Bulletin 450

October 1938

Alfalfa in Colorado

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and O. H. Coleman

Colorado State College
Colorado Experiment Station
Fort Collins

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Alfalfa in Colorado

D. W. ROBERTSON, R. M. WEIHING, AND O. H. COLEMAN

Contents

ALFALFA has long been an important hay crop in the irrigated sections of Colorado. The area seeded to this crop has increased from a small garden patch in 1863 to some 728,542[1] acres as an average for 5 years between 1929 and 1934. Besides being grown for forage, a considerable acreage is grown for seed. Approximately 25,000 bushels[2] of seed are produced annually in Colorado. This amount does not supply the usual demand for seed in the state.

Alfalfa-Producing Areas

Alfalfa is grown for hay in most of the irrigated sections of Colorado. The leading 10 counties in acreage planted are: Weld, Larimer, Garfield, Prowers, Montrose, Mesa, Delta, Bent, Morgan, and Boulder. The bulk of Colorado alfalfa seed is produced in the irrigated Arkansas and Grand Valleys and the non-irrigated sections of northwestern and southwestern Colorado.[3]

Historical Review

Steinel,[4] in his "History of Agriculture in Colorado," discusses the introduction of alfalfa into the state. He states:

> Alfalfa was first sown in Colorado in 1863 in the city of Denver. The first sowing on a farm was in the Clear Creek

[1] COLORADO YEARBOOK, 1930, 1931, 1932, 1933-34, 1935-36 eds.
[2] COLORADO YEARBOOK, 1933-34 ed.
[3] SPENCER, J. N., and STEWART, T. G. *Alfalfa Seed Production.* (Colo. Ext. Bul. 314-A, 1932).
[4] STEINEL, A. T., *History of Agriculture in Colorado* (1926).

> Valley about 1867. Active spread of the crop was begun by the Union Colonists at Greeley in 1872. The seed sown in Denver was brought into the state by Major Jacob Downing, who procured it in Old Mexico while on a military mission during the Civil War in 1862. * * * He procured the seed across the border from El Paso in the Mexican state of Chihuahua.
>
> On his return to Denver, Major Downing planted the seed in the dooryard of his law office, Twelfth Street at Holladay, since renamed Market Street. The alfalfa thrived, and it was the influence of this little patch of green that persuaded Major Downing, in later years, to grow the crop extensively on his Green Mountain Ranch near Golden.

The alfalfa acreage gradually increased from this small acreage to its present important position in Colorado agriculture. At first there was some doubt of its value as a pasture or forage crop. Following the establishment of the Colorado Experiment Station in 1888, considerable study was made of the value of alfalfa. The first bulletin on the subject was published in 1889.[5] Since then, considerable material on cultural methods and the feeding value of alfalfa has been published by the Colorado Experiment Station.

The first real difficulty which confronted alfalfa growers was the failure of alfalfa to set seed in certain areas. Research work was started on this project in 1905, and reports were made on the results obtained by P. K. Blinn. The last report on this

Figure 1.—Meeker Baltic grown for seed.

[5] An extensive bibliography of papers published by the Station on the value of alfalfa is given in the appendix.

work appeared in 1920. All the work was done at the Rocky Ford Substation. Various factors were found to influence seed setting, but no one condition was found to be entirely responsible for seed setting or the lack of seed setting.

In 1904, a new disease was reported affecting the alfalfa at Gypsum, in Eagle County. This was later reported by Professor Paddock as not being related either to leaf spot or mildew. This disease was described later by Sackett[6] as stem blight. He states that stem blight is a bacterial disease which is probably always present. It seems to gain entrance into susceptible alfalfa only when the outer skin or bark is broken by a late frost or some other injury. When the disease appears following such injury, the best control is to cut the alfalfa early. Such early cutting stops the progress of the disease, increases later cuttings, and may save the crop by preventing the disease from working down into the crown and roots. The southern types are susceptible. The northern or hardy types, such as Grimm, Baltic, and Cossack, are more or less resistant.

In certain sections on the Western Slope a serious pest, the alfalfa weevil, was reported in 1917.[7] The area infested is described by Newton to include all or part of the following counties: Moffat, Routt, Rio Blanco, Garfield, Mesa, Delta, Montrose, and Ouray.

In recent years, severe losses have been caused by bacterial wilt. This disease was first found in Colorado in 1924 and has caused severe losses since that time. Tests to determine the value of various varieties and strains of alfalfa were started at Fort Collins in 1929. Previous to this time, several strains were seeded in nursery rows at various places in Weld, Boulder, and Larimer counties to determine if a disease-resistant variety could be found.

Cultural Methods

Seedbed

In Colorado, most alfalfa is grown under irrigation. It is exceedingly important that the field be smooth and of uniform grade, permitting rapid and easy use of irrigation water. Since the crop is usually left in for 3 years or more, the leveling of the seedbed before planting may save additional expense in seed, water, and labor at a later date. Besides proper leveling, a smooth, firmly packed, moist seedbed free of weeds is necessary for the germination and development of the small alfalfa seedlings.

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[6] SACKETT, W. G., *A New Alfalfa Disease—Stem Blight* (Colo. Exp. Sta. Bul. 159, 1910).

[7] NEWTON, J. H. *The Alfalfa Weevil in Colorado* (Colo. Exp. Sta. Bul. 399, 1933).

Figure 2.—A firm seedbed of uniform grade.

Planting

Spring planting is the most common practice under irrigated conditions in Colorado. Good results may be obtained by fall planting and irrigating. Fall plantings to succeed must be made early enough to permit the young alfalfa plants time to grow sufficient roots and crown to store up enough reserve food to go through the winter. In most seasons, September 1 is about the latest safe date. July and August planting give still more time for plant development. There must be a reliable supply of fall irrigation water to germinate the crop and to keep it growing vigorously to make fall planting successful.

From 8 to 10 pounds of good, clean seed of high germination have given excellent stands at the Colorado Experiment Station at Fort Collins. Either drilling the seed one-half to one inch deep or broadcasting will give good results under favorable conditions. Drilled seeding gives better stands. After seeding, the land should be harrowed or packed to properly cover and contact the seed with firm, moist soil.

In tests conducted at the Fort Collins station, table 1, good results were obtained when alfalfa was seeded alone and with companion crops (wrongly called nurse crops) of either field peas or flax. A companion crop of barley sown at the rate of 45 pounds per acre decreased the yield of the succeeding alfalfa crop when it was compared with alfalfa sown alone, alfalfa sown with field peas, and alfalfa sown with flax. Table 1 gives the results of these tests sown in 1930 and 1931. Alfalfa after the various companion crops yielded in the following order: Peas, none, flax, and barley, for the crop planted in 1930. For the crop

TABLE 1.—*Effects of various companion crops upon subsequent hay yields of alfalfa.*

1930 Seeding

Companion crop	Tons of moisture-free hay						Average of three cuttings
	Total yields			Three-year average			
	1931	1932	1933	First cutting	Second cutting	Third cutting	
Peas	5.23	5.94	4.90	2.37	1.70	1.29	5.36
None	5.45	5.96	4.49	2.35	1.68	1.27	5.30
Flax	4.68	6.01	5.09	2.24	1.67	1.32	5.23
Barley	4.39	5.74	4.76	2.10	1.62	1.24	4.96

1931 Seeding

Companion crop	Tons of moisture-free hay					Average of three cuttings
	Total yield		Two-year average			
	1932	1933	First cutting	Second cutting	Third cutting	
None	6.35	5.30	2.63	1.77	1.42	5.82
Flax	6.18	5.26	2.54	1.77	1.41	5.72
Peas	6.15	5.19	2.53	1.68	1.46	5.67
Barley	5.64	5.14	2.42	1.62	1.35	5.39

planted in 1931, the yields were in the following order: None, flax, peas, and barley. Alfalfa after barley in both cases gave the lowest average yield.

The rates of seeding were as follows: Peas, 90 pounds; flax, 20 pounds; and barley, 45 pounds.

Irrigation

Under Colorado conditions, irrigation is required for maximum yields. There is no one method applicable to all alfalfa-producing regions. In northeastern Colorado, the so-called "flooding" method is used almost entirely. In the Arkansas Valley and in western Colorado, the furrow or corrugated method is used successfully and is, in most cases, better adapted for their conditions.

If the flooding method is used with irrigation water carrying considerable quantities of fine soil, it tends to silt up the soil so that it cracks badly, becomes hard, and bakes between irrigations. Proper use of the furrow method of distribution is very much better for the alfalfa which such silty waters prevail.

In northeastern Colorado the flooding method is used. The general practice is to flood between field laterals. In the Brush-Fort Morgan section the border method of irrigation is sometimes used. In either of the above methods the laterals or borders should not be too far apart (50-150 feet) and the length of the land should not exceed 500 or 600 feet. Longer lands over-irrigate the upper end if sufficient water is applied to the lower ends.

At the Experiment Station at Fort Collins, an experiment

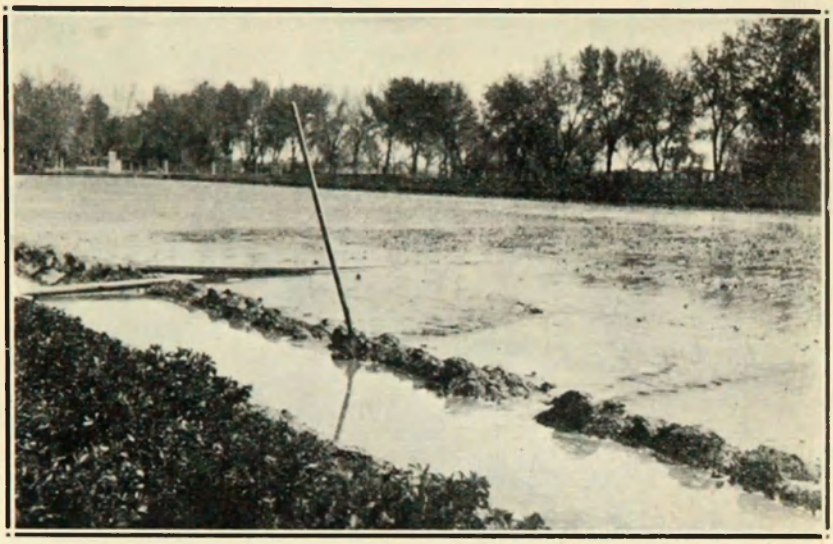

Figure 3.—Flooding from field laterals.

was started to determine the effect of long runs and short runs of irrigation water on alfalfa. Plats were diked to form a basin one-twentieth acre in size. Three plats were irrigated for an 8-hour period at each irrigation. The other plats were irrigated normally (less than one hour). The water was measured on the plats, and the runoff was also measured. The difference between the water running on the plats and the water running off is the total amount remaining on the plats. Table 2 gives the amount of water remaining on the plats at each irrigation and the total amount applied per season. An average of 12.88 acre-feet of water remained on the long-run (8 hours) plats per season. An average of 1.68 acre-feet was applied to the short-run (less than one hour) plats. The yields in tons per acre of dry hay show a slight but insignificant difference in favor of the short-run plats (table 3). The soil on which the test was located is classified as Fort Collins loam and has a summer water table between 10 and 12 feet below the surface on the area used for the test. The results clearly show that on a soil of this type nothing is to be gained from flooding alfalfa for an 8-hour period. Under farm practice a better use of irrigation water could be obtained by shortening the run, either by narrowing the distance between the laterals or cutting the water off sooner and opening the ditch farther down to irrigate the lower end of the land. A combination of the two methods might give the same results.

The number of irrigations to apply each season is governed by the water supply and the soil type. In the plains areas, the

TABLE 2.—*Acre-feet of water applied in long and short irrigation studies at Fort Collins for alfalfa seeded in 1933.*

Year	Irrigation			Total
	First*	Second*	Third*	
	Long run (8 hours)			
1934	11.76	2.64	2.60	17.00
1935	3.64	3.03	2.91	9.58
1936	2.88	3.44	3.57	9.89
1937	4.89	4.69	5.48	15.06
Average	5.79	3.45	3.64	12.88
	Short run (less than one hour)			
1934	1.07	0.32	0.39	1.78
1935	0.33	0.60	0.47	1.40
1936	0.58	0.54	0.33	1.45
1937	0.68	0.62	0.78	2.08
Average	0.67	0.52	0.49	1.68

*Average of 3 plats.

TABLE 3.—*Acre yield of alfalfa receiving long and short-run irrigations, 1933 seeding (1934-1937).*

Treatment	Tons of moisture-free hay							
	Total yields				Four-year average			
	1934	1935	1936	1937	First cutting	Second cutting	Third cutting	Three cuttings
Long run	5.59	4.89	5.01	4.25	2.13	1.56	1.22	4.91
Short run	5.06	5.08	5.45	4.72	2.27	1.58	1.22	5.07

following statement by McLaughlin[8] represents in general the irrigation treatments which give the best results:

> The character of the soil and the subsoil determines, to a considerable extent, the proper time to irrigate. A heavy soil with a tight subsoil will receive and hold large quantities of moisture, making it possible to irrigate copiously and at long intervals. If a heavy soil is underlain with gravel, the water will drain out and more frequent irrigations will be necessary. This same principle holds true with lighter soils; the lighter the soil and the more open the subsoil, the more frequently will irrigation be necessary, because the water-holding capacity of the light soils is less than that of the heavy soils.

One irrigation before each cutting of alfalfa at the Experiment Station at Fort Collins has been ample to produce a normal, healthy growth throughout the season. On lighter soils, more frequent irrigations may be necessary. All irrigations should be applied long enough before mowing the crop to allow the surface of the soil to dry. A wet soil hinders the proper curing of alfalfa hay.

[8]McLAUGHLIN, W. W., *Irrigation of Small Grains* (U.S.D.A. Farmers' Bul. 1556, 1937).

Manuring and Fertilizing

Alfalfa in Colorado is cut from two to four times a year. It, therefore, makes a heavy draft on the available plant food supply in the soil. After a time, even rich soils show reduction in yield from lowered fertility. The soil at the Station has been kept in relatively high fertility by the systematic spreading of farmyard manure at rather definite intervals. Two experiments were conducted at the Station to determine the effect of different manurial and fertilizer treatments on alfalfa. Duplicate plats were treated in 1929 and 1931 with one of the following treatments: 10 tons of manure; 100, 200, or 300 pounds of treble superphosphate; and 100 or 200 pounds of potassium sulfate.

Table 4 presents the yields of the different treatments. No benefit was gained from any of the fertilizers used. The stands in all plats were depleted by wilt in the spring of 1933, and the plats were plowed.

An additional test was started in 1934 with applications of 20 tons of manure, 300 pounds of treble superphosphate, 300 pounds of calcium nitrate, and 300 pounds of ammonium sulfate per acre. Triplicate plats were used, and the treatments were applied in 1934 and 1936. Table 5 gives the yields of alfalfa obtained in 1935, 1936, and 1937. There seems to be a slight gain in yield for the plats receiving treble superphosphate, calcium nitrate, or 20 tons of manure. However, these differences are too small to be considered of importance. From these results, it seems that little is to be gained from applying either manure or fertilizer to highly productive soils in northeastern Colorado. On soils known to be deficient in plant food, considerable increases in yield have been obtained from the application of treble superphosphate or manure.

TABLE 4.—*Effect of various fertilizers upon the yield of alfalfa seeded in 1929.*

	Tons of moisture-free hay						
	Total yields			Three-year average			
Treatment	1930	1931	1932	First cutting	Second cutting	Third cutting	Three cuttings
Treble superphosphate, 300 lbs.	4.17	5.73	5.04	2.26	1.54	1.18	4.98
Manure, 10 T.	4.40	5.48	4.88	2.27	1.45	1.20	4.92
Treble superphosphate, 200 lbs.	4.16	5.35	5.09	2.14	1.59	1.13	4.86
None	4.40	5.34	4.76	2.14	1.54	1.15	4.83
Treble superphosphate 100 lbs.	4.22	5.30	4.79	2.15	1.45	1.18	4.76
Potassium sulfate, 200 lbs.	4.35	5.26	4.64	2.18	1.41	1.16	4.75
Potassium sulfate, 100 lbs.	4.16	5.28	4.44	2.06	1.48	1.09	4.63

TABLE 5.—*Effect of various fertilizers upon the yield of alfalfa seeded in 1934 (1935-1937).*

	Tons of moisture-free hay						
	Total yields			Three-year average			
Treatment per acre	1935	1936	1937*	First cutting	Second cutting	Third cutting*	Three cuttings
Treble superphosphate, 300 lbs.	4.17	4.42	3.01	1.94	1.27	0.99	3.87
Calcium nitrate, 300 lbs.	4.00	4.39	3.13	1.89	1.29	0.99	3.84
Manure, 20 tons	3.93	4.56	3.00	1.88	1.27	1.01	3.83
Ammonium sulfate, 300 lbs.	3.97	4.40	2.93	1.87	1.23	1.00	3.77
None	4.00	4.37	2.63	1.82	1.22	0.94	3.67

*In 1937, the third cutting was completely destroyed by grasshoppers.

Date of Cutting

Alfalfa should be cut for hay when in one-tenth to one-fourth bloom stage. If blossoms are scarce, as happens in some seasons, the crop should be cut just before the new basal shoots will be clipped by a mower. Alfalfa cut at this stage can be cured into a leafy hay high in feeding value. Later cutting results in hay with coarse stems, fewer leaves, and lower digestibility.

The effect on yield of early and late harvest of the third or last cutting of hay at Fort Collins is reported in table 6. The first two cuttings were made at the usual dates. For the 4-year period 1930-34, the average annual yield was 4.54 tons per acre for cutting September 20, whereas it was 4.17 tons for August 30. For plats cut only twice during the season, the yield was only 3.96 tons. The yields for similar treatments from 1935-37 are in the same order. All plats had to be plowed at the same time due to thin stands caused by bacterial wilt.

Harvesting

Since alfalfa is grown chiefly for hay in the irrigated sections, the method of curing is of importance. In order to have a good quality hay, the stand should be thick and free from weeds. The cured hay should be green in color, leafy, and the stalks fine. Coarse, stalky hay, lacking in leaves, is of poor quality. In a recent bulletin[9] published by the Station, it has been shown that the method of curing influenced the vitamin content of the hay. The fact that weathering decreased the value of hay was known early in the history of the crop in Colorado. A. E. Blount, James Cassidy, and D. O'Brine, in Bulletin 8 of the Colorado Experiment Station, published in 1889, state:

[9]DOUGLASS, E., TOBISKA, J. W. and VAIL, C. E., *Studies of Changes in Vitamin Content of Alfalfa Hay* (Colo. Exp. Sta. Tech. Bul. 4, 1938).

Alfalfa should be cut before blooming, somewhat earlier than red clover. At that stage of its growth the plant contains the greatest amount of valuable feeding substances. When slightly wilted it should be raked into windrows and then put into cocks to be cured. If left to cure before raking, the stems become hard and dry, the leaves drop off, the color is lost, and much of the hay is rendered unfit for feed. Curing is the most important operation of all in making alfalfa hay.

TABLE 6.—*Effect of early and delayed harvest of the third cutting upon the yield of alfalfa.*

1929 Seeding

	Tons of moisture-free hay							
	Total yields				Four-year average			
Treatment	1930	1931	1933	1934	First cutting	Second cutting	Third cutting	All cuttings
3 cuttings, 3d on Sept. 20	4.38	5.57	3.76	4.47	1.87	1.46	1.21	4.54
3 cuttings, 3d on Aug. 30	4.10	4.90	3.13	4.56	1.92	1.51	0.74	4.17
2 cuttings	3.37	4.49	3.55	4.44	2.27	1.69	.....	3.96

1933 Seeding

	Tons of moisture-free hay							
	Total yields				Four-year average			
Treatment	1934	1935	1936	1937	First cutting	Second cutting	Third cutting	All cuttings
3 cuttings, 3d on Sept. 20	6.64	5.73	6.41	5.14	2.49	2.11	1.38	5.98
3 cuttings, 3d on Aug. 30	6.51	5.13	5.46	4.41	2.24	2.05	1.09	5.38
2 cuttings	4.81	4.91	5.45	4.85	2.72	2.28	.....	6.00

The foregoing statements made 49 years ago are very similar to the recommendations of today. Alfalfa hay should be cut when in one-tenth to one-fourth bloom and should be raked into windrows when wilted. It should be allowed to partially cure in the windrow, and while still a little damp, either bunched or cocked and allowed to cure. Any method which will preserve the leaves and green color aids in producing a high-quality hay. The hay should be thoroughly cured before stacking. Several methods of stacking hay are used in the state. The advantages and disadvantages of each method will not be discussed here. When stacking hay, methods which preserve the leaves should be used and high, well-peaked stacks made where possible. The greatest loss in properly stacked hay is in the top, and this is due to weathering after stacking. Any type of stack which will reduce the percentage of loss in top will save more high-quality hay.

Figure 4.—Windrowing alfalfa with a side-delivery rake.

Measuring Hay In Stack

The tonnage of an immense amount of Colorado hay is estimated in the stack. The United States Department of Agriculture, through the Bureau of Agricultural Economics, carried on experiments in cooperation with the western states for a series of years in an effort to get more accurate rules for measuring hay in the stack. The results of these studies are published in Leaflet 72 of the United States Department of Agriculture,[10] which gives rules for three types of stacks commonly found in this territory. Quoting from page 3 of Leaflet 72, these rules are as follows:

> The three types of stacks with the rule for each type are as follows:
>
> For square, flat-topped stacks $(0.56\times O)-(0.55\times W)\times WL$
> For high, round-topped stacks $(0.52\times O)-(0.46\times W)\times WL$
> For low, round-topped stacks $(0.52\times O)-(0.44\times W)\times WL$
>
> In these rules O equals the over, W equals the width, and L equals the length.
>
> Example.—To determine the volume of a rectangular stack of the high, round-topped type that is 20 feet wide, 45 feet over, and 50 feet long.

[10] HOSTERMAN, W. H., *Measuring Hay in Stacks* (U.S.D.A. Leaflet 72, 1931).

Volume = (0.52×45)—(0.46×20)×(20×50).

45	20	50
0.52	0.46	20
90	9.20	1000
225		
23.40		
-9.20		
14.20		
1,000		

14,200.00 cubic feet in the stack.

These rules estimate closely the number of cubic feet in a stack. To get at the number of cubic feet to allow for a ton, the following table, taken from page 4, Leaflet 72, is used:

	30 to 90 days	*Over 90 days*
Number of cubic feet to allow for a ton of alfalfa hay	485 cubic feet per ton	470 cubic feet per ton

To obtain the number of tons in the stack, divide the number of cubic feet in the stack by the number of cubic feet to allow for a ton. The 14,200 cubic feet in the above example would be divided by 485 cubic feet where the stack had settled from 30 to 90 days, or by 470 cubic feet if the stack had settled over 90 days.

Variety Tests at Fort Collins

The early records of alfalfa production in Colorado show that many stands remained productive for 10 or more years. At the present time and since about 1924, most varieties die 4 or 5

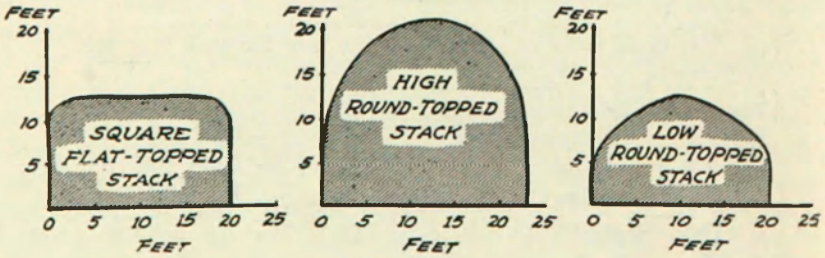

Figure 5.—These three types of stacks are typical of the oblong stacks built in different parts of the United States. The square, flat-topped stacks are found principally in the Sacramento and San Joaquin Valleys of California; the high, round-topped stacks are common in the inter-mountain states of Utah, Nevada, and Idaho; and the low, round-topped stacks are the type built in the Great Plains states, where the overshot stacker is used.

years after seeding or are harvested only 3 or 4 years for hay. In some cases the short life of alfalfa stands is due to winter killing; but by growing hardy, northern-grown alfalfa this difficulty can be overcome. Even with northern-grown, hardy seed, there will be some damage by winter-killing if the alfalfa is cut or grazed too late in the fall.

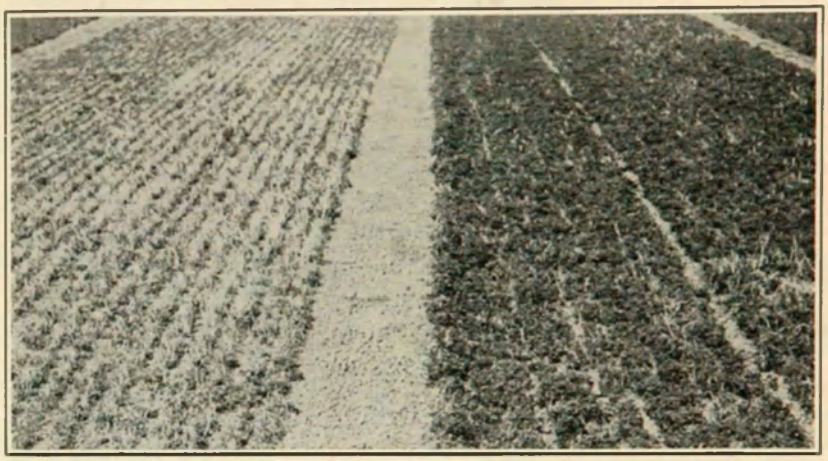

Figure 6.—Plats of Nebraska Common (left) and Hardistan (right) seeded in 1933; photograph taken in spring of 1937.

In the irrigated sections of Weld, Boulder, and Larimer counties, a new disease was reported in 1924. This disease shortened the field life of alfalfa, often killing the entire crop in 3 years. This disease was shown to be "bacterial wilt," reported by Jones[11] and later found in Nebraska and now affecting stands in Colorado and most of the surrounding states. No cultural method tried, to date, at the Colorado Experiment Station has offered a solution to the problem. Tests have shown that some varieties are more resistant than others and are productive for 1 or 2 years longer.

Experimental Methods

Variety tests were started in 1929 to determine the yield and number of productive years of various strains and varieties of alfalfa. The seed of these varieties was obtained from the principal alfalfa seed-producing states and from Canada. Other varieties from foreign sources were secured through the cooperation of H. L. Westover of the Office of Forage Crop Investigations, Bureau of Plant Industry, U. S. Department of Agriculture.

[11] JONES, F. R., and MCCULLOCH, L., *A Bacterial Wilt and Root Rot of Alfala Caused by Aplanobacter insidiosum L. McC.* (Jour. Agr. Res., 33:493-521, 1926).

The varieties were seeded in plats one-tenth acre in size, at the rate of 8 pounds per acre, without a companion crop. Three cuttings of hay were harvested each year until the stands were too thin for hay production. The cut alfalfa when wilted was windrowed with a side-delivery rake and allowed to dry. Later it was cocked by hand and allowed to finish curing. When sufficiently dry to stack, the hay was weighed, sampled for moisture, and the yield later corrected to an oven-dry basis. All the results are reported in hay free from moisture (oven-dry basis).

Yield of Varieties

Variety tests were conducted with the so-called variegated and common alfalfas. Tables 7 and 8 present the data for the tests of variegated alfalfa sown in 1929 and 1933. Meeker Baltic yielded highest in both tests. In the 1929 test, Colorado Common and Grimm both yielded well. However, in the 1933 test, Nebraska Common (Crawford County) yielded second, with Cossack and Ladak third. In both tests hay was produced for 3 years.

The summarized yields of all tests of variegated alfalfa are given in table 9. The variety Meeker Baltic was seeded in all tests and was the most productive in all cases, averaging 5.61 tons of hay annually. Nebraska Common and Colorado Common were seeded in only one test, but produced for those years 99 and 98 percent, respectively, as much hay as Meeker Baltic.

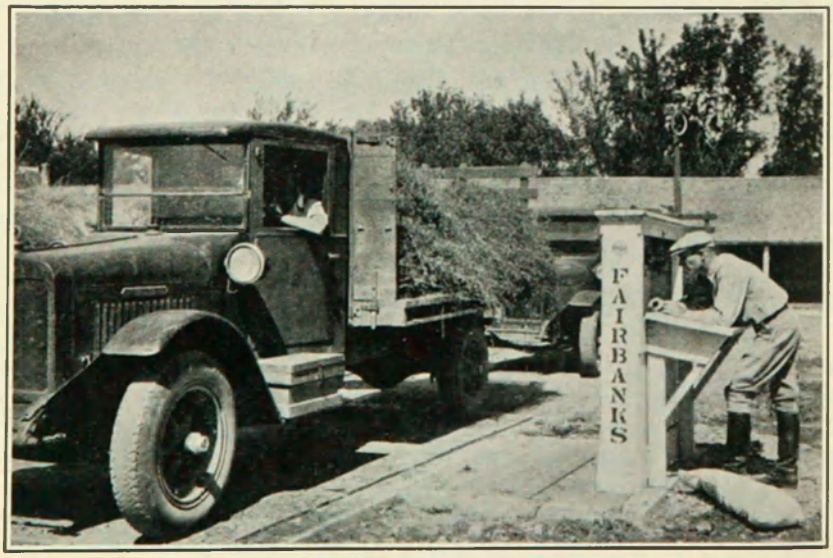

Figure 7.—Weighing alfalfa hay from experimental plats at Fort Collins.

The varieties Hardistan, Grimm, Cossack, Ladak, and Utah Common produced 96 to 93 percent as much as Meeker Baltic.

A variety test to determine the yield and survival of Hardistan was planted in 1930. The test shows that Hardistan remained

TABLE 7.—*Yield of variegated strains of alfalfa seeded in 1929 (1930-32).*

	Tons of moisture-free hay						
	Total yields			Three-year average			
Variety	1930	1931	1932	First cutting	Second cutting	Third cutting	Three cuttings
Meeker Baltic	5.20	5.88	5.26	2.50	1.71	1.24	5.45
Colorado Common	4.47	5.96	5.53	2.34	1.72	1.26	5.32
Grimm	5.11	6.12	4.60	2.69	1.55	1.13	5.28
Cossack	5.51	5.43	3.93	2.54	1.48	0.94	4.96
Hardigan	5.31	5.65	3.72	2.46	1.45	0.98	4.89
Ladak	5.40	5.41	3.81	2.64	1.41	0.82	4.87
Ontario Variegated	5.07	5.38	4.01	2.27	1.52	1.03	4.82
Turkestan	4.24	4.99	3.62	2.13	1.32	0.83	4.28

TABLE 8.—*Yield of variegated strains of alfalfa seeded in 1933 (1934-36).*

	Tons of moisture-free hay						
	Total yields			Three-year average			
Variety	1934	1935	1936	First cutting	Second cutting	Third cutting	Three cuttings
Meeker Baltic	7.00	5.98	4.94	2.62	1.79	1.56	5.97
Nebraska Common	6.26	5.95	5.50	2.50	1.82	1.58	5.90
Cossack	6.53	5.82	4.96	2.50	1.72	1.55	5.77
Ladak	6.43	5.52	5.21	2.78	1.60	1.34	5.72
Grimm and Ladak	6.60	5.61	4.88	2.58	1.66	1.45	5.69
Hardistan	5.52	5.68	5.58	2.43	1.76	1.40	5.59
Grimm	6.28	5.61	4.38	2.36	1.66	1.40	5.42
Baltic 19001	6.06	5.39	4.66	2.22	1.61	1.54	5.37

TABLE 9.—*Yield of alfalfa seeded in variegated strain tests at Fort Collins, Colo.*

	Average yield of moisture-free hay in tons per acre					Yield in percent of
Variety	3 years 1930-32	4 years 1931-34	3 years 1934-36	All tests	Years grown	Meeker Baltic
Meeker Baltic	5.45	5.11	5.97	5.61	10	100
Grimm	5.28	5.24	5.42	5.31	10	95
Hardistan			5.33	5.59	5.46	7	96
Cossack	4.96		5.77	5.36	6	94
Ladak	4.87		5.72	5.29	6	93
Nebraska Common			5.90	5.90	3	99
Colorado Common	5.32			5.32	3	98
Grimm and Ladak			5.69	5.69	3	95
Utah Common		5.02		5.02	4	93
Baltic, F.C.I. 19001			5.37	5.37	3	90
Hardigan	4.89			4.89	3	90
Ontario Variegated	4.82			4.82	3	88
Turkestan	4.28			4.28	3	79

productive at least 1 year longer than the other varieties. It is more resistant to bacterial wilt than the other varieties tested. For the 4-year period 1931-34 (table 10), Hardistan was nearly as productive as Meeker Baltic, although for the first 3 years Meeker Baltic averaged 0.65 ton more hay per acre annually. The 4-year average yield gives Meeker Baltic a slight margin of only 0.08 of a ton. Hardistan produced two good cuttings the fifth year; and Meeker Baltic, Grimm, and Utah Common had such a thin stand that the plats had to be plowed.

The yields of the varieties of Common alfalfa planted in 1929 and 1933 are given in tables 11 and 12. In the 1929 test, Montana and Idaho Common yielded the highest. Argentine and Dakota 12 yielded lowest. In the test planted in 1933, Nebraska, Kansas, and Colorado Common gave the highest yields, with the southern-grown Commons, Chilean, Arizona, and New Mexico giving the lowest yields.

The combined yield of all tests of Common alfalfa are given in table 13. The Common varieties from Colorado, Kansas, Nebraska, and Montana all produced well. All the above-mentioned varieties are winter-hardy in Colorado, with the exception of southern-grown Kansas Common.

Arizona Common, Argentine, and Chilean produced 94, 89,

TABLE 10.—*Variety test of alfalfa seeded in 1930 (1931-34).*

	Tons of moisture-free hay							
	Total yields				Four-year average			
Variety	1931	1932	1933	1934	First cutting	Second cutting	Third cutting	Three cuttings
Meeker Baltic	6.11	6.21	4.77	4.54	2.40	1.67	1.34	5.41
Hardistan*	4.84	5.81	4.48	6.21	2.48	1.64	1.21	5.33
Grimm	5.58	6.46	4.68	4.23	2.28	1.64	1.32	5.24
Utah Common	4.87	5.98	4.56	4.70	2.18	1.56	1.28	5.02

*All varieties except Hardistan were plowed in the spring of 1935. In 1935, Hardistan yielded 1.82 and 2.43 tons per acre for the first and second cuttings, respectively. The third cutting was destroyed by grasshoppers.

TABLE 11.—*The yield of common varieties of alfalfa seeded in 1929 (1930-33).*

	Tons of moisture-free hay						
	Total yields			Three-year average			
Variety	1930	1931	1932	First cutting	Second cutting	Third cutting	Three cuttings
Montana	4.71	5.92	5.00	2.36	1.65	1.20	5.21
Idaho	4.16	5.99	5.43	2.28	1.70	1.21	5.19
New Mexico	4.31	5.97	4.95	2.21	1.62	1.24	5.07
Colorado	4.13	5.80	5.21	2.29	1.50	1.25	5.04
Blended R333	4.31	5.68	5.01	2.34	1.48	1.18	5.00
Kansas	4.25	5.73	4.67	2.18	1.52	1.18	4.88
Utah	3.80	5.56	4.42	2.07	1.43	1.09	4.59
Dakota 12	4.02	5.53	4.16	2.08	1.40	1.09	4.57
Argentine	4.49	5.68	3.35	2.08	1.39	1.03	4.50

and 80 percent as much hay as Colorado Common. None of these strains is winter-hardy in Colorado, and none should be seeded when hardy strains are available.

Two Turkestan strains were seeded in these tests. The one reported in table 9 produced only 79 percent as much hay as

TABLE 12.—*Yield of common varieties of alfalfa seeded in 1933 (1934-36).*

	Tons of moisture-free hay						
	Total yields			Three-year average			
Variety	1934	1935	1936	First cutting	Second cutting	Third cutting	Three cuttings
Nebraska	6.24	5.58	5.11	2.40	1.74	1.50	5.64
Kansas	6.10	5.52	5.24	2.34	1.75	1.53	5.62
Colorado	6.24	5.27	4.79	2.28	1.68	1.47	5.43
Turkestan	5.42	5.27	5.13	2.41	1.62	1.24	5.27
New Mexico	5.84	5.05	4.68	2.10	1.63	1.46	5.19
Arizona	5.97	4.83	4.60	2.12	1.56	1.45	5.13
Chilean	4.90	4.26	3.85	1.88	1.30	1.15	4.33

TABLE 13.—*Yield of alfalfa seeded in common strain tests at Fort Collins, Colo.*

	3-year average yield of moisture-free hay in tons per acre			Years grown	Yield in percent of
Variety	1930-32	1934-36	All tests		Colo. Common
Colorado	5.04	5.43	5.24	6	100
Kansas	4.88	5.62	5.25	6	100
New Mexico	5.07	5.19	5.13	6	98
Nebraska		5.64	5.64	3	104
Montana	5.21		5.21	3	103
Idaho	5.19		5.19	3	103
Blended R333	5.00		5.00	3	99
Turkestan		5.27	5.27	3	97
Arizona		5.13	5.13	3	94
Utah	4.59		4.59	3	91
Dakota 12	4.57		4.57	3	91
Argentine	4.50		4.50	3	89
Chilean		4.33	4.33	3	80

Meeker Baltic, whereas the strain in table 13 yielded 97 percent as much as Colorado Common. As is evident, strains of Turkestan alfalfa are variable and should not be seeded unless it is definitely known that they are good producers. There is no seed supply of the Turkestan strain reported in table 13; but the variety Hardistan, which is a Turkestan alfalfa, can be obtained.

In recommending varieties, Common alfalfa cannot be considered, since there is no way of tracing the source or origin of seed to the original lots used in these tests. However, with Meeker Baltic, Grimm, and Hardistan, registered sources of seed are available, and the pedigrees are more easily traced. In recommending varieties for short rotations, Meeker Baltic comes first,

with Grimm and Hardistan second. For long rotations, where it is desired to keep a stand of alfalfa more than 3 years, Hardistan is recommended.

Yield of Various Cuttings

The relationship of each cutting to the total yield at Fort Collins is given in table 14. The first cutting represents about 45 percent of the total yield. The second cutting amounts to about 30 percent of the total yield and the third cutting about 25 percent. The relationship of the cuttings to the total yield may be of value in determining which variety to grow under ditches which may be short of late water. In tables 7 and 8 the average yield of each cutting is given. These tables show Ladak had the highest yield for the first cutting but falls off in yield in the second and third cuttings. In a case where there is insufficient water for the second and third cuttings, Ladak should be grown. In high altitudes where the length of season is so short

TABLE 14.—*Average percentage each cutting represents of total amount of hay produced.*

Years grown	Varieties	First cutting	Second cutting	Third cutting	Total
		Pct.	*Pct.*	*Pct.*	*Pct.*
1930-32	Variegated	48.84	30.50	20.66	100.00
1933-36	Variegated	43.98	29.99	26.03	100.00
1930-32	Common	45.18	31.04	23.79	100.00
1933-36	Common	42.42	30.81	26.77	100.00

that only one, or at most two, cuttings can be made, Ladak may find a place because of its habit of producing a high first-cutting yield.

Survival of Varieties

In all the tests, stand counts were taken on square-meter quadrats[12] located permanently in the plats. These quadrat counts showed that all the varieties tested, with the exception of Hardistan, did not have enough resistance to bacterial wilt to recommend their being cropped for more than 3 years. Hardistan showed enough resistance as determined by survival of plants in the stand to justify its being grown for at least 5 years.

Description of Varieties

Grimm

A history of the origin of Grimm is given in the Yearbook of Agriculture, U. S. D. A., 1937. The present commercial stocks are the progeny of the original importation made by Wendelin

[12] WEIHING, R. M., ROBERTSON, D. W., and COLEMAN, O. H., *Survival of Several Alfalfa Varieties Seeded on Irrigated Land Infested with Bacterial Wilt* (Colo. Exp. Sta. Tech. Bul. 23, 1938).

Grimm into Carver County, Minn., in 1857. The following description is given by R. A. Oakley and H. L. Westover:[13]

> To the casual observer the Grimm alfalfa does not differ materially from the Common strains, but a closer examination will reveal a greater diversity of forms, upright and decumbent individuals often occurring side by side. A large percentage of the flowers are of the same color as those of Common alfalfa, but there are a few that are greenish, smoky, or blackish, and occasionally a plant is found with yellow flowers, indicating definitely that the strain is the result of a cross between the Common and yellow-flowered species. Variegated flowers are usually more in evidence in semi-arid than in humid districts.
>
> The hardiness of Grimm alfalfa is probably due in part to the presence of the yellow-flowered alfalfa in its ancestry and in part to the process of natural selection which took place under the severe climatic conditions to which it was subjected for a long period of years in Minnesota.

Grimm alfalfa is susceptible to bacterial wilt.

Baltic

According to R. A. Oakley and H. L. Westover:

> There is no authentic record of the introduction of Baltic alfalfa into this country, although there is no doubt that the original stock came from Europe. The name Baltic was first applied to it in 1906 for the reason that it had been grown near Baltic, South Dakota, for about 10 years and not, as has been supposed, in the Baltic Sea region of Europe. The original seed sown at Baltic was purchased from a dealer at Hartford, South Dakota, but further than this no information regarding the history of the seed is available.
>
> The Baltic differs slightly from the Grimm alfalfa in some minor details, but the two are so similar that it is seldom possible to distinguish one from the other, and the description as given for the Grimm variety applies equally well to the Baltic.

Meeker Baltic

The history of Meeker Baltic is somewhat similar to that of Baltic. A lot of seed evidently of the variety Baltic was sent to S. A. Shelton at Price Creek, Colo., in 1914, by Congressman E. T. Taylor of Colorado. The seed was sown on non-irrigated land, and finally through natural selection the strain known as Meeker Baltic was developed. Seed from this source was obtained from P. A. Hausser of Meeker, Colo., tested at the Colorado Experiment Station, and found to be superior in hay yield.

[13] OAKLEY, R. A., and WESTOVER, H.L., *Commercial Varieties of Alfalfa* (U.S.D.A. Farmers' Bulletin 1467, 1926).

The strain was named, and all sources of seed supply which could be traced to the original planting were registered as "Meeker Baltic." This variety is susceptible to bacterial wilt.

Ladak

The origin and description of Ladak is given by H. L. Westover in a mimeographed pamphlet published by the Division of Forage Crops and Disease, U. S. Department of Agriculture, in 1934, as follows:

> In 1910, a small package of alfalfa seed was received from Lek, Province of Ladak, Kashmir, northern India, through the Office of Forage Plant Introduction of the United States Department of Agriculture, under S. P. I. No. 26927. In 1911, four other packets of seed were received from the same general region.
>
> The five packets of seed were labeled *Medicago falcata*, but proved to be hybrids of the yellow-flowered species *M. falcata* and the purple-flowered species *M. sativa*, with the *falcata* characteristics, especially as regards color of flowers, shape of pods, and general habit of growth, predominating.
>
> In preliminary tests this alfalfa attracted attention by its unusually vigorous growth, its resistance to cold and drouth, and its good seed habits. When it seemed likely to become of commercial importance, the name "Ladak" was given to the variety by the United States Department of Agriculture.
>
> No other alfalfa grown commercially in the United States shows such a diversity of forms, some being highly desirable and a few of little value. In the original sowings, the flowers were predominantly yellow, but the natural crossing that has taken place with purple-flowered strains since its introduction has resulted in a gradual increase in the proportion of purple flowers. Ladak alfalfa, however, still shows more variegated flowers with a higher proportion of yellow than any other alfalfa grown commercially in the United States. At the same time, the seed pods have gradually become more coiled in contrast to the sickle-shaped pods of the yellow-flowered alfalfa. An outstanding characteristic of the variety is its ability to make an exceptionally heavy first crop, exceeding all other varieties in this respect. It is, therefore, especially suited for growing in those regions where one cutting only is normally obtained. Ladak alfalfa recovers slowly after cutting, but after a short period of comparative dormancy the growth is very rapid, and by the time of the second cutting it has nearly attained the stage of maturity of other varieties.

Under Colorado conditions this variety has shown very little resistance to bacterial wilt.

Hardistan

Kiesselbach, Anderson, and Peltier[14] give the origin of Hardistan as follows:

> The immediate seed source of this new variety is an old superior field of alfalfa belonging to Arnold Brothers in Dawson County, Nebraska. Special attention was first called to this field by County Extension Agent A. R. Hecht, who described it as the most outstanding field known in Dawson County. In 1927, 16 years after sowing, it was recognized as having a practically perfect stand aside from depredation by pocket gophers. Hecht investigated the history of the seed from which this field had been sown and found it was secured from a seed house as Turkestan seed.

Under Colorado conditions this variety has been the most resistant to bacterial wilt and has produced a good crop of hay for 5 years after planting.

Common

Common alfalfa includes the ordinary purple-flowered, non-hairy strains. There are numerous regional strains grown in the United States and in several other countries. After alfalfa of this type is grown for several generations in an area, it is designated as, for instance, Colorado Common, Kansas Common, Argentine, etc. Much of the Common alfalfa grown in the United States was imported from South America and consisted of natural mixtures of winter-hardy and non-hardy types. The growing of several generations of such alfalfa in areas with severe winters has eliminated the non-hardy plants. Accordingly, southern-grown Common is less hardy than northern-grown. Seed from foreign countries likewise shows great variability in hardiness.

Southern-grown Commons and many foreign importations are not winter-hardy in Colorado. In the United States, seed produced south of Colorado is nearly always non-hardy in this state. Importations from Argentine, Chile, and South Africa are generally inferior to seed produced in Colorado or in northern sections of the United States.

At the present time, none of the Common strains of alfalfa are known to be resistant to bacterial wilt.

Comparative Yields of Various Forage Crops

The data in table 15 give the hay yields of several crops grown at Fort Collins for varying numbers of years. Alfalfa yielded annually over 5 tons of hay per acre from 1928 to 1936,

[14] KIESSELBACH, T. A., ANDERSON, A., and PELTIER, G. L., *A New Variety of Alfalfa* (Jour. Amer. Soc. Agron., 22:181-182, 1930).

inclusive. None of the other perennial crops yielded enough hay per acre to be considered equal to alfalfa as a hay crop. Of the annual forage plants, the forage sorghums are most productive, yielding 4.51 tons of fodder per acre. The amount of hay from sudan grass, field peas, soybeans, and oats is too small to justify growing these crops in preference to alfalfa and sorghums under irrigation in northeastern Colorado.

TABLE 15.—*Comparative yields of alfalfa and other forage plants at Fort, Collins, Colo.*

Name of Crop	Years grown	Moisture-free weights in tons per acre
Alfalfa (Meeker Baltic)	1930-36	5.61
Alfalfa (4 varieties)	1928-30	5.15
Corn (Golden Glow)	1930-33	4.60*
Forage sorghums (6 varieites)	1934-35	4.51*
Sudan grass	1923-25	2.58
San Luis field peas	1923-25	1.81
A K soybeans	1923-25	1.92
Oats	1923-25	1.96
Hubam sweet clover	1923-25	2.41
Yellow sweet clover	1928-31	1.88
White sweet clover	1928-31	2.44
Red clover (2 varieties)	1928-30	4.17
Ladino clover	1928-29	2.74
Alsike clover	1928-29	2.40
Tall oat grass	1924-30	1.63
Slender wheat grass	1924-30	1.38
Brome grass	1924-30	1.28
Orchard grass	1924-30	1.11
Meadow fescue	1924-30	1.08
Crested wheat grass†	1924-30	0.76

*Air dry weight.
†Yields for 3 years only.

Appendix

Papers on Alfalfa Published by the Colorado Experiment Station
1888 — 1937

BULLETIN 8 Alfalfa, Its Growth, Composition, Digestibility, etc. Blount, A. E., Cassidy, J., and O'Brine, D. 1889.

BULLETIN 26 Farm Notes for 1893. Cooke, W. W., and Watrous, F. L. 1894.

BULLETIN 35 Alfalfa. Headden, W. P. 1896.

BULLETIN 39 A Study of Alfalfa and Some Other Hays. Headden W. P. 1897.

BULLETIN 57 Farm Notes. Alfalfa, Corn, Potatoes, and Sugar Beets. Cooke, W. W. 1900.

BULLETIN 68 Pasture Grasses. Leguminous Crops. Cantaloupe Blight. Arkansas Valley Substation. Griffin, H.H. 1902.

PRESS

BULLETIN 13 Best Time to Cut Alfalfa. Headden, W. P. 1902.

BULLETIN 90 Unirrigated Alfalfa on Upland. Payne, J. E. 1904.

BULLETIN 93 Colorado Hays and Fodders. Alfalfa, Timothy, Native Hay, Corn Fodder, Sorghum, Saltbush. Digestion Experiments. Headden, W. P. 1904.

BULLETIN 110 Alfalfa (Results Obtained at the Colorado Experiment Station). Headden, W. P. 1906.

BULLETIN 111 Alfalfa (A Synopsis of Bulletin 35). Headden, W. P. 1906.

PRESS

BULLETIN 28 New Alfalfa Disease. Paddock, W. 1906.

BULLETIN 121 Alfalfa, Sugar Beets, Cantaloupes. Notes. 1906. Blinn, P. K. 1907.

BULLETIN 128 Alfalfa Studies. Blinn, P. K. 1908.

BULLETIN 154 Alfalfa Studies (Third Progress Report). Blinn, P. K. 1910.

BULLETIN 158 A Bacterial Disease of Alfalfa. Sackett, W. G. 1910.

BULLETIN 159 A New Alfalfa Disease: Stem Blight (An Abbreviated Edition of Bulletin 158). Sackett, W. G. 1910.

BULLETIN 181 Alfalfa; the Relation of Type to Hardiness. Blinn, P. K. 1911.

BULLETIN 191 Alfalfa Seed Production (A Progress Report). Blinn, P. K. 1913.

BULLETIN 214 Forage Crops for the Colorado Plains. Kezer, A. 1915.

BULLETIN 248 Alfalfa Dodder in Colorado. Robbins, W. W., and Eggington, G. E. 1918.

The Vitality of Alfalfa Seed as Affected by Age. Headden, W. P. Proceedings of the Colorado Scientific Society, vol. XI, 239-250. 1919.

BULLETIN 257 Factors that Affect Alfalfa Seed Yields. Blinn, P. K. 1920.

BULLETIN 281 Methods of Handling Hay in Colorado. Cummings, G. A. 1923.

Some Notes on Hard Seeds in Alfalfa. Lute, A.M. Association of Official Seed Analysts Proceedings 14:40. 1923.

Alfalfa Seeds Made Permeable by Heat. Lute, A. M. Science 65:166. 1927.

BULLETIN 319 Effects of Clover and Alfalfa in Rotation. Part I. Headden, W. P. 1927.

BULLETIN 326 Impermeable Seed of Alfalfa. Lute, A. M. 1928.

BULLETIN 339 Vascular Structure and Plugging of Alfalfa Roots. LeClerg, E. L., and Durrell, L. W. 1928.
PRESS
BULLETIN 66 Root Rot of Alfalfa. Durrell, L. W. 1928.
BULLETIN 362 Effects of Clover and Alfalfa in Rotation. Part II. Headden, W. P. 1930.
BULLETIN 363 Effects of Clover and Alfalfa in Rotation, Part III. Headden, W. P. 1930.
BULLETIN 364 Effects of Clover and Alfalfa in Rotation. Part IV. Headden, W. P. 1930.
BULLETIN 389 Quality of Alfalfa Seed Sold in Colorado. Lute, A. M. 1932.
BULLETIN 399 The Alfalfa Weevil in Colorado. Newton, J. H. 1933.
TECHNICAL
BULLETIN 4 Studies on Changes in Vitamin Content of Alfalfa Hay. Douglass, E., Tobiska, J. W., and Vail, C. E. 1933.
TECHNICAL
BULLETIN 18 Vitamins in Alfalfa Hay. Vail, C. E., Tobiska, J. W., and Douglass, E. 1936.
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BULLETIN 23 Survival of Several Alfalfa Varieties Seeded on Irrigated Land Infested with Bacterial Wilt. Weihing, Ralph M., Robertson, D. W., and Coleman, O. H. 1938.

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BULLETIN 314-A Alfalfa Seed Production. Spencer, J. N., and Stewart, T. G. 1932.
BULLETIN 329-A Growing Alfalfa in Colorado. Kezer, Alvin. 1933.

NOTES

BULLETIN SERVICE

The following late publications of the Colorado Experiment Station are available without cost to Colorado citizens upon request:

Popular Bulletins

Number	*Title*
423	The Parshall Measuring Flume
424	Grape Growing in Colorado
425	Timber Milk Vetch as a Poisonous Plant
426	Oiled-Gravel Roads of Colorado
427	Insect and Mite Pests of the Peach in Colorado
428	Pyrethrum Plant Investigations in Colorado
430	Oat Production in Colorado
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432	Western Rose Curculio
433	Equipping a Small Irrigation Plant
434	Improving the Farm Wagon
435	North Park Cattle Production—An Economic Study
436	Fitting Sheep into Plains Farming Practices
437	Controlling Colorado Potato Pests
438	Proso or Hog Millet
439	Dry-Land Grasses and Clovers
440	Seal Coats for Bituminous Surfaces
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89	Some Injurious Plant Lice of the American Elm
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