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KANSAS STATE COLLEGE OF AGRICULTURE
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MANHATTAN, KS

ALFALFA IN KANSAS

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MANHATTAN, KS

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ALFALFA IN KANSAS

C. O. GRANDFIELD AND R. I. THROCKMORTON[2]

ALFALFA INVESTIGATIONS

Alfalfa investigations have been conducted in Kansas since 1875 (18)[3], twelve years before the experiment station was established. The early experiments were devoted largely to obtaining information to be used in convincing the people of Kansas that alfalfa is a good crop. Its value is no longer questioned, but in the early years of its introduction there was a difference of opinion as to its value as indicated by Mohler (13) who quoted opinions of farmers given to him as late as 1887. A correspondent wrote: "It is a plant having many warm friends and also a squad of bitter enemies. I have read much in favor of it and much condemning it in severest terms." A pioneer from Geary county wrote: "My neighbor along in the early Seventies tried alfalfa—when it had grown to a height of 16 inches, an armful was cut for the horses but they didn't even taste it. The grower concluded therefore, that it was a noxious weed."

Alfalfa was first mentioned in the State Board of Agriculture Report in 1877. In 1882 Professor E. M. Shelton of the Kansas State College advocated the sowing of alfalfa and gave directions for seeding.

Investigations have continued throughout the years on many phases of alfalfa production. Since alfalfa became definitely established in the agriculture of Kansas, the experimental work has been diverted from management problems to problems of breeding new varieties for agronomic perfection and resistance to diseases and insects.

IMPORTANCE OF ALFALFA

The importance of alfalfa in Kansas agriculture cannot be overestimated. It has played the role of balancing crop production in two ways; by building soil fertility and by furnishing a high quality feed for livestock. The annual production of alfalfa fluctuates less than does that of most grain crops. Alfalfa is the best of all commonly grown hay crops because it is high in protein and minerals, and is an excellent source of vitamin A. The average feed returns per acre from alfalfa hay as compared to a few other crops are shown in Table 1.

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1. These studies have been made cooperatively by the Kansas Agricultural Experiment Station and the Division of Forage Crops and Diseases, Bureau of Plant Industry, Soils and Agricultural Engineering, Agricultural Research Administration, United States Department of Agriculture, since 1927. Contribution No. 368, Department of Agronomy

2. Associate Agronomist, Division of Forage Crops and Diseases, Bureau of Plant Industry, Soils and Agricultural Engineering, Agricultural Research Administration, United States Department of Agriculture, and Agronomist in Charge, Kansas Agricultural Experiment Station.

3. Numbers in parentheses are references to complete citations on pages 63 and 64.

Table 1.—*Average returns per acre from alfalfa hay and other crop.**

	Yields per acre.	Dry matter.	Digestible proteins.	Total digestible nutrients.
	Tons	*Pounds*	*Pounds*	*Pounds*
Alfalfa hay	2.04	3,688	432	2,052
Clover hay	1.48	2,601	207	1,536
Timothy or timothy-clover hay	1.23	2,173	90	1,167
Corn for silage	7.28	3,888	100	2,533

*From "Feeds and Feeding" 20th edition, by Morrison.

It is not uncommon to obtain yields of alfalfa hay that are larger than the average figures quoted and, when we consider the fact that alfalfa is high in minerals and carotene, its comparison to other

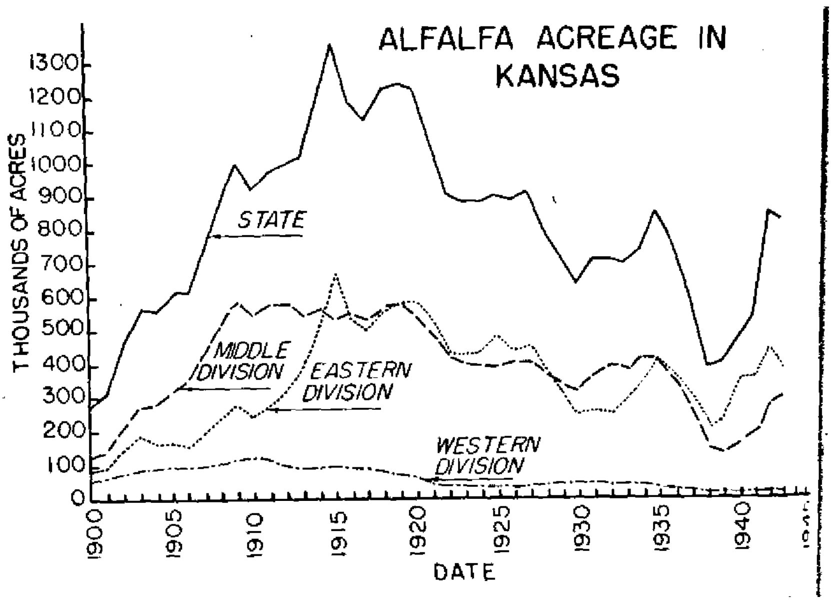


Fig. 1.—Alfalfa acreage in Kansas since 1900. The eastern division is that area east of the west line of Marshall county extending south across the state along the west line of Butler and Cowley counties. The middle division west of this line to a north and south line along the west side of Phillips and Comanche counties. The western is the area west of this line to the Colorado line.

roughage feed is highly favorable. Alfalfa hay contains an average of 14.7 percent protein as compared to sorghum fodder with 6.4 and corn fodder with 5.9 percent. This makes alfalfa hay a desirable supplement to other carbonaceous forage and grain.

It has been said, "Nowhere are conditions more favorable to the production of alfalfa than in Kansas." As a result of experimental work and farm experiences, this is no longer considered true. Other areas have found adapted varieties and developed successful production practices which have shifted the larger acreages of alfalfa from Kansas and Nebraska to the northern, north-central states. The littlest available figures show that Kansas ranks eleventh in total acreage of alfalfa and ninth in total hay production.

A number of factors have contributed to the fact that there is less alfalfa in Kansas now than 30 years ago. The trend of alfalfa acreage in Kansas since 1900 is shown in Figure 1. Economic changes always cause more or less fluctuation in the acreage of crops. Much has been accomplished in research on adapted varieties, control of insects and diseases, soil treatments, and the developing of new varieties, all of which tend to stabilize the acreage. Not until in the 1920's was much thought given to the problem of maintaining stands of alfalfa when it was brought to the attention of the public by Call (2).

ALFALFA IN THE ROTATION

Figure 1 shows that the alfalfa acreage is now shifting from central to eastern Kansas, with more than half of the total acres being grown in the eastern third of the state. This is, in part, due to the fact that crop rotations using alfalfa are a general practice in balancing agriculture in that part of the state.

Alfalfa in the rotation has a marked effect on the fertility of the soil, influencing the yields of the crops that follow. Experiments conducted by this station demonstrate the value of alfalfa in the rotation with grain crops in comparison to other rotations. The data in Table 2 show the rotation containing alfalfa to be superior to the others in its effect on the yields of corn and wheat.

TABLE 2. Effect of mopping systems on yields.

Cropping Systems.	Yield in bushels per acre. Average, 1911 to 1944.	
	Corn.	Wheat.
Alfalfa 4 years; corn, wheat, wheat, for 12 years	27.7	19.1
Corn, soybeans, wheat	25.0	16.8
Corn, corn, wheat	20.1	14.4
Continuous cropping	16.1*	14.7

* 1911-1940.

Grain crops are heavy users of soil fertility, and alfalfa in the rotation will replenish the soil with nitrates and organic matter for increased yields. It must be recognized, however, that alfalfa is a heavy user of the soil's calcium, phosphorus and potassium. The yield of crops immediately following alfalfa may be decreased the first year in seasons of low rainfall, but this should not discourage the use of alfalfa in the rotation, as over long periods the gains more than offset the losses. The successful farmer operates on a long-time basis and will use alfalfa because of the superior value of the crop itself as well as its influence on the productivity of other crops grown in the rotation.

EFFECT OF ALFALFA ON SUBSOIL MOISTURE

It is a well known fact that alfalfa is a deep rooted crop. Instances have been reported of alfalfa roots penetrating the soil to a depth of 35 to 40 feet. On the agronomy farm at this station, on upland soil, roots were traced to a depth of 25 feet.

Experiments by Grandfield and Metzger (6) have shown that alfalfa will deplete the subsoil moisture to a depth of 23 feet within two years after seeding. Also, that after all reserve subsoil moisture has been removed by alfalfa, it takes approximately two years of fallow under conditions at Manhattan to restore that moisture. Other experiments have shown that following alfalfa with other crops will permit the restoration of only a part of the subsoil moisture over a period of years. This, however, should not interfere with the satisfactory production of shallow rooted crops such as the cereals. It is evident from these experiments that after alfalfa has been on the ground for two years or more the yield of the hay crop will depend on current rainfall. This is illustrated by data of Tysda1 and Kiesselbach (20) in Table 3. The average yield for the first three years was more than three tons higher than the average yields for the last five years. The difference in the amount of precipitation during the two periods was little over an inch.

CROPS TO FOLLOW ALFALFA

The crops most likely to succeed immediately following alfalfa are the forage sorghums. This type of crop, if used for ensilage, will make very heavy yields if abundant moisture is available, and satisfactory yields under limited moisture. If burning or firing occurs, the crop can be harvested immediately with good results. In regions of abundant rainfall, corn is a good crop to use. Small grains may be grown after alfalfa on most soils. When wheat follows alfalfa, the stand should be broken about the first of August to permit time to store moisture previous to seeding wheat. The stiff-strawed varieties of oats, as Osage and Neosho, and flax, may be grown successfully after alfalfa. When these crops follow alfalfa, the stand should be broken in the fall, and a firm seedbed should be formed previous to seeding. Usually after the first year, any adapted crop can be grown successfully.

TABLE 3.—* *Comparative yields in tons, of alfalfa varieties before (1923-1925) and after (1926-1930) deep subsoil moisture depletion.*†

VARIETY.	Yield of hay per acre, 15 percent moisture, weed-free basis.								Average yields.		
	1923	1924	1925	1926	1927	1928	1929	1930	First 3 years.	Last 5 years.	8-year average.
Cossack	4.83	7.77	5.64	2.11	2.98	2.52	3.03	2.52	6.08	2.63	3.93
Baltic	4.76	7.49	5.51	2.10	3.02	2.80	2.84	2.57	5.92	2.67	3.89
Hardistan	5.04	6.98	5.09	1.81	2.44	2.46	2.77	2.59	5.70	2.41	3.65
Kaw	4.71	6.67	4.83	1.87	1.49	2.33	2.50	2.33	5.40	2.10	3.34
Turkistan	4.24	6.41	4.35	1.93	2.34	2.50	2.76	2.15	5.00	2.33	3.34
Averages	4.72	7.06	5.08	1.96	2.45	2.52	2.78	2.43	5.62	2.43	3.63
Precipitation (inches)	28.95	21.91	25.09	26.24	21.41	27.83	23.51	20.74	25.32	23.95	24.46

* Taken from Nebraska Agricultural Experiment Station, Bul. 331, 1941.
† Favorable stands persisted throughout the period of these tests.

ALFALFA PRODUCTION

CROPS TO PRECEDE ALFALFA

In the eastern half of Kansas where fallow is not necessary, it is a good practice to precede alfalfa with a small grain crop, preferably oats as less trouble will be encountered from volunteer. The oats will be harvested early enough to allow an early start on the preparation of the seedbed, thus permitting time to kill weeds and volunteer throughout the summer by cultivation. Wheat may precede alfalfa successfully if the volunteer can be destroyed previous to seeding. In central and western Kansas where summer fallow may be necessary to store soil moisture as well as kill weeds, any adapted crop may precede the fallow period. Generally, a winter and one summer of fallow is sufficient to store soi1 moisture for a successful seeding.

PREPARING THE SEEDBED

A good seedbed for alfalfa is one with a compact, finely pulverized and mellow soil to the depth of seeding. (Fig. 2.) This condition can best be obtained by starting the seedbed preparation

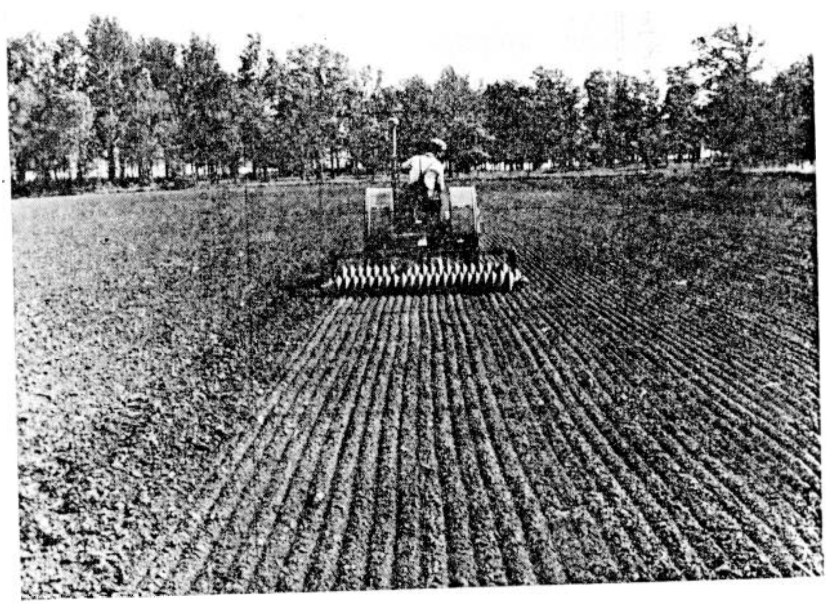


FIG. 2.-A good seedbed is important in establishing a uniform stand of alfalfa. Seed with a drill and pack before and after seeding.

early. If following a small grain crop, plow as soon after harvest as possible, and if following a fall crop with an intervening fallow, the plowing should be done shortly after weed growth has started in the spring. In both instances, further operations in the seedbed preparation will depend on weather conditions. In either case, the ground should be handled so as to be kept free of weeds, store and conserve moisture, liberate plant food materials, and prevent soil erosion by wind and water.

Shallow plowing is preferable to deep plowing, as a firm seedbed is more easily obtained. The ground should be worked to kill weeds, volunteer grain, and to settle the seedbed. Other methods of seedbed preparation are sometimes used, particularly where soil moisture is not a factor, such as disking wheat, oats, or barley stubble immediately following harvest, with additional cultivations to kill weeds and volunteer grain. These practices are not generally recommended. The successful operator will have a crop rotation plan that calls for the more thorough method, involving less risk.

Methods used for obtaining the desirable seedbed will vary in different sections of the state because of weather and soil differences, but if the objectives are kept in mind during the two or more months of preparation, the failures in obtaining a stand of alfalfa will be few.

SOIL TREATMENT

Before seeding alfalfa it is important to know what the soil needs. Alfalfa can be grown successfully where the soil is well supplied with the essential plant food elements, lime, phosphorus and potassium. Kansas soils are generally well supplied with potassium, but lime and phosphorus are lacking in the eastern third of Kansas and may frequently be profitably used in the central third of the state.

Lime. **—**Soil requirements for lime will vary and it is advisable to make a lime requirement test if there is any doubt. The application of three to four tons of ground limestone per acre is not uncommon in eastern Kansas, while less than one ton is seldom used. Agricultural limestone with a purity of 90 to 95 percent calcium carbonate that is ground fine enough for 100 percent to pass through a 10-mesh sieve and 40 percent through a 100-mesh sieve is satisfactory and should be applied to the land shortly after plowing. When coarsely ground limestone is used, the rate of application must be materially increased. Other forms of lime are sometimes available, such as caustic lime, hydrated lime, and air-slacked lime, but these are not generally used because of the greater expense involved.

The necessity of using lime on acid soils is well illustrated in Table 4. In these experiments the use of lime alone more than doubled the average yield for the 37 crop years, and when superphosphate was added to the lime the yield was nearly three times greater.

TABLE 4.—*Effect of fertilizer on alfalfa hay yields on Southeast Kansas Experiment Fields.*

	Average Yield, air-dry hay, tons per acre.			
	Thayer, 4-year average.	Moran, 17-year average.	Columbus, 16-year average.	Weighted average 37 crop yrs.
No treatment	1.27	.90	.58	.80
Lime	1.13	1.56	1.95	1.68
Manure	1.57	1.65	....	1.63*
Lime and superphosphate	2.29	2.44	2.31	2.37
Lime, manure and superphosphate	2.98	2.78	2.87	2.84
Lime, potash and superphosphate	2.00	2.37	2.41	2.35

* 21 crop years.

Farm experiences and experimental evidence show that alfalfa stands will be maintained longer by the use of lime. An experiment conducted in Allen county over a period of nine years showed that lime prolonged the life of the stand to the close of the experiment; whereas where lime was not used, the stand was completely killed out in five years. The application of manure did not overcome the deficiency of lime.

The time, rate and method of applying lime are important. The lime should be applied early in the period of seedbed preparation and at a rate predetermined by tests made by the county agent or the experiment station. The rate of application will depend on the following factors: Acidity of the soil, purity and fineness of the limestone. Each of these can be determined by laboratory testing.

Limestone can be spread either by use of the lime spreader, manure spreader, or by hand. Any method that will apply the limestone evenly and at the desired rate is satisfactory.

Fertilizers.—Alfalfa should be planted only on soils abundantly supplied with phosphorus. Phosphorus is needed on most of the soils of eastern Kansas and may be profitably used on many soils in the central region. The data in Table 4 are from experiments conducted at the Southeast Kansas Experiment Fields where the soils are deficient in both lime and phosphorus. The response to lime and phosphate was good. The combination of lime and superphosphate increased the hay yield 1.57 tons per acre over the no-treatment. Manure added to lime and superphosphate gave an additional increase in yield of 0.47 ton per acre. Where potash was added, no response was obtained, which is the general result for all of the Kansas soils.

Results obtained from the South Central Kansas Experiment Fields indicated that phosphate may be used in central Kansas. Increased yields of alfalfa hay averaged 0.20 ton per acre over the no-treatment from the use of superphosphate. At the Manhattan station in north central Kansas an average increase of 0.33 ton per acre was obtained from the use of superphosphate. On some central Kansas soils alfalfa can be grown without phosphorus, but generally it will profitably increase the yields, improve the quality of the crop, and aid in maintaining stands. Experiments conducted in many sections of Kansas show that the need for phosphorus in alfalfa production is increasing and that soils which formerly did not respond to phosphorus are now showing economic returns.

Continuing applications of phosphatic fertilizers to alfalfa usually pays as is shown from results reported from the experiment station at Manhattan. (Table 5.) Larger increases in hay yields were obtained the last 14-year period than from the first 14-year period.

TABLE 5.—*Increases in alfalfa yields due to manure and superphosphate and to manure and lime, singly and in combination, for the periods 1911-1925 and 1926-1940.*

PERIOD.	Average annual increase in pounds per acre due to			
	Manure and superphos.	Manure.	Manure and lime.	Lime.
1911-1925	977	1,063	1,404	341
1926-1940	1,610	1,002	1,650	648

When soils are low in nitrogen, and manure is not available, the application, before seeding, of a mixed fertilizer containing some nitrogen along with the phosphorus would be advisable. A light application of nitrogen will give the small seedlings added vigor and aid them to come through the first winter.

The rate of application of phosphatic fertilizer will depend on the form used, whether the application is being made at seeding time or later, and will also depend on the P_2O_5 content. The most common form now used is superphosphate. Others, such as bone meal or raw rock phosphate, are rarely used. Superphosphate is available in varying contents of P_2O_5 ranging from 16 to 48 percent. The 20- and 45-percent materials are more common than others. They should be applied at the rate of 225 pounds of 20-percent or 100 pounds of 45-percent superphosphate at seeding time and every second year thereafter, or the application may be made annually at one-half of these rates.

For new seedings, superphosphate should be applied with the combination drill at seeding time or it can be applied just before seeding. In the latter case the fertilizer should be worked into the surface soil. On established stands, the superphosphate may be applied as a surface dressing in the early spring.

Barnyard manure is beneficial to alfalfa, and preferably should be applied on the crop preceding the alfalfa seeding. This will allow the manure to decompose and also give time for weed seed spread with the manure to germinate and be destroyed. Manure may also be used as a top dressing on established stands. It should be applied in the late fall or winter to prevent interference with haying.

TIME OF SEEDING

Fall seeding is desirable for all of Kansas when conditions are favorable. From east to west, across the state, the hazard of fall seeding becomes greater because of the low soil moisture conditions that often prevail and the heavier infestation of grasshoppers. Fall seeding eliminates the weed hazard often encountered with spring seeding and, in addition, a profitable crop can be obtained the first year. Seeding should be done only when the weather and seedbed conditions are favorable. If seedbed preparations are started early and continued so as to conserve moisture and control weeds, the weather will be the controlling factor at seeding time. The earliest date at which weather and soil moisture conditions are most likely to become favorable is about August 15. If the seeding is done earlier than this date, a period of hot dry weather may occur before the small plants are well rooted into the moist subsoil and cause them to die. When moisture has been conserved during seedbed preparation, the first good rain after August 15 will wet the surface soil down to the subsoil moisture. If the seedbed is ready and the seeding is done immediately following the rain, quick germination will occur and the roots will reach the subsoil moisture before much drying has occurred. The important factor is to have the seedbed ready. The less the ground is worked after the rain and before seeding, the better the chances are of a successful stand.

The latest date that alfalfa may be successfully seeded will again depend on the weather and seedbed. Generally September 10 is considered the latest safe date for northern Kansas and September 20 for southern Kansas. The chance of success diminishes rapidly if seeding is done later than these dates.

Spring seeding should be resorted to only when fall seeding is not practical. The time for spring seeding will vary from the first of April to the last of May. Again soil moisture and weather conditions will be the determining factors. With spring seeding, the hazards of maintaining a stand the first summer are greater than from fall seeding, largely because of weeds. Usually this would not be true on summer fallowed land. Spring seeded alfalfa seldom produces a profitable crop the first year.

A companion crop, such as oats, seeded with alfalfa at one-half the usual rate is sometimes successful, but should be avoided if possible and will not be necessary if the seedbed has been prepared properly and the seeding is done on clean ground. A companion crop will help control weeds in the spring but will also use soil moisture and plant food needed by the alfalfa.

MANNER OF SEEDING

It is always more difficult to obtain good stands of small-seeded crops like alfalfa than of the larger-seeded crops. It is necessary to get the small seed in close contact with the soil particles to hasten germination and make possible a rapid early growth of the seedlings. That is why it is so important to have a seedbed similar to that shown in Figure 2.

Drilling is the best method of placing the seed in the ground. It assures a uniform distribution of seed at a uniform depth. An alfalfa drill is preferable (Fig. 3), but the common grain drill can be

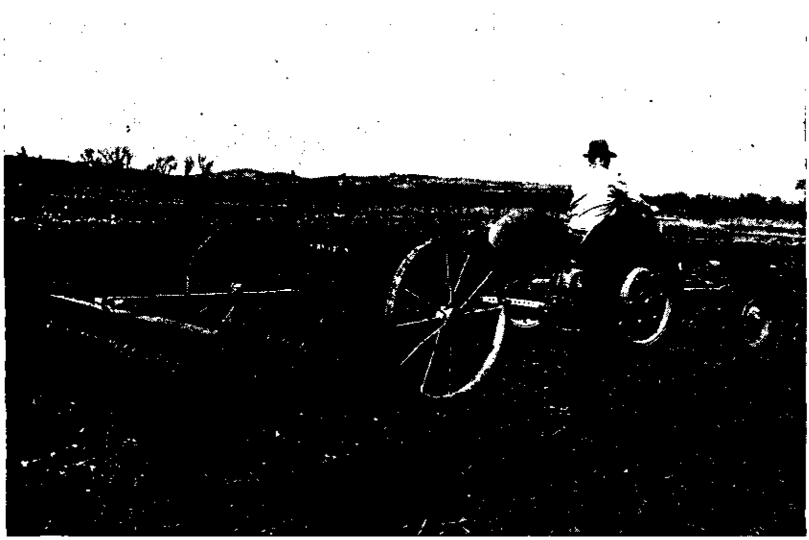


FIG. 3. An alfalfa drill should be used in seeding alfalfa if possible. Drilling assures an even distribution of the seed at a uniform depth. Packing after drilling will place the seed in close contact with the soil.

used successfully. If the row spacing of the grain drill is over six inches it would be advisable to drill both ways, planting one-half of the seed at a time. The seed should be sown at a depth of approximately one-half inch. If the seedbed has been reasonably well covered and is packed by a cultipacker before and after drilling, the seed will be in close contact with the soil and immediate germination will follow.

Broadcasting is not a good method but, if used, the seedbed preparation should be the same as for drilling. The seed should be covered by a drag harrow followed by a packer. It is usually necessary to plant more seed per acre when broadcasting.

RATE OF SEEDING

There are approximately 220,000 alfalfa seeds in a pound. This is sufficient to make five plants per square foot if all seeds germinate and grow. However, the present seeding equipment makes it impossible to obtain an even distribution of seed in such small quantities. The hazards encountered in establishing stands of alfalfa make it necessary to recommend that 10 to 15 pounds of seed be used per acre. In western Kansas, under ideal conditions, as low as 8 pounds of seed per acre are sometimes used.

HIGH QUALITY SEED

With all the work necessary to condition the ground and prepare the seedbed, it would be a poor practice to use low-quality seed. The use of seed of known purity and germination is an insurance covering some of the unpredictable difficulties encountered in ob-

FIG. 4.—(1) Alfalfa seedlings that have not been well inoculated are weak. (2) Those supplied with bacteria are strong and vigorous. Extreme right is a young alfalfa plant illustrating the type of nodules found on the roots when good inoculation occurs.

taining a stand of alfalfa. Whether home-grown or purchased seed is used, only seed of high purity and germination should be planted. This can be determined by sending a sample to the State Seed Laboratory, Manhattan, Kansas, for testing. Kansas seed laws require that all seeds sold through seed dealers carry a tag giving the purity and percent of germination and hard seed. Regardless of the source of the seed, it should be tested before using.

Alfalfa seed, like sweet clover, may contain a high percentage of hard seed immediately after harvesting. If the germination test shows that the percentage of hard seed is as high as 30 or more, the seed should be scarified or not seeded until the next fall. Holding seed over greatly reduces the percentage of hard seed. A good grade of alfalfa seed would have approximately the following analysis: Germination, 80 percent; hard seed, 15 percent; purity, 99 percent; and noxious weeds, 0 percent.

INOCULATION OF SEED

Alfalfa will thrive well only if the symbiotic, nodule-forming bacteria are present. (Fig. 4.) The only way to be sure that they are present is to inoculate the seed. The bacteria *(Rhizobium meliloti)* may be supplied by artificial inoculation of the seed with commercial cultures available at all seed stores. These bacteria may be locking in soils on which sweet clover or alfalfa has not been recently grown. The cost of inoculating the seed is so small that it is a good practice always to inoculate.

CULTIVATING ALFALFA

Cultivation of alfalfa is not recommended. Generally it does not pay. It may be desirable in some instances to cultivate in order to reduce weed growth, but usually if the stand is so thin that the meadow becomes weedy, it had better be plowed up. Cultivation may be effective in eradicating winter grasses as cheat and downy brome. When these grasses are present, the cultivating should be done in the late fall and again in the spring.

The best implement to use for cultivating alfalfa is the alfalfa renovator or the spring-tooth harrow. The disk should not be used as it is apt to split the crowns and injure the plant.

THICKENING THE STANDS

It is not practical to try to thicken old stands by seeding or cultivating, either generally over the field or in small patches. If the patches are large, the field had better be plowed up. Cultivation alone will never thicken a stand. The new seedlings from seed planted in an old stand cannot compete with the older plants. If the stand is so thin that the new plants can survive, then the stand is so thin that it should be plowed up and the acreage reseeded after a seedbed has been prepared. The only place where reseeding might be successful would be in reseeding patches in a field or border killed by grasshoppers the first spring following a fall seeding. In that case the seedbed may be prepared by disking and the seeding may be done in the usual manner.

ALFALFA VARIETIES

GROUP CLASSIFICATIONS

Alfalfas as known in the United States were divided into five groups by Oakley and Westover (14), namely: Common, Variegated, Turkistans, non-hardy, and yellow-flowered. All strains or varieties have characteristics which place them within one of these groups.

Common alfalfa *(Medicago sativa* L.).—The common alfalfa as it exists in Kansas probably traces back to importations from Chile to California in 1850, and then moving across country from the Southwest. This group is purple-flowered, the intensity of the color varying somewhat. Since alfalfa was introduced, this group has become divided domestically into regional strains named after the state in which they are commonly grown, such as Kansas Common, Dakota Common or Arizona Common. All are purple-flowered, non-pubescent, differing only in their cold-resistance and in their habits of growth in the fall and spring. These characteristics were no doubt acquired by natural selection in the region grown.

Variegated alfalfa *(M. media* Pers.).—Variegated alfalfas are distinguished by their variegated flower color, ranging from a yellow to a light purple. They are probably the result of a natural cross between the common group and the yellow-flowered group. They are generally more cold-resistant than the common alfalfas because of their inheritance from the yellow-flowered parent. There are a few regional strains of this group, such as Hardigan, but most of them are importations such as Grimm, Cossack, Ladak, Baltic and Canadian variegated.

Turkistan alfalfa *(M. sativa).* —All alfalfas originating from Turkistan are grouped together as Turkistan alfalfas. They are purple-flowered and may differ slightly from the common alfalfa in their habits of growth.

Nonhardy alfalfa *(M. sativa).* —This is a group of alfalfas grown only in the extreme southern region and differs from other regional strains in their cold-resistance and habits of growth. They are characterized by their lack of cold-resistance, their upright habits of growth, quick recovery after cutting, and their long periods of growth. Most of the alfalfas commonly found in this group are importations of Peruvian or Arabian origin. There are some regional strains that closely resemble this group when grown in Kansas, such as Arizona Chilean.

Yellow-flowered alfalfa —This group includes several species of *Medicagos*, all of which have yellow flowers. The most common of these is *M. falcata.* Most of the *falcatas* are from Siberia; therefore, are known for their cold-resistance. They have little economic importance in this state except possibly as breeding material.

ALFALFAS COMMONLY GROWN

Kansas Common. —Kansas Common is the most widely grown alfalfa in Kansas. It is one of the original strains of the common group that has been grown in Kansas until natural selection has adapted it to the state. It is purple-flowered and is known to be in the intermediate group of common alfalfas, being intermediate in its habits of growth and cold-resistance.

Ladak.—Ladak is an importation by the United States Department of Agriculture in 1910 from northern India and has gained a good reputation in Kansas because of its ability to make a good

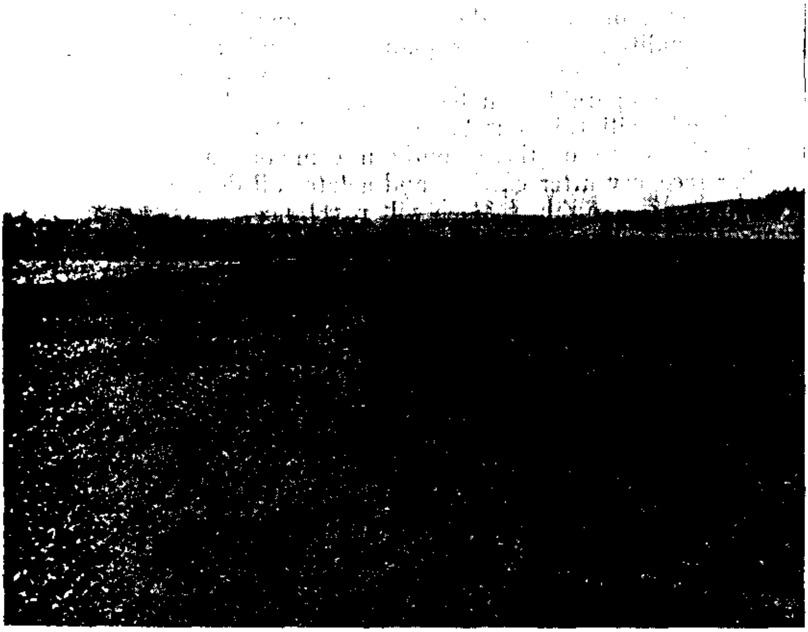


FIG. 5. —Alfalfa seed from Arizona (left) killed out almost 100 percent the first winter, while the Kansas Common (right) maintained a good stand. A certain degree of cold-resistance is necessary for alfalfa seeded in Kansas.

yield of high quality hay and its moderate resistance to bacterial wilt *(Corynebacterium insidiosum)*. It has the ability to produce approximately half of its total yield the first cutting, even though three or four cuttings are harvested. This makes it adapted to the central and western parts of Kansas where they depend upon the first crop for most of their hay. It is cold-resistant, slow to recover after cutting, and goes dormant early in the fall.

Grimm.—Grimm is an importation made by Wendelin Grimm in 1857 into Minnesota. By the process of natural selection it became very winter-hardy and in 1905 the Minnesota Agricultural Experiment Station recognized it as a suitable variety for the northern region of the United States. Grimm belongs to the variegated alfalfas and it probably inherited its cold-resistance from the yellow-flowered *falcatas*. There are a few fields of Grimm grown in Kansas, but it is rapidly disappearing because of its susceptibility to bacterial wilt.

Southern commons. —While not extensively grown in Kansas, southern commons are sometimes seeded when a shortage of seed of the adapted varieties occurs. In this group are such regional strains as Oklahoma Common, Arizona Common, New Mexico Common, etc., all of which have shown to be lower in yielding ability than Kansas Common. (Fig. 5.) The group of commons originating south of Kansas do not have enough cold-resistance for Kansas conditions and their planting should be avoided. Their ability to yield hay is equal to Kansas Common as long as the stands are comparable, but because of their lack of cold-resistance their stands will thin out before that of Kansas Common. The habits of growth of these southern commons are more upright, quicker recovery after cutting, and a late fall dormancy. None of the commons have shown much wilt-resistance.

Northern commons. —These are classed as those that have become adapted to the northern regions of the United States and are so designated because of their cold-resistance. In Kansas they do not yield so well as Kansas Common. They are not wilt-resistant and have the growth characteristics of all northern alfalfas, such as slow recovery after cutting and early fall dormancy.

In recent years a number of alfalfas have been given names which indicate some of their characteristics or origin. It seems desirable to mention some of these as they are, in certain characteristics, a definite improvement over the original strains grown in their respective regions. The most of these are direct importations or are traceable to importations, such as:

Hardistan. —This is one of the varieties that has gained commercial prominence in Nebraska and farther north. It is a superior strain of Turkistan brought into prominence by the Nebraska Agricultural Experiment Station. It has the characteristics of Turkistans and was introduced as a new variety because of its wilt-resistance. At the time it was being introduced as a new variety, bacterial wilt of alfalfa was becoming one of the great hazards to growers in the central region of the United States. Hardistan was the first wilt-resistant alfalfa designated as a new variety.

Orestan. —This is a strain of Turkestan imported under the number F.C. 19301. It did well under Oregon conditions and was named by the Oregon Agricultural Experiment Station. This importation was tested in Kansas and is considered one of the better Turkistans. It carries a high degree of wilt-resistance but yields are below that of Kansas Common and, as with most Turkistans, it is susceptible to the leaf and stem diseases under Kansas conditions.

Nemastan. —An importation F. C. 19304, it was named by the Nevada and Utah agricultural experiment stations because of its resistance to stem nematodes, an organism that is quite destructive to alfalfa in certain sections of the western part of the United States. In the Kansas tests it is considered one of the poorer importations from Turkistan, being very susceptible to the leaf and stem diseases and low in hay yield compared to Kansas Common. The first cutting is usually of a poor quality. Its nematode-resistance makes it a desirable variety for some western areas and it is used as a source of material in breeding for that character.

Meeker Baltic. —This variety originated from the variety known as Baltic and was named by the Colorado Agricultural Experiment Station because of its fine performance in that state. It is a variegated alfalfa and is very similar to Grimm. In Kansas it produces a high yield the first few years, but under wilt conditions loses its stand very rapidly.

There are other varieties that have been given names such as Hardigan, Baltic and Ontario Variegated, none of which are grown commercially in Kansas.

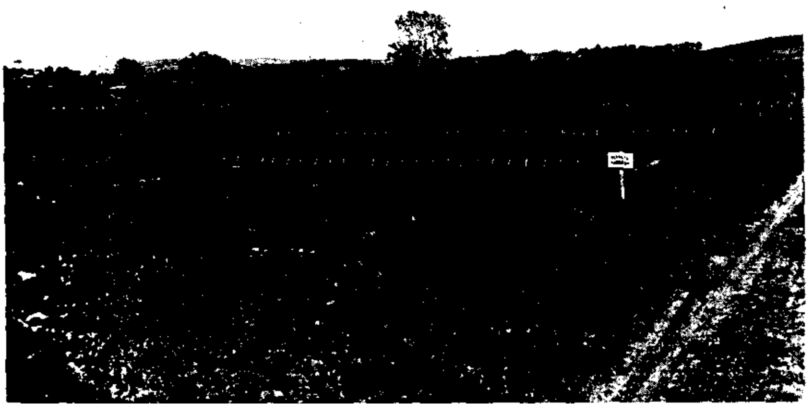


FIG. 6.-Buffalo alfalfa was obtained by testing and selecting from nurseries where hundreds of rows and individual plants were observed. An alfalfa breeding nursery at Manhattan.

NEW VARIETIES

The Kansas Agricultural Experiment Station in coöperation with the Division of Forage Crops and Diseases, United States Department of Agriculture, has been working on the development of a new alfalfa with the purpose of producing a variety resistant to bacterial wilt and still retain all the other characteristics of Kansas Common. Kansas Common has a wide area of adaptation and because of this the Kansas Common seed produced in the state has a ready market in the East and usually brings a few cents a pound premium over other common varieties.

During the past 14 years the intensified program has been one of testing for resistance to bacterial wilt, cold, and leaf and stem disease; and selecting for the principal agronomic characters that make

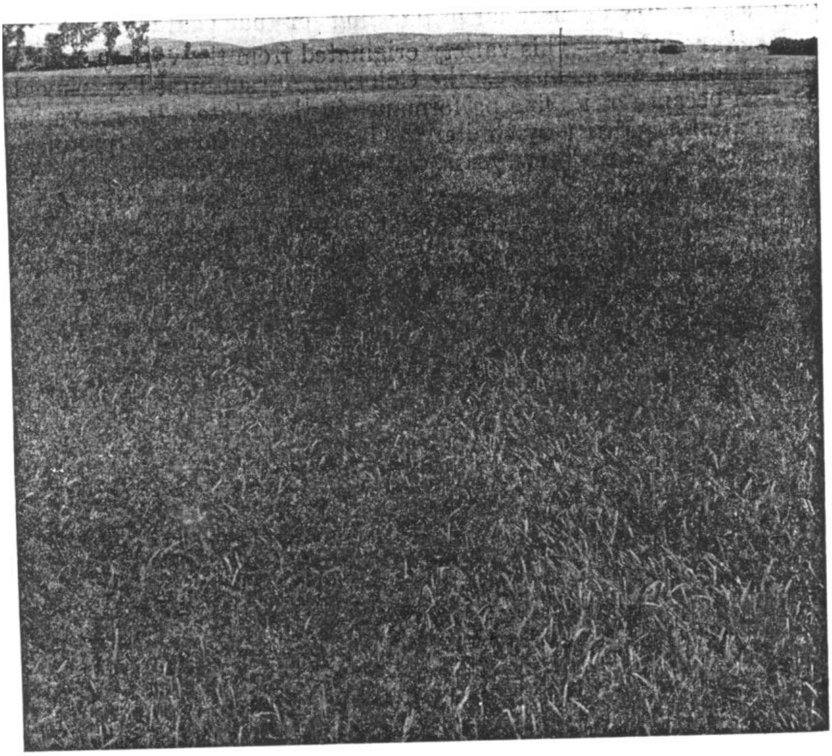


FIG. 7.—Buffalo alfalfa (left) growing in a field beside Kansas Common (right) on the agronomy farm, Kansas Agricultural Experiment Station, Manhattan. The thin stand in the Kansas Common, as indicated by the foxtail grass (*Hordeum pusillum* Nutt) was caused by bacterial wilt (*Corynebacterium insidiosum*).

Kansas Common a desirable variety for the central and southeast section of the United States. During this time hundreds of importations have been tested (Fig. 6), as have thousands of selected plants from year to year. The process of testing these selections for different factors has involved the cooperation of the departments of botany and plant pathology, chemistry, agronomy, and the Fort Hays and Garden City branch experiment stations with the Division of Forage Crops and Diseases, United States Department of Agriculture. Progress has been made, and a selection from an old line of Kansas Common was named Buffalo in 1943 and made available to the farmers.

Buffalo alfalfa.—This variety, obtained from Kansas Common by close breeding and selection, is important particularly for its resistance to bacterial wilt. It has been widely tested throughout the United States in advanced nurseries in cooperation with the Alfalfa Improvement Conference. The original strain of Kansas Common alfalfa used in this selection is known to have been grown in Kansas before 1907. The superiority of the strain was brought to the attention of L. E. Call, then head of the Department of Agronomy, by W. J. Sayre, a farmer formerly of Chase county, Kansas. Seed was first planted on the agronomy farm at Manhattan in 1922. In that test it was equal to other Kansas Common strains in yield and

TABLE 6.—*Comparative stands and yields of hay in alfalfa variety test at Manhattan.*

VARIETY.	Percentage stand.		*Tons air-dry hay per acre (12% moisture).				
	1939	1942	1939	1940	1941	1942	Average.
Buffalo	95	95	3.26	4.01	3.53	3.26	3.51
Kansas Common	100	25	3.69	4.22	3.18	2.53	3.40
Grimm	98	12	3.25	3.92	2.97	2.50	3.16
Oklahoma Common	98	20	3.85	4.29	3.28	2.46	3.47
Dakota Common	98	6	3.50	3.94	3.23	2.85	3.38

* Not reported as grass-free hay.

quality of hay and in cold-resistance, and was superior in longevity of stand. In 1928 about 1200 selected plants were transplanted from the plots and seed harvested in 1929. The progeny of the selected plants were tested in observation nurseries for general agronomic characters and in nurseries for resistance to this disease.

Buffalo alfalfa, like all common alfalfas, has a bluish-purple flower ranging from a light blue to a reddish-purple. It is upright in type of growth, has a medium-sized stem, and makes a medium to a leafy quality of hay. When grown by itself, Buffalo cannot be distinguished from ordinary Kansas Common alfalfa. Its growth in spring and fall is a little more upright than that of Kansas Common and it makes a slightly more rapid recovery after cutting.

The main advantage of Buffalo alfalfa is its high resistance to bacterial wilt. (Fig. 7.) As a result of this, good stands are maintained longer than is possible with varieties that are susceptible to this disease. In comparable tests with other varieties in Kansas, Buffalo has yielded nearly the same as other adapted varieties in new stands and has outyielded those varieties when the stands became older. This is illustrated in a test made at Manhattan on wilt-infested soil and reported in Table 6 comparing Buffalo with several commonly-grown varieties. The varieties listed are susceptible to bacterial wilt and for that reason did not hold their stands for more than three years. The 1942 figures reveal this fact: The wilt-susceptible varieties which had nearly a perfect stand in 1939, had no more than one-fourth stand in 1942, whereas Buffalo maintained its stand of 95 percent throughout the four seasons. The difference in stand is reflected in the 1942 hay yield. This difference would have been much greater if the hay yields had been reported as grass-free hay.

In another experiment at Manhattan in which 50 strains and varieties were tested in the advanced nurseries for four years, Buffalo outyielded the commonly-grown varieties. Yields of Buffalo and Ranger, the two new wilt-resistant varieties now being produced commercially, may be compared with numerous other strains and varieties in Table 12.

The data in Table 7 show similar results for a test on wilt-infested ground at the Iowa Agricultural Experiment Station, Ames, Iowa. Results of a similar test conducted at Davis, Calif., are given in

TABLE 7.—*Alfalfa variety test, Iowa Agricultural Experiment Station, Ames, Iowa.*

VARIETY.	Tons per acre.				
	1941	1942	1943	1944	Average.
Buffalo	5.57	4.33	3.60	2.54	4.01
Kansas Common	5.78	4.59	1.75	0.60	3.18
Grimm	5.60	4.47	2.47	0.84	3.34
Ranger	5.39	4.43	3.55	2.34	3.93

Table 8. The hay yields for 1940-1943 were not reported in this test, but the stand figures given indicate that Buffalo with a stand of 87 percent would still be able to produce high yields, while the yields of the two wilt-susceptible varieties with stands of 32 and

TABLE 8.—*Alfalfa test, California Agricultural Experiment Station, Davis, California.*

VARIETY.	Percentage stand.		Average yield (3 years) tons per acre, 1937-1939.
	1937.	1943.	
Buffalo	92	87	7.3
Kansas Common	90	32	6.7
California Common	95	42	7.8

42 percent would be greatly reduced. The yields reported for 1937-1939, while stands were then similar, show that Buffalo is capable of producing a high yield under the conditions at Davis.

Buffalo alfalfa is as good a variety for the production of seed as Kansas Common. This is important not only for planting in the state but also for supplying seed to other states. Buffalo alfalfa is well suited for growing where Kansas Common is adapted. This is generally recognized as the central and southern areas of the United States, including the range across the country having approximately the same latitude as Kansas and those areas southeast of Kansas. It is also adapted to regions somewhat farther north and it may be expected, therefore, that seed of Buffalo will be in even greater demand than that of Kansas Common.

Buffalo has a higher stand survival in the northern alfalfa areas of the United States than Kansas Common, as shown in Table 9.

TABLE 9.—*Stand survival of Buffalo and Kansas Common in comparable tests in advance nurseries in north central United States.*

YEAR.	Number of states reporting.	Percent of original stand.	
		Buffalo.	Kansas Common.
1940	11	91	87
1941	3	89	67
1942	11	95	94
Averages	....	92	83

For this reason its range of adaptation probably will include areas somewhat north of the northern Kansas latitude. Because of the more rapid recovery of Buffalo after cutting and its larger fall growth, it may be more popular than Kansas Common has been in this area.

Ranger alfalfa —As described by Tysdal (19), this is a synthetic variety produced through the cooperative efforts of the Nebraska Agricultural Experiment Station and the Division of Forage Crops and Diseases, United States Department of Agriculture. It has been widely tested under the auspices of the Alfalfa Improvement Conference. Ranger may be called a multiple strain variety, having been synthesized from five selections originating from the varieties Cossack, Turkestan and Ladak. Some of the original strains of Turkestan entering Ranger were brought direct from that country by H. L. Westover, plant explorer for the United States Department of Agriculture.

In morphological characters it exhibits considerable variability, both in habit of growth and flower color. It is distinctly variegated in flower-color, but only occasionally, if at all, are yellow-flowered plants observed. The plants vary in habit of growth from decumbent to upright. The variety has greater rapidity of recovery after cutting than Ladak or Cossack, being about the same as Grimm in this respect. It is slightly more susceptible to leaf spot diseases and leaf hopper yellowing than Grimm but not so susceptible as Hardistan or the Turkistans in this respect. These latter characteristics should not prove a handicap under conditions west of the Mississippi river, but may be somewhat detrimental for eastern areas. However, where bacterial wilt is a serious handicap, its resistance to this disease will more than offset its susceptibility to leaf diseases. It is distinctly superior in seed production to Hardistan or the Turkistans, being about equal to Grimm. In forage production it is intermediate between Grimm and Hardistan when all have equally good stands. It is about equal to Grimm in cold-resistance. The outstanding characteristics of Ranger alfalfa is its resistance to the bacterial wilt disease, being greatly superior to all domestic strains commonly grown at this time and equal or superior to the Turkistans, including Hardistan and Orestan.

In Kansas, Ranger has proved to be one of the high-yielding varieties, ranking slightly below Buffalo. It is highly wilt-resistant but more susceptible to the leaf and stem diseases than is Buffalo. Some yield data on Ranger will be noted in Tables 7 and 12.

Atlantic alfalfa.—This variety was produced at the New Jersey Experiment Station and is a composite resulting from the combination of many different strains. It has been a consistently good forage producer. In leaf spot resistance, Atlantic is above the average. This also can be said regarding its cold-resistance which is not so high as Ladak or Grimm. Atlantic is not so resistant to bacterial wilt as Buffalo or Ranger. It has made a good record at the New Jersey Agricultural Experiment Station and may be used in northeastern United States where bacterial wilt is not a serious disease. In Kansas, Atlantic makes a good hay yield until wilt thins the stand. The lack of wilt-resistance makes it undesirable for this state.

VARIETY TESTS

The history of alfalfa in Kansas indicates that the seed for the early seedings came from the Southwest, probably New Mexico and California. At that time no thought was given to the origin of the seed or the variety. Many of the seedings were successful and by natural selection became adapted to Kansas and later became known as the regional strain, Kansas Common.

H. L. Westover (22) stated that up to 1898 there were no recognized alfalfa varieties in the United States. As alfalfa spread over the country, differences were recognized which resulted in the naming of adapted varieties such as Kansas Common, Montana Common, etc.

Since 1922 more than 1,200 varieties, regional strains and selections have been tested at the Kansas station, many of them importations from 32 different countries of the world. The first variety test conducted included 15 varieties, most of the seed being furnished by the Division of Forage Crops and Diseases, United States Department of Agriculture. The Kansas Common used in this test as a check was the strain from which Buffalo alfalfa originated. The objective of this test was to find a wilt-resistant variety. In Table 10 are given the data from this test. The results show that Cossack yielded more hay than any of the other varieties, with Grimm second and Kansas Common third. However, at the end of the experiment Cossack had a 30-percent stand, Grimm 20 percent, and Kansas Common 38 percent. An importation from France, designated as Province F. P. I. 34886, maintained the highest stand in the test. These results were the first indication that some varieties may carry a higher degree of wilt-resistance than others. When this set of plants was plowed up in 1928, individual plants were selected from the Kansas Common and Province plots and isolated for further study.

TABLE 10.—*Alfalfa variety tests, Manhattan, Kansas, 1923-1928.*

VARIETIES.	Yields in tons, of air-dry hay per acre.							Stand survival, percent.
	1923	1924	1925	1926	1927	1928	Average.	
Turkestan	3.29	5.35	4.28	3.12	3.37	1.50	3.40	40
Italian	3.69	5.33	5.08	2.78	3.30	.88	3.51	16
Kansas Common	3.27	5.17	5.29	2.95	3.46	1.40	3.59	38
Spanish	2.56	3.34	3.96	2.05	1.54	.06	2.25	6
Province 34886	2.80	4.59	4.08	3.04	3.11	1.48	3.20	70
Cape Lucern	2.58	4.22	4.06	2.23	1.81	.17	2.51	3
Ladak	2.38	4.80	4.45	2.81	3.84	1.83	3.35	50
Dakota Common	2.61	4.39	5.06	2.64	2.90	1.04	3.11	29
Grimm	3.95	5.15	5.23	2.93	3.17	1.21	3.61	20
Cossack	3.80	5.41	4.83	2.88	3.78	1.56	3.71	30
Dakota 12	3.40	5.20	5.33	2.82	3.35	1.15	3.54	24
Argentine	3.41	5.23	4.78	2.51	3.10	.59	3.27	10
Utah	3.18	5.22	5.02	2.56	2.95	.61	3.26	13
[illegible]	3.39	5.62	5.43	2.58	3.04	.55	3.43	17
[illegible]	3.51	5.71	5.29	2.64	2.95	.75	3.47	13

From 1926 to 1931 several hundred square rod plots were seeded (Fig. 8) consisting largely of importations. Each year a new set of plots was seeded, as during this period many new importations were being made by H. L. Westover, who made several trips to Turkistan and other European and Asiatic countries in search of new varieties that might have wilt-resistance. By 1931 there was a total of 431 plots in this test. They were used largely for observations. The data accumulated made it possible to determine whether the importations were as good as Kansas Common in regard to resistance to cold, wilt leaf and stem diseases, and in agronomic characters. The test revealed that the only group of importations that contained much wilt-resistance was the Turkestans. Also, it was found that the Turkestans were not suited to Kansas conditions because of their susceptibility to the leaf and stem diseases.

In 1930, two series of drill-width variety plots were seeded in duplicate on upland and bottom land with selected varieties and

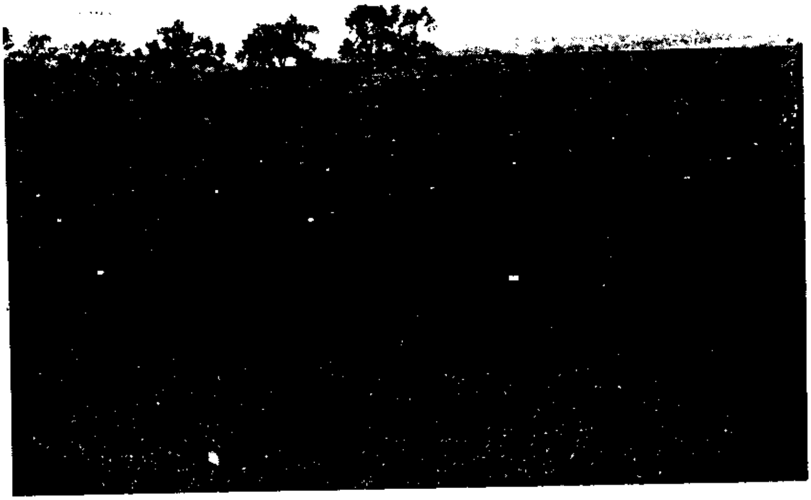


FIG. 8.—The best selections and lines from row nurseries and many foreign introductions are seeded in small plots to obtain information on resistance to diseases and cold, and on agronomic characters.

TABLE 11.—*Hay yield of alfalfa varieties and stand survival on upland and bottom land.*

VARIETY.	F. C. or F. P. I. number.	Upland experiment. Yield air-dry hay per acre.*	Upland experiment. Stand. 1931.	Upland experiment. Stand. 1936.	Bottom-land experiment. Yield air-dry hay per acre.*	Bottom-land experiment. Stand. 1931.	Bottom-land experiment. Stand. 1936.
		Tons	*Percent*	*Percent*	*Tons*	*Percent*	*Percent*
Grimm	16030	2.42†	100	55	4.15†	100	7
Dakota 12	15997	2.54	100	70	4.17	100	15
Ladak	15988	2.99	100	98	4.45	100	87
Hungarian	81438	2.48	100	43	4.15	100	22
French	19273	2.17	100	33	3.83	100	10
French	81488	2.25	100	35	3.89	100	7
Hardigan	18777	2.63	100	65	4.47	100	7
Baltic	15989	2.63	100	63	4.60	100	2
Italian	85993	2.34	100	35	4.19	100	7
Turkestan	86696	2.45	100	100	3.88	100	100
Turkestan	19301	2.32	100	100	3.75	100	100
Turkestan	19302	2.31	100	100	3.84	100	100
Turkestan	19304	1.88	100	95	3.29	100	100
Dakota Common	16081	2.64	100	53	4.57	100	5
Cossack	18836	2.79	100	93	4.59	100	77
Utah	15986	2.50	100	35	4.62	100	0
Utah	15995	2.56	100	30	4.47	100	0
Hardistan	....	2.23	100	100	3.68	100	100
Argentine	15996	2.69	100	13	4.63	100	5
Kansas Common	18826	2.60	100	63	4.42	100	27

* Average yield for the first three years of the experiment, 1931-1933.

† If the difference between the average yield of any two varieties is less than 0.17 ton on the upland or 0.25 ton on the bottom, it may be assumed that the yielding ability of those varieties is not significantly different.

strains for the purpose of obtaining data on their yielding ability and wilt-resistance. (Table 11.) The yield data are given for the first three years of the test. During this period the stands were comparable in all plots. The reduction in stand as shown by the stand survival figures for 1936, covering a five-year period, were largely due on the upland to the severe winter of 1935 and on the bottom land to both wilt and cold. Figure 9 shows a general view

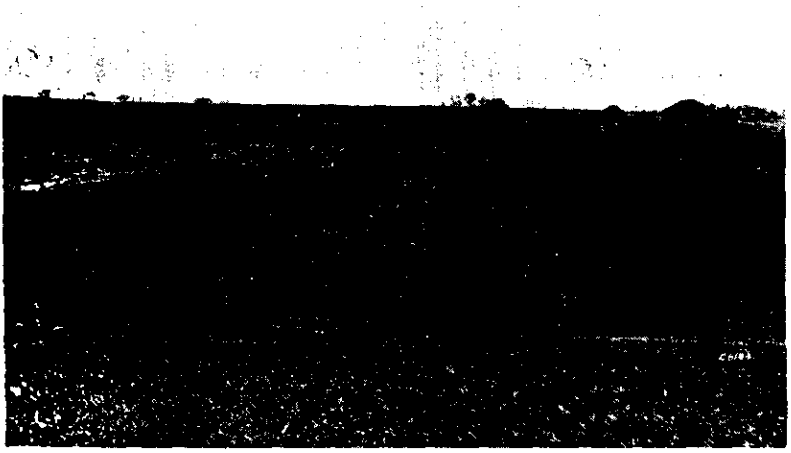


FIG. 9. —Wilt resistance is important in maintaining stands of alfalfa in many regions of Kansas. The strains of Turkestan shown on the left and the right are wilt-resistant, while Kansas Common and Grimm in the center are susceptible to the disease.

of the bottom-land plots taken in the spring of 1936. This is a good example of how the wilt-resistant Turkestans hold their stands in comparison with the wilt-susceptible varieties of Grimm and Kansas Common in the center foreground. The one good plot in the center background is Ladak which carries a moderate amount of wilt-resistance. None of the imported varieties such as Argentine, Hungarian, French, etc., used in this test, held their stands under that condition.

Selection and hybridization of alfalfa has developed to where many new strains are ready for testing. In order to obtain a large amount of information in a short period of time, the Division of Forage Crops and state experiment stations organized the Alfalfa Improvement Conference, consisting of the state and federal research men interested in alfalfa improvement. This organization was charged with the responsibility of securing cooperation for the testing of new alfalfas in nursery rows and advanced nursery plots in the various states. Table 12 gives the yield and stand data secured from the advanced nursery at the Kansas Agricultural Experiment Station.

TABLE 12.—*Comparative yields in tons, of alfalfa strains in advanced nursery, 1941-1944, Manhattan, Kansas.*

VARIETY.	Yield of hay per acre (12 percent moisture).*				4-year average.	Stand survival, percent.	
	1941	1942	1943	1944		1941	1944
1-1012-2 Kansas	1.58	4.78	4.72	5.27	4.09	99	95
1-106-1 Kansas	1.44	4.92	4.67	5.34	4.09	95	95
1-101-2 Kansas	1.71	5.06	4.29	5.08	4.04	95	90
A-11 Kansas (Buffalo)	1.67	4.47	4.31	5.21	3.92	94	90
A-136 Montana (Ranger)	1.61	4.88	4.22	4.56	3.82	95	85
A-165 Nebraska	1.65	4.70	4.18	4.62	3.79	90	70
A-114 Nebraska	1.53	4.55	4.23	4.76	3.79	95	80
A-115 Nebraska	1.67	5.08	4.07	4.22	3.76	99	70
A-106 Nebraska	1.61	4.75	4.16	4.49	3.75	96	80
A-136 Original (Ranger)	1.61	4.80	4.07	4.32	3.70	91	70
A-145 New Jersey	1.74	5.09	3.83	4.10	3.69	92	50
A-136 Utah (Ranger)	1.59	4.59	4.08	4.46	3.68	92	75
A-163 Nebraska	1.42	4.49	4.11	4.57	3.65	90	75
Orestan	1.29	4.59	4.16	4.48	3.63	98	75
19302 Turkestan	1.25	4.43	4.10	4.56	3.59	90	85
86696 Turkestan	1.22	4.68	4.15	4.29	3.58	89	60
19300 Turkestan	1.35	4.53	4.05	4.37	3.58	91	75
Hardistan	1.44	4.49	3.98	4.38	3.57	95	75
A-95 Nebraska	1.56	4.47	4.01	3.97	3.50	92	55
A-162 Nebraska	1.31	4.29	3.91	4.13	3.41	85	70
Oklahoma C. (Tillman Co.)	1.91	4.68	3.80	3.29	3.42	89	30
A-164 Nebraska	1.53	4.17	3.74	3.97	3.35	88	55
Grimm	1.72	4.70	3.55	2.45	3.23	88	15
Kansas Common	1.75	4.04	3.59	3.48	3.22	96	30
22662 Meeker Baltic	1.74	4.95	3.76	2.20	3.16	87	10
136547 Viking	1.54	4.53	3.24	3.19	3.13	89	35
A-134 New Mexico	1.79	4.13	3.19	3.02	3.03	92	35

* A difference in yield of more than 0.22 ton may be considered significant.

VARIETAL RESISTANCE TO DISEASES AND COLD

The stand survival figures given in Tables 11 and 12 are a measure of the wilt and cold resistance of varieties as the plots were seeded on ground heavily infested with the wilt organism. The periodically cold winters were sufficient to eliminate the varieties not having sufficient winter-hardiness for Kansas conditions. Also similar tests were being conducted at other stations and their data made available through the Alfalfa Improvement Conference. This information made it possible to evaluate the varieties tested.

An examination of the data shows that the Turkestans were wilt- and cold-resistant but their hay yields usually were low. They were also found to be susceptible to leaf and stem diseases which eliminate the possibility of their production in Kansas. Alfalfas susceptible to these diseases cannot be grown successfully in the eastern part of the United States, and as Kansas seed producers sell most of their seed in the East, Kansas cannot afford to grow an alfalfa that cannot be grown in that territory.

The variety tests also reveal that none of the common alfalfas were desirable. This was because they were not wilt-resistant. The southern commons were neither wilt-resistant or cold-resistant enough for Kansas conditions; and the northern commons, while they showed sufficient cold-resistance, were not wilt-resistant and were somewhat lower in their hay yields than Kansas Common. Kansas Common was not wilt resistant but was a good producer and had enough cold-resistance for Kansas conditions, making it the most desirable of all of the common alfalfas tested.

These tests revealed that the only solution to the disease-resistance problem was the development of resistant varieties. Buffalo alfalfa for the central and southern regions, and Ranger for the northern, is the immediate solution to the bacterial wilt problem. Buffalo alfalfa is expected to replace Kansas Common in its adapted areas because of its similarity to Kansas Common and its wilt-resistance and cold-resistance.

FIG. 10. —An alfalfa nursery at Manhattan showing the many types of alfalfa that may be obtained. The good types are used for further breeding work.

HYBRID ALFALFA

Hybrid alfalfa, like hybrid corn, is expected to make a great difference in alfalfa production. The plant breeders will produce an alfalfa that will carry a high degree of resistance to diseases and cold, and with that they will have the ability to produce much higher yields than the alfalfas now grown. The hybrid alfalfas now in existence are still in the testing stage. Figure 10 shows a polycross nursery which is one of the steps in the testing of lines that may be used as parental stock for producing hybrids. The production of the foundation stock for hybrid alfalfa will be a highly specialized process, involving the vegetative propagation of the parental stock. Some indication of this process may be seen in Figure 11 as explained by H. M. Tysdal and others *(21)*.

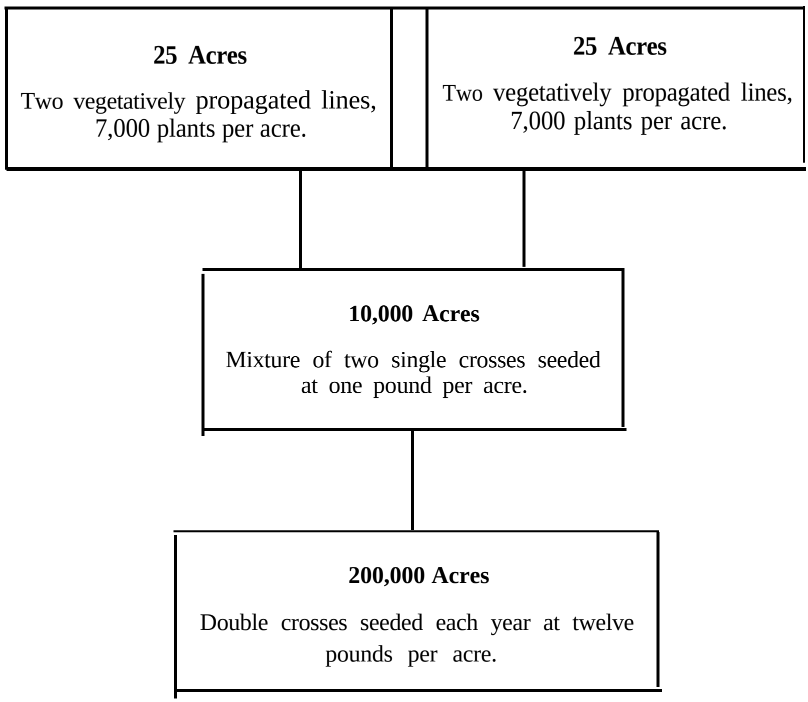


FIG. 11. —Acreage of stocks required to maintain one million acres of double cross alfalfa. (Neb. Agr. Research Bul. 124, 1942.)

TIME OF CUTTING

TO MAINTAIN STANDS

Many alfalfa fields have been ruined because of improper cutting treatments. When the last short growth of alfalfa is taken off the field late in the fall, the alfalfa plants are deprived of the necessary plant food and protection to enable them to resist cold and diseases, and the loss of plants is great. Figure 12 shows a field on which this happened. A green, succulent crop was cut from the portion of this field on the left early in October and on the right the growth was allowed to remain on the plant throughout the winter. The cutting off of this top growth caused a loss of 75 percent of the stand and also reduced the yield obtained from the first cutting the following spring.

The early time-of-cutting experiments were conducted to determine the stage of growth to cut the alfalfa in order to obtain the best yields of high quality hay. These experiments showed that the highest quality hay was obtained by cutting in the early bud stage of bloom and that the highest yields were obtained by cutting in the later bloom stage. Cutting in the late bud stage throughout the

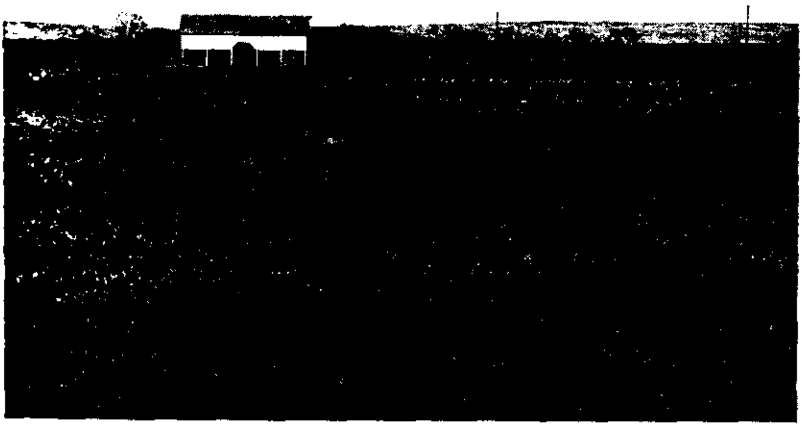


FIG. 12. —A good stand of alfalfa can be ruined in one season by cutting off the late fall growth. On the left, a fall growth of about eight inches was cut in early October, resulting in a thinning of the stand, and a reduction in yield of hay the following season.

year reduced the stand of alfalfa and allowed a rapid encroachment of grass and weeds. (Fig. 13.)

How to obtain quality hay and at the same time protect the stand was the problem that needed to be solved. Reports of work by Graber et al. (3), Willard et al. (23) and Grandfield (4), showed that the fall season is the critical period for the alfalfa plants and necessary to plan the late cutting in order to allow the fall top growth to supply the roots with plant food for the winter. This supply must be sufficient to give the plant a high degree of cold resistance and furnish food for the spring growth. This can best be done by allowing the fall growth to remain on the plants throughout the fall season. Figure 14 shows the trend of total carbohydrates in alfalfa roots as affected by cutting at different dates in the fall. It is evident from these data that if the last cutting is made by the middle of September, as represented in A, B, or C sufficient reserves will be built up. If the growth is cut off about the first of October, as represented by the dotted lines, the reserves would be low throughout the winter; or if the growth is cut off, as represented by line D, not enough time remains for sufficient top growth to develop, to build up reserves throughout the fall.

It has been determined by Grandfield (*5*) that high reserves in

FIG. 13.—Severe cutting treatments will soon cause a rapid encroachment of grass and weeds. Alfalfa does not die out because of the grass and weed encroachment, but they come in as a result of the thinning of the stand. (*Right*) Cut continuously in the bud stage. (*Left*) Cut continuously in the full-bloom stage.

the roots are necessary for maximum cold resistance. Alfalfa plants cannot harden properly to low temperatures without sufficient plant food in the form of sugar. This sugar is obtained by the hydrolization of the starch which is manufactured in the leaves of the plant and stored in the roots. If the tops are cut off of the plant at the beginning of the fall dormant period there can be no starch manufactured for storage.

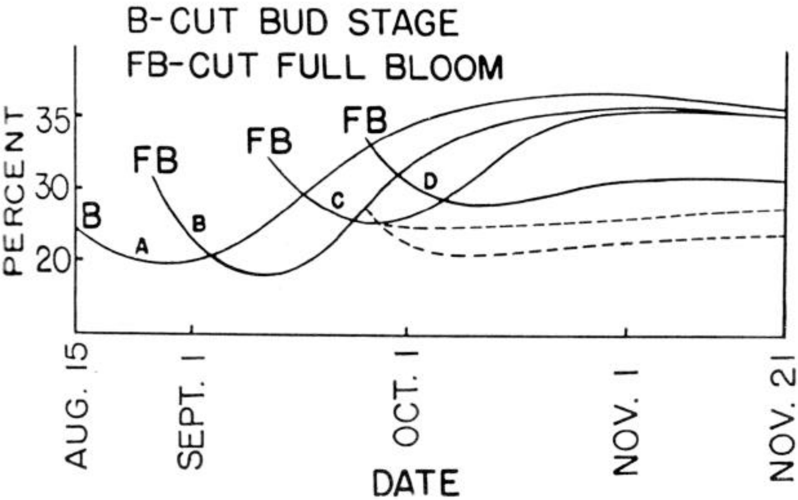


FIG. 14.—The trend of food reserves in alfalfa roots during the fall of the year as affected by cutting treatments.

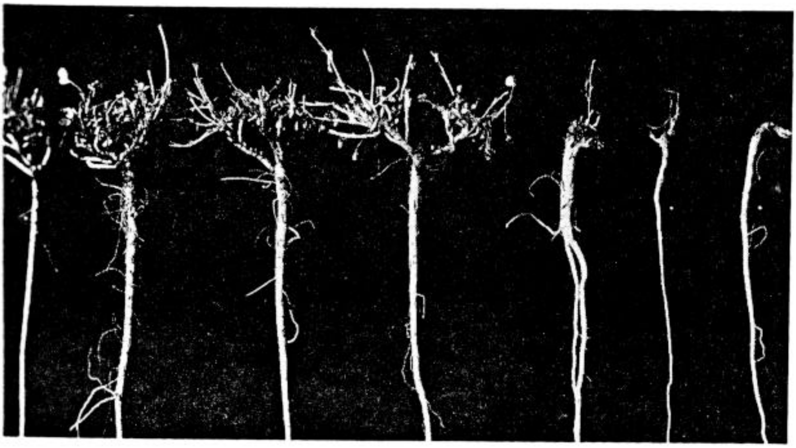


FIG. 15.—The next year's hay crop comes from the crown buds developed in the fall. The four plants on the left, taken from plots cut in the full-bloom stage, have numerous strong crown buds; while the three plants on the right, harvested at the bud stage, have only a few small buds. Proper fall treatment will build up food reserves in the roots and encourage bud development.

TO INCREASE HAY YIELDS

Cutting practices favorable to a high storage of food reserves are also favorable to the development of crown buds and to their hardening to cold. Figure 15 shows the crowns of four alfalfa plants with numerous crown buds taken from plots cut at a time favorable to high food storage. The three plants on the right were from plots cut frequently throughout the year and late in the fall, allowing no fall growth to develop, which was unfavorable to food storage and the development of crown buds. The buds developed in the fall make the next year's hay crop.

In time-of-cutting experiments in Wisconsin, Graber et al. (3) reported a gain of 26 percent in hay the next season from plots cut to insure high food storage and winter protection over those which went into the winter with low reserves and no protection. A similar experiment at this station showed a gain of 16 percent in the yield of the first cutting the next spring.

The conclusions are that from the standpoint of hay yield, quality of hay and permanency of stand, alfalfa can be harvested in the early stages of bloom the first and second cuttings, provided the later cuttings are allowed to go to approximately full-bloom stage and the last cutting is made not later than September 15. The only exception to this is that fall-seeded alfalfa should not be cut early the first spring. Local conditions will vary and weather conditions may be different from year to year. Some years three crops will be harvested and in others four crops, or one or two hay crops and a seed crop may be produced; but high food reserves in the root can be accomplished under any condition by careful management.

TO INCREASE SEED YIELDS

Actual farm experiences of some Kansas alfalfa seed growers have convinced them that more alfalfa seed can be produced per acre by allowing the crop previous to the seed crop to go to the full-bloom stage. The reason usually given for this practice is that the field being left for seed will come into bloom later than most fields in the community, thereby getting a heavier concentration of bees for tripping the flowers. Whether this reasoning is right or wrong, the results have been good.

Recent experiments conducted at the Manhattan and Garden City experiment stations indicate that one of the factors affecting alfalfa seed yield is the accumulation of food reserves. The results of three years of field experiments at the Garden City station show that high food reserves increased the seed yield of alfalfa 16 pounds per acre over the low food reserve treatment. Greenhouse and field experiments at the Manhattan station corroborated these results. If the yield of all of the 153,000 acres harvested for seed in Kansas in 1944 had been increased by 16 pounds per acre, the total would have amounted to more than 40,000 bushels.

There are other factors that affect the amount of seed produced such as weather and insects. These two are closely related because the activities of insects are regulated considerably by weather conditions. Weather also affects the type of plant growth and the amount of food reserves in the roots, determining the number of racimes and flowers. Weather and insects will be discussed more fully under harvesting alfalfa seed, page 43.

HARVESTING ALFALFA FOR FORAGE

HIGH QUALITY HAY

The factors that affect quality in alfalfa hay are influenced by methods of hay production. The emphasis in all haying operations should be to secure quality. This is not only true for the hay to be fed on the farm, but is also true for the product to be marketed as hay or meal. The dehydrated products are bought almost entirely on the basis of quality.

High grade alfalfa hay, as stated by Parker (15), must have high purity, high percentage of clinging leaves, and a green color. Leafiness and color correlate with carotene and protein content, as the leaves contain a much higher percentage of these important nutrients than do the stems.

There are a number of vitamins found in alfalfa hay, vitamins A, C, D, and G being the ones most often discussed in the literature. Vitamin A is the one the livestock feeder associates with quality.

The retention of leaves and a green color are the two things most desired by the hay producer. The time of cutting and haying methods practiced should be done with these in mind. Experiments conducted at this station and at others have shown that there is a direct correlation between the percentage of leaves and the percentage of proteins and that the highest percentage of leaves is obtained by cutting in the early stages of bloom. On the other hand, the largest yields of hay are obtained when the alfalfa is cut between the one-tenth bloom and full-bloom stages. Also, the highest yields of protein per acre are obtained when the crop is cut somewhere between these two stages. There is a gradual decrease in the percentage of protein as the crop matures, but the yield per acre becomes larger. Table 13 shows the effect of cutting at different stages of growth on the yields of hay and protein.

Because leaf color and percentage of leaves are important in hay quality, the best method of haying will be the one that saves the most leaves and retains the green color. According to the data in Table 13, the percent of leaves in alfalfa hay varies from 41.6 to 53.4, depending on the stage of maturity at time of harvesting. Therefore, a loss of leaves is a definite loss of yield and quality.

In making hay, the shorter the time consumed in the curing process, the better the chances are of getting high quality, but the methods employed to obtain rapid drying must not be done to the detriment of a high degree of leafiness. If hay is too dry when handled, the leaves shatter badly; therefore, it is necessary to handle it when it is partially dry or slightly tough. Alfalfa hay with the leaves dry and stems slightly tough contains about 25 percent moisture and can safely be stacked or stored loose in the barn. Hay can be baled from the windrow with a similar amount of moisture if the bales are piled to allow for ventilation. New-mown hay contains from 70 to 80 percent moisture, depending on atmospheric conditions when cut. Well air-dried hay contains about 12 percent moisture.

TABLE 13. —*Effect of stage of maturity of alfalfa on yield of hay, percent of leaves and protein, and total protein produced per acre (average for 8 years).**

STAGE OF MATURITY.	Yield of moisture-free hay per acre.	Leaves in hay.	Protein in hay.	Total protein per acre.
	Tons	*Percent*	*Percent*	*Pounds*
Bud stage	2,427	53.4	19.78	960
One-tenth bloom	2,931	51.1	18.92	1,109
Full bloom	3,037	48.4	17.63	1,071
Seed stage	2,647	41.6	16.04	849

* Compiled from Technical Bulletin 15, Kansas Agricultural Experiment Station.

Overdrying is probably the most common cause for the loss of hay quality. It is often unavoidable, particularly when the operator is handling too many acres for his equipment. The best method of curing to obtain quality is to allow the hay to wilt in the swath and finish curing in the windrow. Windrowing after wilting will

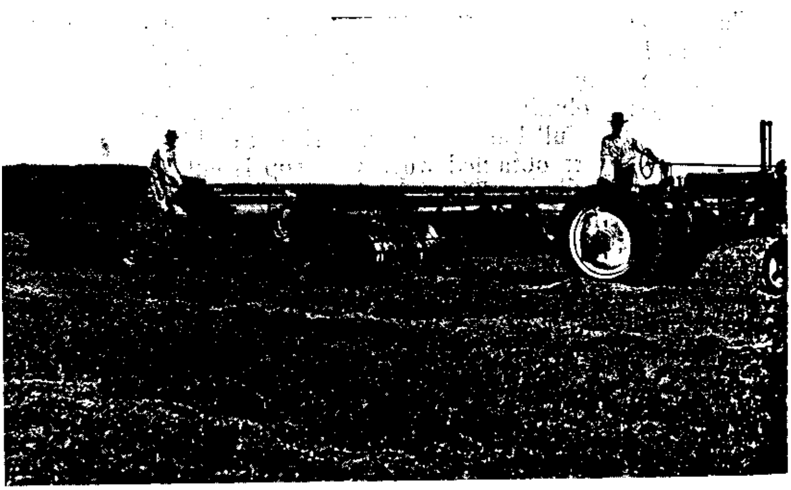


FIG. 16. —Modern haying equipment will enable the producer to save quality in hay. By the use of the pickup baler under good weather conditions the hay is not moved after it has become dry enough to shatter except as it is picked up by the baler.

slow down the curing process, and thereby prevent overcuring. Hay cured in this manner will go into storage with a higher percentage of leaves, carotene and protein.

Weather is an unpredictable factor in haying in Kansas, thus making it impossible to make definite statements on how and when to perform certain operations or on the type of machinery best suited. Long-time operations should be planned to obtain high yields and quality and at the same time avoid damage to the stand. Overcuring should be avoided to prevent loss of leaves, and curing in the windrow should be practiced to save carotene and color.

There are a number of methods of storing alfalfa hay, the most common practice being to bale or stack from the windrow. With the advent of the pickup baler, baling from the windrow is becoming quite general. (Fig. 16.) Baling from the windrow is a good method to obtain good quality hay, weather permitting. Because of the rapidity with which the hay can be handled, there is a minimum loss of leaves. The hay is moved only once after it is cured sufficiently to cause shattering of leaves, and that is by the baler when it is being picked up.

As stated previously, the weather may change the situation and considerable damage may be done to the hay before it can be baled from the windrow. The difference in time that it takes the hay to become dry enough for the pickup baler and when it is dry enough for the stack may mean the difference between good hay and poor hay. The risk is justifiable where large amounts of hay are handled. When small acreages are involved, the best method is to store the hay as quickly as possible in the stack or barn.

Stacking in the field is the most economical method of storing the hay if properly stacked. A well-made, large stack is the most practical because of the lower percentage of weather damage on the outside. A rectangular stack with the same width and length as the diameter of a round stack, both having the same overmeasurement, will have much less outside weathered hay per ton than a round stack. Therefore, the large square or rectangular stack is the most economical one to use.

ALFALFA SILAGE

Alfalfa silage, properly made, is the best method of harvesting alfalfa to conserve all of the feeding value of the plant. In good alfalfa silage none of the leaves is lost and the carotene content is practically the same as in the fresh material. The interest in the use of alfalfa as a silage crop is growing and the practice may become more generally followed. The making of alfalfa silage requires more care than the making of silage of most other crops. The carbohydrate content of alfalfa is relatively low and the protein content high. The reverse is true with crops like corn and sorghums that are known as ideal ensilage crops. The fermentation and bacterial action necessary to make good ensilage will not take place in the abscence of carbohydrates in the alfalfa. Unless the carbohydrates are supplied in the form of molasses or by adding acid to give the proper acidity, the bacteria may act on the proteins, breaking them down into vile smelling substances that make the ensilage unfit for feed.

Alfalfa in the later stages of bloom will have more carbohydrates in the forage than when cut in the bud stage; also, a lower percentage of water which, according to Armstrong, et al. (1), is desirable in making alfalfa silage. A moisture content of from 60 to 70 percent is most satisfactory. When moisture is insufficient, water may be added. If the moisture is above 70 percent, dry roughage should be added. Dry sorgo or corn fodder, threshed alfalfa stems, etc., are among the dry roughages suitable for lowering the moisture content of the green alfalfa. The exact proportion of dry roughage to alfalfa will depend on the moisture content of each type of feed. From 15 to 25 percent of the total silage mixture may consist of dry roughage. The mixing can be done on the cutter table as the silo is being filled.

Molasses is often used to raise the carbohydrate content of the alfalfa forage for silage. This material contains from 50 to 60 percent sugar and only a small amount is needed. Alfalfa cut in the early stages will require more molasses because of its higher water and lower carbohydrate content than alfalfa cut later. The amount of molasses to add will vary from 40 to 80 pounds per ton of ensilage. Corn and cob meal is also successfully used by mixing at the rate of 200 to 300 pounds per ton.

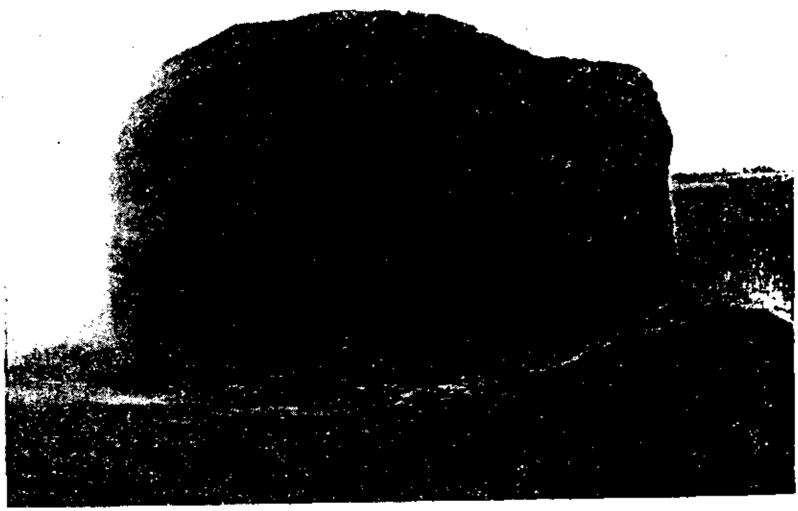


Fig. 17. —Chopping alfalfa hay is an economical method of storing feed. Because of the danger of overheating and catching fire, great care must be taken that the hay moisture content is down to approximately 20 percent before stacking.

ALFALFA MEAL

Alfalfa meal is a product of cured alfalfa, usually sun-cured, stacked and ground later on the farm or by a commercial mill. The quality of the meal depends entirely on the hay used. Therefore, the discussion under the preceding paragraph on good quality hay will hold true for good quality meal.

Leaf meal is made by screening the leaves from the stems. If made from high quality hay, the meal will be a high protein feed used largely in the making of mixed feeds.

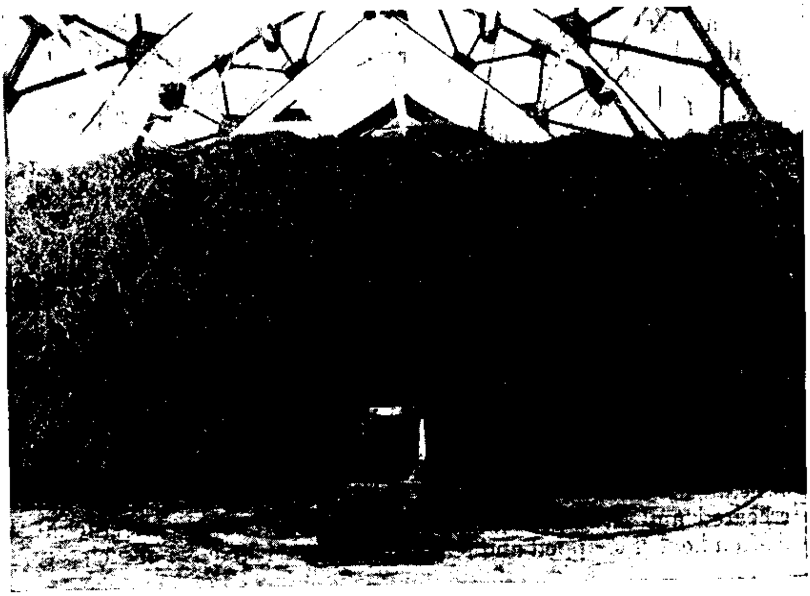
CHOPPED ALFALFA

Chopping alfalfa hay and stacking in the field is a common method of storage. The chopping is done by running the field-cured hay through an ensilage cutter. The chief advantage of chopping hay is that the stock will consume both leaves and stems. Otherwise it is no better as a feed than the hay before it was chopped. It is difficult to keep chopped hay from heating in the stack. Most of the hay handled in this manner will heat sufficiently to be browned. Figure 17 shows chopped hay in the stack that became overheated and caught fire. Hay that is dry enough for stacking will often heat if chopped and stacked, because it packs more closely.

BARN-CURED HAY

The artificial curing of hay in the barn is coming into prominence, particularly in areas where difficulty is encountered in field curing because of weather conditions. Curing in the barn is accomplished by the use of the hay drier. Hay that is to be barn cured is usually cut in the morning, allowed to wilt in the swath from four to five hours if the weather is favorable for curing, and brought to the barn to finish curing. Hay handled in this manner will be reduced from 75 percent moisture to approximately 45 percent in the field and dried by the drier in the barn down to a satisfactory storage content of 20 percent. Figure 18 shows hay being dried in the barn and a plan for a barn hay drier.

The hay drier consists of a blower-type fan used to force air through air ducts built on the barn floor, so designed to give an excellent distribution of air over the entire mow. A layer of hay is evenly distributed over the mow floor not to exceed seven or eight feet in depth for good drying. After this layer is completely cured, another layer may be placed on top of it. For best results the total depth should not exceed 14 feet. The time it takes to cure the hay will depend on the amount of moisture in the hay when brought into the barn and the amount of moisture in the outside air that is being forced through it. The main advantage of a hay drier is to save leaves and color, the chief source of carotene and protein. This is not always possible with field curing.



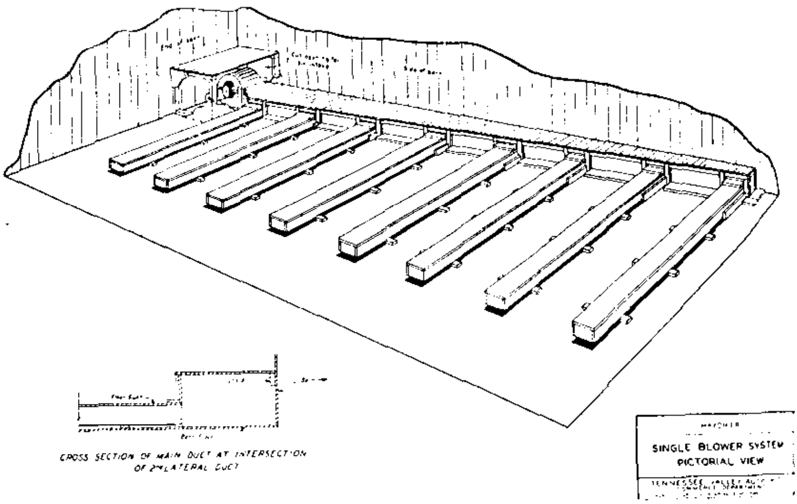


FIG. 18. —The barn hay drier is relatively simple to construct and operate. It must be properly designed for a specific mow, to do a satisfactory job. For particulars, write the Department of Agricultural Engineering, Kansas State College, Manhattan.

DEHYDRATION

Dehydrating alfalfa is a good method of processing the forage to save the food value of the crop. Dehydrating prevents the loss of leaves, insures high protein and carotene content. Dehydrated alfalfa meal made from good alfalfa is a high carotene feed and is used largely by the mixed feed manufacturers. The carotene content of dehydrated alfalfa is much higher than of the sun-cured hay. To hold this high carotene content it is necessary to store the dehydrated product in a cool place or the carotene will disappear rapidly.

Pollock et al. (17) state that the loss of carotene from hay during storage will average 3 percent per month during the winter months when the temperatures are 45° F. or less, and at the rate of 17.8 percent during the summer months when temperatures ranged 66° F. or higher.

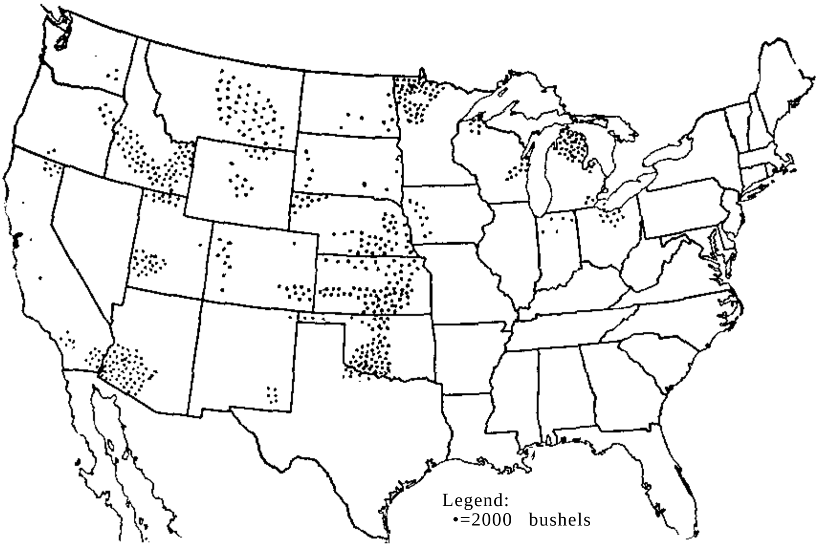


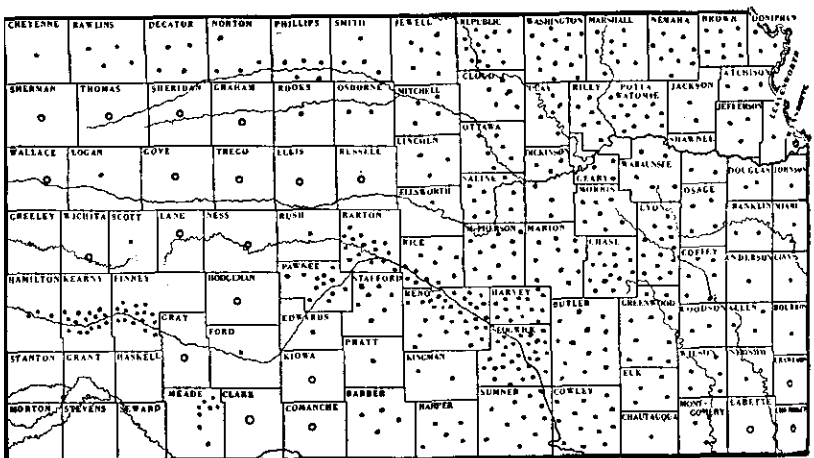
FIG. 19. —Average annual alfalfa seed production in the Untied States for 1933-1942. Kansas leads in alfalfa seed production with an average of 135,840 bushels.

HARVESTING ALFALFA FOR SEED

ALFALFA SEED YIELDS

The demand for Kansas-grown Kansas Common alfalfa seed has made Kansas the leading alfalfa seed-producing state. From 1933 to 1942 Kansas produced an average of 135,000 bushels of seed. (Fig. 19.) In 1942 the farm value of the alfalfa seed produced in Kansas was $1,970,000. The production of alfalfa seed in Kansas is an uncertain farm operation. However, in a few areas it has become a major crop. The majority of the alfalfa seed is produced in the eastern half of Kansas with heaviest production concentrated in the Arkansas valley. (Fig. 20.) Other high producing areas are in the irrigated section of the Arkansas valley from Finney county west to the Colorado line and on the creek bottom lands of northwest Kansas. The 10-year average yield per acre is 1.59 bushels per acre. This small yield is probably because most of the seed is produced on dry land and that no special effort has been made to increase it.

Recent experiments have shown that certain practices will increase seed yields. (See heading "Increased Seed Production.") The increase shown by these experiments, if accomplished in actual production, would mean an annual increase of three-quarter million dollars in the farm value of the alfalfa seed crop.



Legend: • = 250 bushels. o = Less than 125 bushels.

FIG. 20.—Average annual alfalfa seed production in Kansas for 1933-1942. The seed-producing areas of the state are in the Arkansas valley and in east central Kansas, west of the Flint Hills.

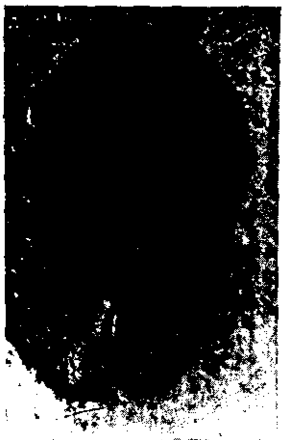
FACTORS AFFECTING SEED PRODUCTION

The question that is most difficult for the grower to answer is whether to leave the alfalfa crop for seed or harvest it for hay. Some of the factors the grower can control to make conditions more favorable for seed production are:

1. Having high food reserves in the roots and, when grown under irrigation, regulating the water in order to produce a slow growing, medium heavy top growth.
2. Control flowering weeds and other competitive crops.
3. Encourage the bee population by keeping bees or providing space for an apiary.
4. Protect the nesting place of the wild bees usually found on or near the ground in waste places.

If these have been taken care of then the more or less unpredictable factors are the weather and insects. It would be helpful to study the long-time weather reports to determine the trend of the general weather conditions. Sunshine and below-normal rainfall are usually associated with good seed setting in alfalfa.

The grower should observe the field closely when in bloom to determine whether the flowers are setting pods or falling off, sometimes called "stripping." If the flowers are stripping, it is an indication that they are not being tripped by the insects. (Fig. 21.) A few



Courtesy Nebr. Agr. Expt. Sta., Res. Bul. 124

Fig. 21. —Alfalfa will set very little seed unless the flowers are tripped. Most of the tripping is done by insects. *(Right)* A flower that has been tripped. *(Left)* An untripped flower.

days of weather favorable for insect activity often will make the difference between a poor and a good seed crop. The tripping of alfalfa flowers is done largely by insects and the extent of insect activity is closely associated with weather conditions. Insect activity is usually greatest on dry, hot days. Insect surveys have shown that solitary or ground bees, *Nomia* and *Megachile* spp. (Fig. 22) are the most effective trippers of alfalfa flowers. The honeybees, *Apis mellifica,* generally do not trip many flowers, but if they are numerous and active they may do considerable tripping. Instances have been reported where honeybees were very effective trippers, but it is thought that when this occurs it is because they are after a supply of pollen. Bumblebees, *Bombus* sp., are effective trippers of alfalfa flowers. However, there are so few of them that they do not greatly increase the total number of flowers tripped.

The alfalfa flower is not easily tripped. Therefore, if the insects are after pollen, they are apt to go to other plants where it may be more easily obtained. Competition between alfalfa fields, between alfalfa and sweet clover, or between alfalfa and wild flowers such as the sunflower, Spanish needle, broomweed, smartweed, chickory,

gum weed, basswood, etc., may be a factor in determining seed yield. This could be particularly true if the weather conditions at the time the alfalfa is in bloom are unfavorable for insect activity.

As most of the alfalfa seed produced in Kansas is non-irrigated, the weather and the amount of soil moisture will affect the type of plant growth. If the alfalfa seed crop starts its vegetative growth with high food reserves in the roots, the ideal weather condition would be one which produces a slow, steady growth throughout the vegetative period with a slight increase at flowering time. This condition will usually accompany a slightly below optimum soil moisture condition up to the bloom stage and optimum soil moisture through the fruiting period.

HARVESTING THE SEED CROP

In Kansas, the crop left for seed varies from the first to the third. However, in normal years it is the third in eastern Kansas and the second in western Kansas. The crop to be left for seed should be determined by observing the conditions given in the preceding paragraph. The quality of the seed harvested depends on the weather condition during the curing of the crop. All the seed pods will never be ripe at the same time. Therefore, the grower must be the judge to determine when a majority of the pods are in the yellow and brown stage. Pods that are plump and yellowing will mature after cutting. If the weather is dry during the ripening period, shattering will be light. If intermittent showers occur, much seed may be lost by shattering.

The method used in handling the seed crop will depend on the prevailing weather conditions. With favorable drying, the best method is to use a windrower attachment on the mower and allow the hay to cure in the windrow and thresh with a pickup combine. Under the most favorable ripening conditions, seed is sometimes combined standing in the field like wheat. Some growers who cannot thresh immediately from the windrow will cock the hay and allow it to cure in the cock and haul it to the thresher.

A profitable seed crop may be lost because unfavorable weather makes it necessary to allow the crop to become over ripe or to be handled several times in curing. If the seed crop can be harvested by early September, there is a good chance of getting the seed cured

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FIG. 22.—Upper left, A carpenter bee *(Xylocopa virginica* Dru.) (Family Xylocopidae) on alfalfa blossoms. Upper right, A sweat bee *(Augochlora striata* Prov.) (Family Halictidae) a small, shining, metallic-green bee on alfalfa. Center left, A small leaf cutter bee *(Megachile brevis nupta* Cress.) (Family Megachilidae) a common, small, bee recognized by a high-pitched tone in flight. Center right, A bumble-bee, *(Bombus pennsylvanicus* Deg.) (Family Bombidae) on alfalfa blossoms. Lower left, The common honeybee *(Apis mellifica* Linn.) (Family Apidae) on alfalfa. Lower right, a soil burrowing bee *(Protandrena trifoliata* Ckll.) (Family Andrenidae) a common, short-tongued, burrowing bee on alfalfa flowers.

All bees shown are about twice natural size. Determinations by J. C. Crawford, Bureau of Entomoloogy and Plant Quarantine, Washington, D. C.

with a minimum of loss. The modern combine thresher equipped with proper sieves is a satisfactory machine to thresh alfalfa seed. A good operator can adjust these machines so that very little cleaning will be necessary to obtain seed with a high purity.

GROWING CERTIFIED SEED

The International Crop Improvement Association and Kansas Crop Improvement Association have established certain standards of certification for alfalfa seed that will insure the purchaser of certified seed that he is obtaining a recognized approved variety of high quality and germination. In order to produce certified alfalfa seed certified seed must be planted on clean ground which has not grown alfalfa for at least two years. The seed crop to be certified must be field inspected by a representative of the association. The reports of this inspector and the results of the purity and germination tests of the seed samples will determine whether the seed can be tagged and sold as certified seed. The rules and regulations for certification can be obtained from the secretary of the Kansas Crop Improvement Association, Manhattan, Kansas.

The Kansas Seed Law passed in 1935 was made to protect the purchaser of seed. The latest figures available show that the Kansas Seed Laboratory at Manhattan tests on an average a thousnnd samples of alfalfa seed each year. A majority of these are commercial samples that are going through the regular marketing channels. Nearly 10 percent of all of the samples tested are unsalable, according to the State Seed Law, because of noxious weeds or low germination. The average germination of all samples tested was 71.5 percent, with a purity of 96.6 percent. Comparing these averages with the minimum requirements (90 percent germination and 97.5 percent purity and no noxious weeds) of the Kansas Crop Improvement Association for certification, the value of certified seed becomes apparent.

In reports on germination tests, the words “hard seed” refer to seed that is viable but does not germinate readily. According to the State Seed Laboratory reports, the samples tested average 16 percent hard seed. New seed, if tested soon after harvesting, will often show more than 30 percent hard seed.

ALFALFA FOR PASTURE AND GRASS MIXTURES

Alfalfa is not generally used as a pasture crop in this country. However, its use in this manner seems to be growing in popularity. In countries such as Argentina it is almost universally used for grazing alone. From the standpoint of seasonal distribution and total yield, alfalfa makes a good pasture crop. It is necessary to pasture it with care or the stand will soon be killed out. The same principles hold true for pasturing alfalfa as for cutting, that is, the plants need protection to build up root reserves, particularly in the late summer and fall.

The grazing should be regulated to allow the top growth to maintain a height of from three to six inches. In the fall it should be allowed to reach a height of six to eight inches and remain that way until the tops are frozen back.

TABLE 14.—*Effect of alfalfa on yield of perennial grasses, Manhattan, Kansas. Yields given in pounds per acre.*

	Pounds air-dry hay per acre.						
	1927	1928	1929	1930	1931	1932	Average
Bromegrass (Av. of 2 plots)	5,960	3,185	3,040	1,480	2,700	2,088	3,076
Ky. bluegrass (Av. of 2 plots)	3,580	3,980	1,880	1,627	2,656	2,570	2,717
Orchard grass	7,200	3,440	3,200	1,744	3,868	2,944	3,899
Bromegrass, Orchard grass, Ky. bluegrass — Mixture	8,400	2,920	1,760	4,572	3,728	2,332	3,952
Bromegrass, Orchard grass, Ky. bluegrass, Alfalfa — Mixture	7,640	8,960	6,592	7,176	7,392	8,460	7,603
Bromegrass, Orchard grass, Alfalfa — Mixture	6,600	6,320	6,272	5,638	6,704	7,664	6,553

Alfalfa is recommended to be used in grass mixtures as a means of preventing or delaying a sod-bound condition that occurs in some grasses if they are seeded alone, and to increase the nutritive value and yield of the forage by supplying nitrogen. (Table 14.)

The alfalfas commonly grown are not well suited for pasture mixtures, as they have an upright type of growth and the stock keeps them grazed too close unless properly managed. Stock will graze the alfalfa first if accessible, except in the case of the most palatable species of grasses. Recent attempts to develop new varieties with growth habits better suited for grazing have made some progress. The types showing the most promise are those which have a prostrate habit of growth and a habit of spreading from the crown shoots and taking root. This type cannot be grazed out so quickly.

Bloating. —There is always danger from bloating when pasturing alfalfa with cattle or sheep. Those who make a practice of grazing alfalfa have learned to take precautions and find that the advantage in favor of pasturing alfalfa outweighs the disadvantages. The danger of bloating will be greatly reduced if the livestock is well fed before being turned onto the alfalfa pasture and if a good supply of salt and water are accessible at all times. Also, the danger will be less if the stock is grazed continuously day and night or if they have access to dry roughage.

DISEASES OF ALFALFA[4]

Diseases are important factors in the production of alfalfa in Kansas, in that they affect the yield and quality of hay produced. It is impossible to estimate accurately how much damage alfalfa diseases actually cause in the state. The crop is subject to many diseases of which only those of economic importance will be discussed in detail, some of which attack the roots and crowns, and others the stems and leaves.

BACTERIAL WILT

Jones (7) states that bacterial wilt (*Corynebacterium insidiosum* (McC.) Bergey et al.) is the most destructive disease of alfalfa in the United States. In Kansas, it causes a loss greater than that of all other alfalfa's diseases combined. The disease is generally distributed over the state, but is more severe in eastern Kansas and diminishes in severity in central and western Kansas with the lower rainfall. It is, however, serious in irrigated alfalfa fields in the western part of the state. Due to bacterial wilt, alfalfa stands often become unsatisfactory for production after the third year.

Alfalfa plants infected with bacterial wilt are dwarfed, and yellowish or pale green in color. The stems are short and usually excessive in number. (Fig. 23.) The leaves are small, yellowish green in color and often curled. During hot weather, severely infected plants sometimes show wilting. The disease can be differentiated from root rots by digging infected plants and cutting the roots diagonally (Fig. 23), exposing the brownish-yellow ring under the bark of the taproot. Discoloration due to other root rots often occurs in the center of the roots or as brownish streaks.

The bacteria causing this disease live in the soil. They may spread from infected to healthy plans by mowers and other farm machinery, by drainage water, or by wind-blown soil. When the soil is infected with these bacteria, winter injury and insect injuries to roots favor the spread of the disease in the spring under conditions of abundant moisture.

The only known method of controlling bacterial wilt at the present time is the growing of resistant varieties of alfalfa. Buffalo alfalfa, a selection made from Kansas Common, is highly resistant to this disease. When growing susceptible varieties of alfalfa, the life of stands may be increased by proper cutting, especially avoiding any practice which favors winter injury.

4. This section prepared by E. D. Hansing, Department of Botany, Kansas Agriculture Experiment Station.

FIG. 23.

Right—Plant infected with bacterial wilt is dwarfed, pale green to yellow in color and has a brownish yellow ring inside the bark of the tap root.
Left—Healthy plant. Bacterial wilt is the most destructive disease of alfalfa in Kansas. This disease can be controlled by growing resistant varieties of alfalfa such as Buffalo.

BLACK-STEM

Black-stem *(Ascochyta imperfecta* Peck) is a major disease of alfalfa in Kansas. During cool, wet spring seasons this disease occasionally causes death of the stems and serious defoliation. The disease is most severe on the first crop of alfalfa in the spring

FIG. 24.—(Upper) Black-stem lesions on the petiole, stipules, and leaves of alfalfa. (Lower) Spore-bearing bodies (pycnidia) of *Asocchyta imperfecta* on over-wintered stems of alfalfa. Black-stem is one of the major diseases of alfalfa in Kansas.

which is produced during the wettest and coolest period of the growing season. It is negligible on the second and third cuttings, but increases considerably on the fourth crop when the weather is cooler and more humid.

The disease is characterized by dark brown or black spots on the stems and leaves. (Fig. 24.). Severely infected stems turn dark brown or black and die. Immature spore-bearing bodies (pycnidia) develop in the older stems in the winter and by the following spring the stems are often covered with them. The leaf lesions vary in size and shape and sometimes coalesce, forming irregular shaped lesions. Heavily diseased leaves turn yellow and wither before they drop. Defoliation commences with the lower leaves and progresses upwards as the disease becomes more severe. Petiole lesions occur as small, black or brown elongated spots and cause the leaves to wither and drop off.

At present there is no satisfactory control of black-stem. It has been demonstrated in plots at this station that the removal of crop residue by burning or raking during the winter would reduce the severity of the disease the following spring. This control, however, would not be practical in commercial fields of alfalfa.

At present there are no satisfactory commercial varieties resistant to black-stem. Peterson and Melchers (16) and Koepper (9), however have obtained selections which are somewhat resistant, thus showing the possibilities. The breeding of good varieties of alfalfa resistant to black-stem will probably be the only practical control of this disease.

YELLOW LEAF BLOTCH

Yellow leaf blotch [*Pseudopeziza jonesii* (Fckl.) *Nannf.*] was first reported in the United States in 1916 by Melchers (11) in Kansas and Jones (7) in Wisconsin. The disease has been of major importance in Kansas ever since it was first observed. In 1916 Melchers (11) reported that in many fields the disease caused a loss of 40 percent of the leaves of the first and second crops. During the last 10 years alfalfa fields infected with yellow leaf blotch have been fairly common.

This disease is characterized by yellowish-orange blotches on the leaves with their long diameters parallel to the direction of the veins. (Fig. 25.) At the time of the first appearance of the leaf blotches or shortly thereafter small orange-colored points appear in the central portions of the blotches primarily on the upper surface of the leaves. These points eventually turn dark brown to black. They are the spore-bearing bodies (pycnidia) of the fungus. During the later stages of the disease, heavily infected leaves curl more or less at the margins and eventually die.

Yellow leaf blotch occurs on the stems but not so abundantly as on the leaves. Stem lesions are elongate and soon turn a dark chocolate brown. Spore-bearing bodies are less common in stem lesions than in leaf lesions. These lesions are generally not numerous enough to cause death of the stems.

There is no satisfactory method of controlling this disease. Losses may be reduced by mowing the crop before the disease becomes severe or causes defoliation.

FIG. 25.—Yellow leaf blotch. Note the yellow blotches within which are the brownish-black, pin-point-like dots containing the spores of the fungus. This disease is of major importance in Kansas, sometimes causing 40 percent defoliation in the first and second cuttings.

VIOLET ROOT ROT

Violet root rot [*Rhizoctonia crocorum* (Pers.) DC.] of alfalfa was first observed in Kansas in 1899 *(12).* It has never become a disease of major importance in Kansas. This disease is more prevalent in years of heavy rainfall and in fields where there has been inadequate drainage.

The disease occurs in spots in the field. (Fig. 26.) In each case the disease starts from a center of infection and the fungus spreads in all directions through the soil, killing most of the plants as it progresses. Diseased alfalfa plants are characterized by the reddish-brown or violet color of the roots and crowns. This color is due to the vegetative threads of the fungus causing the disease. The fungus penetrates the roots and crown and produces a decay. In advanced stages of the disease the bark sloughs off very easily.

Violet root rot may be controlled by crop rotation and adequate drainage.

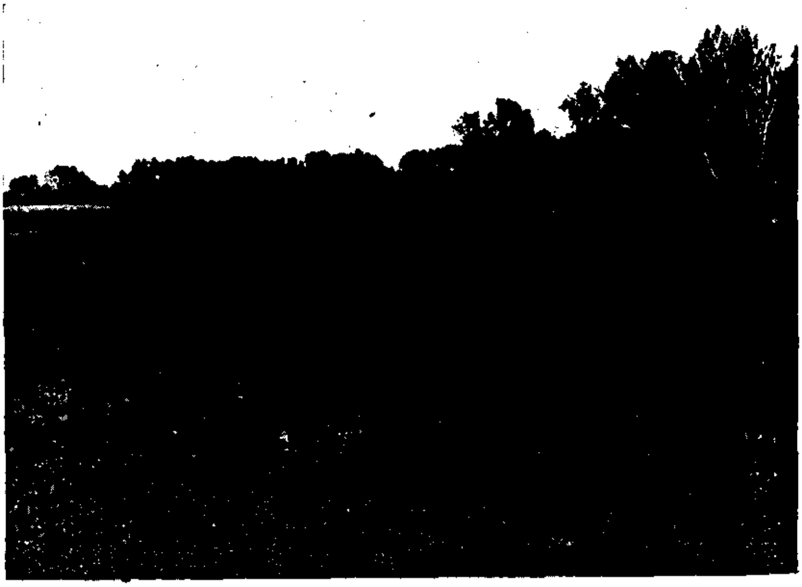

FIG.—Violet root rot in alfalfa field on Blue river bottom near Manhattan. This disease occurs in one to several circular spots in the field. The roots and crowns of the plants are dark reddish-brown to violet in color. This disease can be controlled by rotation and adequate drainage.

RUST

Alfalfa rust *(Uromyces striatus* Schroet) is a minor disease of this crop in Kansas. In years when there has been moderate to heavy rainfall during the summer and early fall, alfalfa is sometimes heavily infected during the latter part of the growing season. The rust generally does the greatest damage to the crop that is being grown for seed. Occasionally, newly seeded alfalfa is heavily infected with this disease. This situation prevailed in the fall of 1944 when newly seeded alfalfa stands were as heavily infected as older alfalfa stands.

Alfalfa rust is characterized by cinnamon-brown pustules on the lower surface of the leaves. The color is due to the mass of powdery spores which has broken open to the surface of the leaves.

To date there has been no practical control of this disease. Mains *(10)* and Koepper *(9)* have demonstrated that alfalfa selections vary in their susceptibility to this disease. Consequently resistant selections which are good agronomically may be bred in the future.

OTHER LEAF SPOTS

Leaf spots are common on alfalfa in Kansas. They occur principally in the spring and fall during periods of cool wet weather. In some years, however, they are common, especially during the early part of the summer. These diseases first appear as scattered spots on the leaves but as the spots increase in size they become more numerous and often coalesce. Heavily infected leaves turn yellow, wither, and drop off. Defoliation, due to leaf diseases, is of great importance since the leaves contain a much higher percentage of protein and minerals than the stems.

Leaf spot [*Pseudopeziza medicaginis* (Lib.) Sacc.] and downy mildew *(Peronospora trifoliorum* D By.) are fairly common diseases of alfalfa in Kansas during certain years but they have never been of major importance. Some of the other leaf spots which are minor diseases of alfalfa in the state are Pseudoplea leaf spot [*Pseudoplea trifolii* (Rostr.) Petrak.], Cercospora leaf spot *(Cercospora zebrina* Pass.), and Bacterial leaf and stem spot *(Pseudomonas alfalfae* Riker, Jones and Davis).

There is no practical way of controlling the leaf spot diseases of alfalfa. Where attempts have been made to select for resistance, progress has generally been made (9, 10, 16). The production of good alfalfa varieties which are resistant to bacterial wilt and to several of the more important leaf spots will require many years of selection and possibly hybridization.

ALFALFA INSECTS[5]

An alfalfa field provides a most favorable environment for large populations of many different kinds of insects. Alfalfa is green and succulent from early spring until late fall, and much of the time it offers a cover of heavy foliage for shelter, protection and food. Many insects in an alfalfa field cause little or no damage; in fact, some are beneficial; but every part of the plant is subject to damage by one insect or another. Curculio larvae consume the fibrous roots and nodules and gouge into the tap root and crown; aphids and leafhoppers suck juices from the stems and buds; grasshoppers and cutworms consume any part of the plant above the soil; fly larvae mine through the leaves, leaving intricate trails behind them; Lygus bugs blast the buds and developing seeds; and chalcid larvae consume all of the substance within the seed coat. A few of the more injurious insects are discussed briefly and control measures are suggested.

INJURIOUS INSECTS

Grasshoppers.—These insects are destructive to alfalfa in some parts of Kansas nearly every year and they must be combated to save the hay and seed crop and to prevent injury, particularly to new stands. There are at least four grasshopper species involved, each species having its own peculiar life history and habits. If the eggs of the injurious grasshoppers are deposited within the alfalfa field, control measures may be required over the entire field. When the eggs are deposited only in fence rows, roadsides and adjoining crops, early treatment of those areas may prevent migration to the alfalfa. An outbreak of blister beetles often accompanies a grasshopper outbreak since the larvae of the blister beetle feed on grasshopper egg pods.

CONTROL

The standard insecticidal control for grasshoppers is poisoned bait which is prepared as follows:

Standard wheat bran or mill-run bran (1 part) plus sawdust 3 parts)	25 pounds
Paris green or crude white arsenic, or	
sodium fluosilicate	1 pound
or sodium arsenite	1 pint
Water	about 3 gallons

If the above formula is to be sowed in rank succulent vegetation, the following ingredients may add to its effectiveness:

Syrup or blackstrap molasses	2 quarts
Citrus fruits	3 fruits

In preparing the bait, the dry ingredients are mixed thoroughly, the liquids are mixed and then added to the dry materials. Sufficient water is used to make a crumbly mash; one that is wet but

5. This section prepared by R. L. Parker and D. A. Wilbur, Department of Entomology, Kansas Agricultural Experiment Station.

which will scatter readily. This bait is distributed by hand or by bait spreaders over the infested areas. The above formula is sufficient for three or four acres.

The poisoned bait is sowed just before the grasshoppers start to eat in the morning. Their feeding ordinarily begins as soon as the temperature reaches 70° F. and may continue throughout the day provided temperatures are from 70° F. to 85° F. Baitings may not be successful above 85° F. or during damp weather. Alfalfa fields are treated most successfully immediately after cutting.

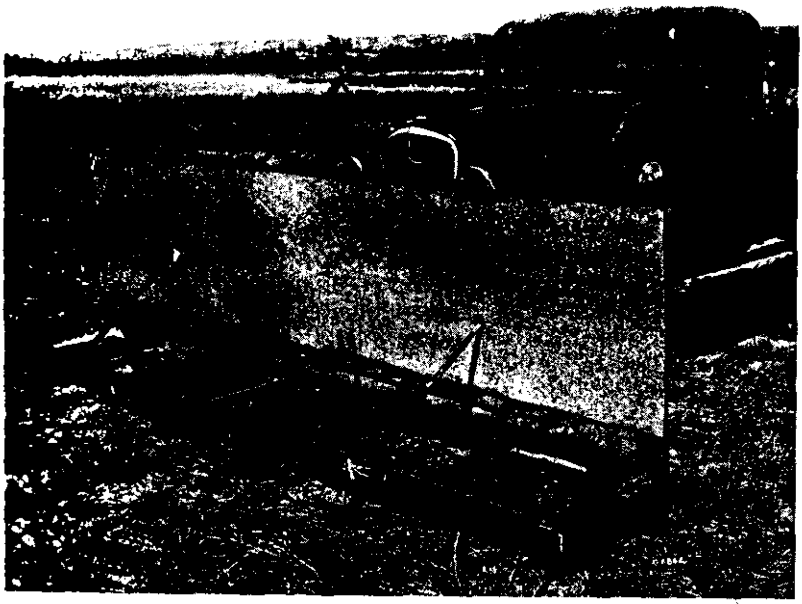

FIG 27.—A hopper-dozer being used on the agronomy farm at Manhattan

The hopperdozer mounted on runners or on the front of a truck (Fig. 27) can be used advantageously in collecting grasshoppers from alfalfa fields. Directions for building a hopperdozer may be secured by writing the Department of Entomology at Kansas State College.

Cutworms, Armyworms and Corn Earworm. —There are several species of cutworms and armyworms which together with the corn earworm feed on alfalfa foliage. Most of these insects feed at night and hide under surface litter or in the soil during the daytime. As a result, alfalfa fields may be severely damaged before the pest is discovered.

The army cutworms are injurious in the early spring, while the variegated cutworms are most serious during June. At the latter time the armyworms may be active also. During September and October the third and fourth cutting may be attacked by the fall armyworm. The corn earworm feeds on alfalfa throughout the summer.

CONTROL

The most successful control measure for this group of insects is the application of the same poisoned bait as recommended for grasshopper control. Since the cutworms and armyworms feed mostly in the evenings and during late afternoons of cloudy days, the poisoned bait is distributed during the late afternoon. The most successful results have been obtained when the bait is distributed soon after cutting.

Pea Aphid. —This is a small, green, soft-bodied insect which destroys alfalfa, vetch, clover and peas by inserting a slender piercing mouthpart into the stem or leaf of its host and sucking the plant juices. Plants which are attacked by large numbers of pea aphids become stunted in growth and have an unthrifty appearance. Soon the leaves turn yellow and frequently the plants die. The severe outbreak of pea aphids which occurred in the spring of 1921 was largely responsible for the destruction of more than 100,000 acres of alfalfa.

Pea aphids may overwinter on alfalfa plants either as wingless female aphids or as eggs. The eggs hatch in late February or early March and aphid activity starts at a time when most insects are still in hibernation. An aphid outbreak starts in small circular spots scattered over the alfalfa field. These initial spots enlarge rapidly and soon merge, so that the infestation covers the entire field. Most pea aphid outbreaks are eventually brought under control by ladybird beetles, syrphid fly larvae, minute parasitic wasplike insects, and fungus diseases, though generally this is not accomplished until after serious damage has been done.

CONTROL

When pea aphid damage is detected while the aphids are confined to small patches, the control problem is simplified. If these small areas are thoroughly sprayed or dusted with nicotine or rotenone-bearing insecticides, the aphid population is greatly reduced. A large canvas, dragged behind the duster over areas dusted with nicotine preparations, will increase the effectiveness of the treatment. New insecticides which will be on the market after the war emergency, may prove useful in pea aphid control on alfalfa.

Sowing calcium cyanide granules by hand or with a duster at the rate of 25 to 30 pounds to the acre over small infested areas is a satisfactory method of destroying pea aphids. First, a pole is dragged over the infested plants to knock the aphids to the ground; then the granules are scattered among the plants. There are four **PRECAUTIONS** in the use of calcium cyanide: (1) It is a violent poison, so neither the gas nor the dust should be breathed. (2) Excessive material may burn the plants. (3) The cyanide should be applied when the temperature is near 70° F. (4) The material should not be used when plants are wet or damp.

Dragging the alfalfa with a low platform dreg designed to catch the aphids as they are knocked off of the plants has been used successfully to reduce aphid populations below the danger numbers. Aphids collected on the platform are swept into bags and destroyed. When a series of chains, as old tire chains, are attached to the back of the platform, many of the aphids which are not collected on the platform will be killed. The platform should be about three feet wide and may be 10 or 12 feet long. The greater number of aphids are collected on the platform when it is dragged at a speed of four miles an hour.

Clover-seed Chalcid. —Occasionally, alfalfa growers have harvested a small crop of especially light-weight seed when prior to the harvest they considered that conditions were favorable for a large yield of alfalfa seed. Upon examination of the seed, it was found to be empty and to have one or more small circular and somewhat jagged holes in the seed coat. This was the work of a tiny wasp-like insect called the clover-seed chalcid. Soon after the female chalcid wasps inserted their eggs into immature seeds, the eggs hatched into white footless larvae. These consumed the contents of the seed, leaving only a thin seed coat.

CONTROL

Screenings accumulated during the threshing process contain many of the insects. To protect the next year's seed crop the screenings pile should be worked into livestock feed and utilized during the winter or it should be burned or otherwise destroyed.

Of equal importance is the destruction of all alfalfa along field margins, ditches, roadsides and other waste places, for such plants provide a continuous source of infestation.

Garden Webworm and Beet Webworm. —These insects are frequently injurious to alfalfa in Kansas. Their life history, habits and control are similar. They not only consume the leaves but they also spin a fine web which may completely envelop the plants. As soon as webbing is observed in an alfalfa field, the grower should look for pale, greenish-yellow to dark yellow worms which are marked with numerous black dots. If these are found, it is recommended that the alfalfa be cut immediately, since the hay crop may be lost.

BENEFICIAL INSECTS

Cross-pollination is necessary to seed-setting in most flowering plants, thus the flower-visiting insects are essential for production of seed. Alfalfa flowers must be tripped before seed-setting will take place. Tripping is the release of the staminal column from the keel of the flower, allowing it to snap forward onto the standard petal. (Fig. 21.)

The most important of these insects in alfalfa seed production are certain of the stem and soil-inhabiting solitary bees, *Megachile,* spp., and *Paranomia* spp. (Fig. 22.) *Megachile* spp., or leaf-cutter bees, are fairly common in Kansas, while the *Paranomia* spp., or alkali bees, may occur on the high plains and do occur on the mountain plateaus and valleys in the mountain states. Bumblebees, *Bombus* spp., are fairly effective pollinators, but again are relatively few in number. Honeybees, *Apis mellifera,* are not effective tripping agents, but do considerable tripping if present in large enough numbers.

The placing of colonies of honeybees adjacent to alfalfa fields at the rate of two to three strong colonies for every acre of alfalfa materially helps in pollination and seed-setting. The average seed production per acre is a little more than one bushel. This seed production could be increased to two to four bushels per acre by the encouragement of greater populations of the beneficial pollinating insects.

As a general rule, insects in their activities are influenced markedly by temperature. Weather conditions in which there is a lack of sunshine and concurrent relatively high temperatures, adversely influence insect activity. Nectar secretion is influenced by weather and soil conditions. The primary attraction in alfalfa to pollinating insects is the available nectar present in the flowers.

RODENTS[6]

POCKET GOPHERS

The pocket gopher is a serious pest in alfalfa fields. If uncontrolled these ground-living rodents may become so numerous in certain fields that the crop is no longer profitable. The mounds interfere with mowing and large numbers of plants are smothered.

Pocket gophers may be controlled satisfactorily by poisoning

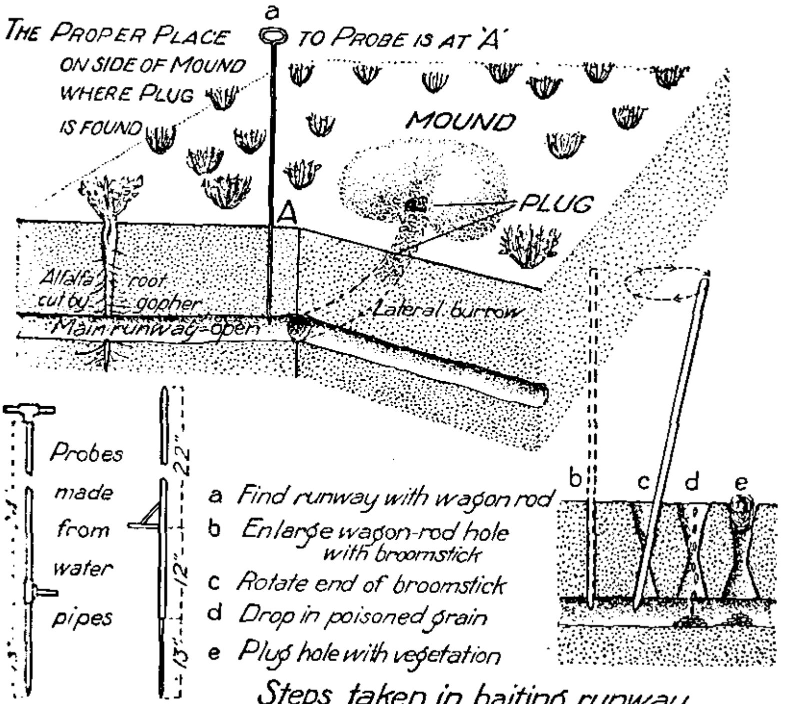

FIG. 28.—Diagramatic representation of a pocket gopher runway, showing method of placing poison.

with strychnine-treated wheat. Trapping is less effective and labor costs are considerably greater. Treated wheat or directions for preparing it may be obtained from the Department of Zoology, Kansas State College.

Poisoning Gophers. —Pocket gophers may be poisoned at any time they are active. Especially favorable seasons are late fall when burrows are being extended and early spring when new mounds are being thrown up.

In order to poison gophers successfully, one must understand the relations of their runways to the mounds. From its main tunnel, the

6. This section prepared by E. H. Herrick, Department of Zoology, Kansas Agricultural Experiment Station.

pocket gopher digs short lateral burrows to the surface and here pushes out the soil to form a bean-shaped mound. (Fig. 28.) After the burrow is completed, the opening at the surface is plugged, leaving a circular area on the indented side of the mound. There is no ridging of the soil above the runway between the mounds as in the case of mole work.

Placing the Bait —The main runway is found by probing with a wagon rod (a). This is done eight to twelve inches from the mound on the side where the plug to the hole is seen. When the rod has been pushed into the ground a few inches and suddenly sinks about three inches more without increased pressure, the runway has been located. The hole made by the rod is enlarged by inserting a sharpened broomstick (b). The broomstick should not be pushed too far in or a depression will be made in the bottom of the runway into which the bait will fall. With the broomstick properly inserted, the top end of it is rotated in a circle to make the hole still larger and make its walls firm so they will not cave in (c). The stick is then drawn out and a tablespoon of poisoned grain is dropped in (d), and the hole is covered (e), care being taken not to let dirt fall in and cover the bait. The mound should be marked by partially kicking it down. Every fourth or fifth mound should be baited, or each system belonging to one gopher should be treated in at least two places.

A probe made by a blacksmith from a water pipe about 34 inches long and a rod about 18 inches long are a help where much baiting is to be done. This probe and another type preferred by some are illustrated in Figure 28.

MOLES

Moles often do considerable damage in newly-planted fields of alfalfa by raising the soil when making their burrows. Young plants usually die along these burrows. Mounds, unlike those made by pocket gophers, are at times thrown up.

Many types of poisons have been tried in controlling moles, but no method has proved to be very successful. The use of traps especially constructed for catching moles, is more stable than any other method of control. Considerable care must be exercised in setting mole traps.

FIELD MICE

If a growth of alfalfa is left standing in the fall, a large population of mice of different species may be attracted to the field. Little damage to alfalfa has been reported, but orchard trees, if nearby, may be badly gnawed at or below the surface of the ground. Pieces of hollow tile or even tin cans laid on their sides may be placed along fence rows and baited with strychnine-poisoned grain to protect trees or other crops from mice that may be living in alfalfa fields.

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