover is essentially the same as for Hubam. This species can be harvested with less loss by direct combining than can Hubam. By the time the plant matures, most of the leaves have fallen off. In area III, oats and annual yellow sweetclover sometimes are grown as a mixture and sweetclover seed may be separated from the oat seed in the process of cleaning the oats.

Madrid, being a biennial sweetclover, requires different management for seed production. Madrid seed are not produced commercially in area III. Spring-planted Madrid in area II produces a seed crop the second year somewhat ahead of Hubam. Under most conditions, it is not advisable to graze second-year Madrid in the early spring if maximum seed yields are desired.

Evergreen, a white-flowered biennial sweetclover, is well adapted to Texas growing conditions but has low seed yields. This variety produces flowers over a long period of time and at no one time is there a heavy seed set. Clipping or grazing the plants in the spring forces a uniform growth, which sets seed more uniformly. Under Texas conditions, however, yields of more than 100 pounds of seed per acre are seldom obtained.

The same procedures discussed for harvesting Hubam should be followed with biennials. Acceptable yields of sweetclovers have been obtained when seeded with small grains.

DISEASES OF SWEETCLOVER

Sweetclover may become infected with one or more severe diseases such as seedling damping-off, anthracnose, cotton root rot, charcoal rot, spring blackstem, summer blackstem and leaf spots.

This group of diseases is difficult to control. The cost of protective fungicidal sprays, dusts and fumigants is too great to permit their general use, therefore, control must be accomplished by seed treatment, crop sanitation, rotation and the development of disease-resistant or disease-escaping varieties.

Southern Anthracnose

Anthracnose, *Colletotrichum trifolii*, frequently is severe on clovers, alfalfa and lespedeza. Light to dark-brown, elongated, sunken spots with scattered, short, dark-brown bristles of the

fungus occur on the crown and lower stems. Killing and browning of the foliage results when the spots completely encircle the stem.

Cotton Root Rot

Sweetclover, used as a green manure crop, effectively controls cotton root rot, *Phymatotrichum omnivorum*. However, it will be infected and killed when the crop is grown during the summer in root-rot-infected areas. The presence of the disease is shown by the development of dead spots in the field. In local areas, the plants wilt and turn brown with the dead leaves remaining attached to the plant. Symptoms of root rot are evident below the soil surface. Brownish-yellow, ropy-like strands of the fungus appear on the surface of the rotted roots and, upon cutting a cross section of the root, brown streaks through the inner portion of the root and crown can be seen. Rotation with corn, oats or some other grass crop, or plowing under of large green manure crops are the only economical means of control.

Charcoal Rot

This disease, *Botryodiplodia phaseoli*, is difficult to control because of the wide variety of crops it will attack. It occurs as a rot on the roots and lower stems of legumes and grass crops. Numerous small black bodies of the fungus develop in and on the rotted tissues of the clover. The disease is most severe during hot, dry seasons. The main economical control is by irrigation.

Spring Blackstem

This disease, *Ascochyta caulicola*, causes crooked and distorted stems. The blighted areas on the stem are not black but tan or brownish gray. The common name of the disease is derived from the symptoms which occur on alfalfa where the stem is blackened. Black spore-carrying bodies of the fungus develop over the blighted areas. Under severe conditions the entire plant may die.

Summer Blackstem

Summer blackstem, *Cercospora zebrina*, frequently occurs with the spring blackstem during early summer and becomes severe during midsummer, resulting in extensive killing. The spots may be scattered or the entire stem may be affected. The reddish-brown, sunken spots later turn ashy-gray from the abundant development of spores of the organism. The blackstem organisms are seed-borne and live overwinter on old stems.

Leaf Spot

Leaf spot, *Stagonospora meliloti*, generally is of minor importance, appearing in significant proportions only in early spring and late fall. Damage results from the dropping of the infected leaves. The leaf spot is circular to angular, pale buff with light brown margins and with numerous spore-carrying bodies of the fungus in the central portion of the lesion.

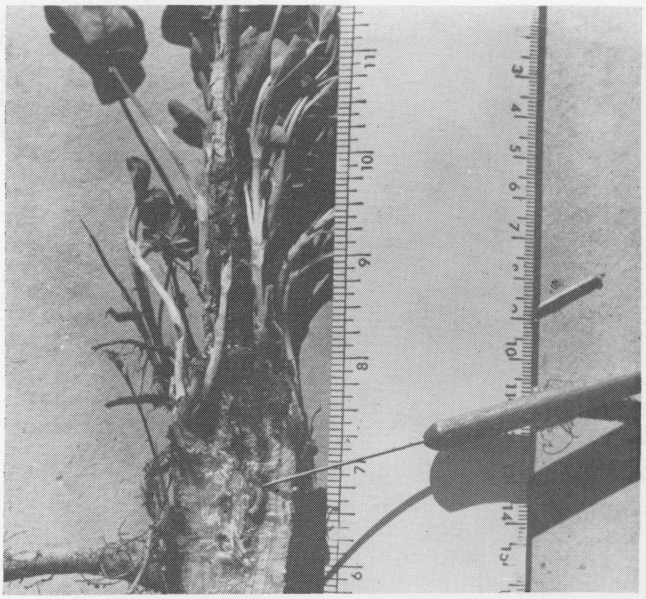

Figure 17. A biennial sweetclover plant showing the "sweetclover root borer."

INSECTS

A new insect pest was discovered in 1950 on biennial sweetclover near Denton. The insect is commonly known as the "sweetclover root borer," *Walshia amorphellia*. The infested plants wilt and die during the late summer or early fall of their first year of growth. Above-ground symptoms are similar to those caused by cotton root rot. The roots of infested plants show numerous grooves and burrows and a small white worm may be found, Figure 17. This insect has not been found on annual sweetclovers such as Hubam. Because of its early maturity, Hubam probably escapes damage. No control measures are known (12).

Tarnish plant bug, a member of the lygus group, often is a serious pest on sweetclover used for seed. This insect sucks the plant sap and often concentrates on the buds and flower parts, causing them to wilt and die. It also will feed on the young pods, causing the seed to shrivel and turn brown. The use of 25 pounds of 10 percent DDT dust or sufficient emulsion spray to give 1½ pounds of DDT per acre gives effective control. A single application as the plants begin to bud often gives adequate protection. Forage treated with DDT should not be used as a feed for dairy animals, animals being finished for slaughter, or for poultry.

Several other insects that may damage sweetclover are webworms, cutworms, stink bugs, green clover worms and grasshoppers.

LITERATURE CITED

1. Binford, E. E. Progress report, Substation No. 1, Beeville, Texas, 1910-1914 Tex. Agr. Exp. Sta. Bull. 214, 1917.
2. Brooks, L. E. Hubam clover as a cash and soil-improving crop for the Wichita Valley. Tex. Agr. Exp. Sta. P. R. 1069, April 1947.
3. Connell, J. H. and Clayton, James. Field experiments at McKinney substation and Wichita Falls substation with wheat, corn, cotton, grasses and manures; field experiments at College Station with corn, cotton, grasses, pea and manures. Tex. Agr. Exp. Sta. Bull. 34, 1895.
4. Cory, V. L. Progress report Texas substation No. 6, Denton, Texas. Tex. Agr. Exp. Sta. Bull. 199, 1916.
5. Forage Crops. Tex. Agr. Exp. Sta. Bull. 59, 1901.
6. Hill H. O., et.al. Hubam clover in rotations causes higher yields and less root rot. Tex. Agr. Exp. Sta. P. R. 868, December 1943.
7. Jackson, J. W. Progress report. Substation No. 9, Pecos, Texas, 1910-14. Tex. Agr. Exp. Sta. Bull. 221, 1917.
8. Johnston, J. R. Research sets patterns for the central Blacklands. Tex. Agr. Exp. Sta. Misc. Pub. 65, 1951.
9. Karper, R. E. Progress report, Substation No. 8, Lubbock, Texas. Tex. Agr. Exp. Sta. Bull. 219, 1917.
10. Laude, B. S. Progress report, Substation No. 4, Beaumont, Texas. Tex. Agr. Exp. Sta. Bull. 200, 1916.
11. Lyle, E. W., et. al. Control of cotton root rot by sweetclover in rotation. Tex. Agr. Exp. Sta. Bull. 699, July 1948.
12. Norris, M. J. New insect pest attacks biennial sweetclover in North-Central Texas. What's new in crops and soils. Vol. 4, No. 4, January 1952.
13. Norris M. J., et.al. Effect of legume management and nitrogen on corn yields at Denton. Tex. Agr. Exp. Sta. P. R. 1439. February 1952.
14. Pittuck, B. C. Grasses and forage plants. Tex. Agr. Exp. Sta. Bull. 46, 1898.
15. Rea, H. E., et.al. Effect of legumes, nitrogen and row systems on the yield of corn on Miller clay soil. Tex. Agr. Exp. Sta. P. R. 1440, February 1952.
16. Tippit, O. S. and Jones, J. H. Soil conservation management system for best production in the Blacklands of Texas. Tex. Agr. Exp. Sta. M. P. 90, March 1953.
17. Trew, E. M. Yield and adaptation of certain forage species in the Lower Rio Grande Valley. Tex. Agr. Exp. Sta. P. R. 1269, September 1950.
18. Weaver, Nevin, et.al. Pollination of Hubam clover by honey bees. Tex. Agr. Exp. Sta. P. R. 1559, March 1953.
19. Winters, N. E. Experiments at Substation No. 3, Angleton, Texas, 1909-16. Tex. Agr. Exp. Sta. Bull. 229, 1918.
20. Dow Chemical Co., Down to earth, Vol. 1, No. 1, Summer 1954.