Special Bulletin No. 104 February 1926

ALFALFA AIDS PROGRESS IN MINNESOTA

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Minnesota Pigs in Minnesota Alfalfa

UNIVERSITY OF MINNESOTA
AGRICULTURAL EXTENSION DIVISION

Published by the University of Minnesota, College of Agriculture, Extension Division, F. W. Peck, Director, and distributed in furtherance of the purposes of the co-operative agricultural extension work provided for in the Act of Congress of May 8, 1914.

Advantages of Growing Alfalfa

For economical production of all farm crops, yield per acre as well as kind and quality of the crop is important. The best yields of grains and corn are secured when these crops are grown in rotation, with clover or alfalfa occurring once in from three to five years. Alfalfa and clover in the rotation usually bring increases in yields even tho a fair application of manure, from 6 to 8 tons per acre, is made preceding the corn crop. Gains due to including clover in a four-year rotation where manure was applied at the rate of 8 tons per acre, compared with growing these crops without rotation but with the same amounts of manure applied, are shown in Table 1.

Table 1.—Relation of Cropping Systems to Yields of Wheat, Oats, and Corn, 1909-18, Ten-year Average, University Farm

Crop	Ten-year av. yields		Increase per acre due to rotation	
	Rotation cropping	Continuous cropping		
	Bu.	Bu.	Bu.	Per cent
Wheat	27.77	19.95	7.82	28.16
Oats	68.30	55.27	13.09	19.08
Corn	51.45	40.12	11.33	22.02

Rotation cropping produces as many bushels on fewer acres

Wheat—5 acres continuous cropping yielded	99.75 bushels
3.6 acres rotation cropping yielded	100.00 bushels
Oats—5 acres continuous cropping yielded	276.35 bushels
4 acres rotation cropping yielded	279.20 bushels
Corn—5 acres continuous cropping yielded	200.60 bushels
4 acres rotation cropping yielded	205.80 bushels

These results indicate that as large total yields of grain and corn can be secured at a lower cost by keeping from one-fifth to one-third of the farm in clover or alfalfa as by cropping the entire farm without legumes. There are very few farms where the business can not be rearranged to make profitable use of these leguminous crops as pasture and hay.

Increases in yields of grain and corn as large as those shown in the table may be obtained on practically all farms in the state by including alfalfa, red clover, or sweet clover in rotations where they have not been grown before.

Alfalfa a Soil Builder

As indicated in Table 1, red clover aids materially in increasing yields of corn and grain in rotation. Alfalfa is at least equally valuable, as far as the roots are concerned, and more valuable than clover when the fertilizing constituents per ton of hay are considered also. A ton of alfalfa hay contains more nitrogen and about the same amounts of phosphoric acid and potash as a ton of clover hay. Alfalfa and clover are able to secure a considerable part of their nitrogen from the air. On the other hand the only source of nitrogen to the timothy plant is

the soil. From the standpoint of nitrogen in the soil, alfalfa and the clovers are distinctly soil builders while timothy adds nothing.

Table 2.—Fertilizing Constituents per Ton*

Crop	Nitrogen	Phosphoric acid	Potash
	Lbs.	Lbs.	Lbs.
Alfalfa	46.8	12.2	35.8
Red clover	39.4	11.0	37.4
Timothy cut in full bloom	19.2	10.0	28.2

* Henry, W. A. Feeds and Feeding. 12th ed. pp. 555, 556.

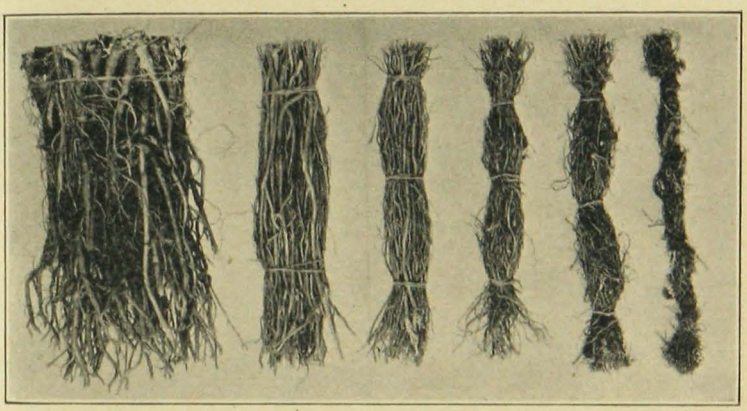

Fig. 1. Alfalfa Roots from One Square Yard Area

From surface ten inches of soil at left; and from that to right, from each of five successive ten-inch layers of soil. Weight per acre, dry matter: First ten inches, 1960 pounds; second, 560 pounds; third, 280 pounds; fourth, 140 pounds; fifth, 140 pounds; sixth, 80 pounds; total, 3250 pounds.

Animals are able to utilize only from 15 to 20 per cent of the nutrients in their feeds in producing products useful to man as food. Additional amounts are used in heating the bodies of the animals and in furnishing energy for their activities. Approximately from 34 to 43 per cent of the dry matter in animal feeds goes into the manure. Therefore much the larger part of these materials on well managed farms, goes back to the land. When hay is sold, all these materials are lost to the farm. Besides the organic matter in the manures from the hay, the roots of alfalfa and clover, when they die or are plowed under, add still more of this material to the soil.

Alfalfa has a heavier and deeper root system than clover and therefore adds more nitrogen and organic matter to the soil, and makes it more efficient in utilizing the mineral plant foods in the subsoil and in improving the condition of heavy subsoils. Alfalfa and clover draw heavily on the phosphate supply in the soil. Where the supply is too low for vigorous growth of these crops, it should be supplied in a convenient commercial form.

The highly beneficial results on grain and corn crops secured from including alfalfa and clover in rotations have been generally known for about fifteen years and less well known for a much longer period. That there is still much opportunity to put this information into practice is indicated by the relation of the area devoted to the growing of legumes to the total cultivated acres in Minnesota and adjoining states, as shown in Table 3.

Table 3.—Comparison of Ratio of Areas of Legumes to Non-legumes and Areas of Legumes per Head of Cattle in Minnesota and Adjoining States, 1925

State	Area cultivated	Legumes	Ratio of legumes to non-legumes	Additional area of legumes to make ratio of legumes to non-legumes 1:5
	Acres	Acres		Acres
South Dakota	15,450,000	917,000	1:16.5	2,173,000
Minnesota	17,303,000	1,771,000	1: 9.8	1,689,000
Iowa	20,950,000	2,585,000	1: 8.1	1,605,000
Wisconsin	9,503,000	2,835,000	1: 3.4	.....

	All cattle	Area of legumes per head of cattle	Area of legumes per head of cattle with ratio of legumes to non-legumes 1:5
		Acres	Acres
South Dakota	2,073,000	0.4	1.5
Minnesota	2,856,000	0.6	1.2
Iowa	4,371,000	0.6	1.1
Wisconsin	3,034,000	0.9	0.9

Increase the Legume Acreage

From Table 3 it will be noted that Minnesota has one acre of legumes for each 9.8 acres of non-leguminous crops. In Iowa the ratio somewhat more nearly approaches the ideal. Wisconsin has a desirable ratio and this is reflected in the higher yields per acre of the corn and grain in that state than in Minnesota.

In order to reach a ratio of one acre of legumes to 5 acres of non-legumes, it is necessary in Minnesota to double the acreage of leguminous crops. Practically all of the 368,000 acres devoted to the growing of pure timothy in the state and a considerable portion of the two million acres now producing prairie hay may well be sown to alfalfa as soon as practicable. If Minnesota had twice the present area in leguminous crops there would be 1.2 acres of legumes per head of cattle instead of 0.6 acre. This would more nearly supply sufficient high-protein pasture and hay for the livestock on farms, and should result in more satisfactory returns from livestock products.

Alfalfa Acreage Increasing

In Table 4 are shown the increase in the alfalfa acreage in the state, and the ratio of legumes to non-legumes from 1900 to 1925. In 1900 there were only 658 acres of alfalfa in the state, mostly in Carver

County. The increase in acreage to 1920 was very gradual. However, from 1920 to 1925 the acreage increased about 700 per cent, indicating that many growers appreciate the value of alfalfa and have learned to grow it successfully. This increase in the alfalfa acreage has aided materially in bringing about a more desirable ratio of the area of legumes to non-legumes in the state.

Table 4.—Comparison of Acreage of Legumes to Total Cultivated Acreage in Minnesota, 1925-1900

Crops	Acreage			
	1925	1920	1910	1900
Leguminous crops				
Clover	582,000	96,202	57,358	74,669
Alfalfa	330,000	45,410	2,288	658
Clover and timothy	849,000	938,045	829,600	754,246
Annual crop	11,000	6,110	.....	.....
Total	1,772,000	1,085,767	889,246	829,573
Total cropped acres	17,303,000	16,362,000	14,731,000	15,119,000
Ratio of legumes to to non-legumes	1:9.8	1:15	1:17	1:18

Leguminous Crops Cheap Source of Protein in Feeds

Almost all of the common farm crops are rich in starches, sugars, and similar substances called carbohydrates, that produce heat and energy in the animal body but are relatively poor in protein, which builds muscle and bone. If protein is not produced on the farm, it must be purchased at a high cost in such feeds as bran, oilmeal, or cottonseed meal, to balance the ration. Clover is relatively high in protein and very valuable as a feed, but alfalfa is still higher and therefore still more valuable in balancing rations.

Table 5.—Comparison of the Protein Content of Several Commonly Grown Farm Crops

Feeds	Nutrients in 100 pounds of feed*	
	Digestible crude protein	Total digestible nutrients
Hay and silage	Lbs.	Lbs.
Alfalfa	10.6	51.0
Red clover	7.4	49.6
Timothy	2.8	48.9
Corn silage	1.2	16.8
Concentrates		
Wheat bran	12.0	59.7
Oats	9.7	70.4
Barley	9.0	79.4
Corn	7.1	81.7

* From Bulletin 218, Minnesota Experiment Station.

Alfalfa is an excellent feed for all classes of young stock and especially for dairy cows and brood sows.

In 1925, 368,000 acres of timothy hay were reported in Minnesota. Timothy gives only a moderate yield per acre, and is not a good feed for young stock or for dairy cows. Timothy adds nothing to the soil, hence it is in the same class as the grain crops in this respect. With a return of $7.57 per acre for timothy and $19.46 for alfalfa, there is a gain of $11.89 for every acre of alfalfa that replaces an acre of timothy. This would be, on the basis of the crop yield of 1925, an increase in value of Minnesota crops of more than four and a quarter million dollars, or an average of nearly $22.50 per farm, and the alfalfa would leave the soil with more vegetable matter and as much nitrogen as was there before the crop was grown, or more.

Alfalfa Hay Yields High

Where soil conditions are favorable for alfalfa or can be made so without too great expense, it produces higher yields of a more valuable hay than clover. Comparative yields at University Farm, where conditions for alfalfa are only fairly favorable, are given in Table 6.

Table 6.—Comparison of Three-Year Average Yields per Acre of Alfalfa on a 15 Per Cent Moisture Basis

Crop	Year				
	1925	1924	1923	1922	Average
	Tons	Tons	Tons	Tons	Tons
Red clover	1.65	1.90	1.90	2.52	1.99
Alfalfa	2.20	3.13	1.70	2.29	2.34
Sweet clover	1.95	2.00	2.58	2.35	2.12
Red clover and timothy	1.18	1.60	1.91	2.70	1.97
Alfalfa and timothy	1.66	2.89	2.04	2.18	2.19
Timothy	1.18	0.97	1.19	1.07	1.10
	Relative yields, based on the yields of red clover as 100				
	Per cent	Per cent	Per cent	Per cent	Per cent
Red clover	100.0	100.0	100.0	100.0	100.0
Alfalfa	133.3	164.7	89.5	94.9	117.6
Sweet clover	118.2	105.3	135.8	93.3	106.5
Red clover and timothy	71.5	84.2	100.5	107.2	99.0
Alfalfa and timothy	100.6	151.6	107.4	86.5	110.1
Timothy	71.5	51.1	62.6	42.5	55.3

Alfalfa averaged one-third of a ton per acre more than clover. On the heavier lands of southern Minnesota, the prairie lands of western and northwestern Minnesota, and on sandy lands where alfalfa is the most successful leguminous hay crop, the differences are much greater.

Alfalfa-Timothy Mixture Practical

The yields of alfalfa and timothy sown together, as indicated in Table 5, averaged 2.19 tons per acre as compared with 1.97 tons for clover and timothy mixed. The growing of alfalfa and timothy together is as practical as the growing of clover and timothy mixtures. From the feeding standpoint, timothy with alfalfa does not improve

the value of the crop. However, if the alfalfa is winter killed the timothy is there to produce something. The yields given in the table were secured from seeding 6 pounds each of alfalfa and timothy per acre. Eight pounds of alfalfa and 4 of timothy is a more desirable mixture. On sandy lands, alfalfa should be grown alone rather than in mixtures with grasses.

Alfalfa a Dependable Crop

On many farms it is becoming more difficult to secure stands of clover, and the danger of losing the clover through winter killing makes more than usually uncertain the dependence on clover as the only source of high-protein roughage. Good stands of alfalfa are secured as readily as stands of clover.

After satisfactory stands of alfalfa are secured, the plants rarely kill so severely the first winter that no crop is harvested. The amount of killing that takes place the following years depends largely on the kind of seed sown and the way in which the fields are handled. The use of seed of hardy varieties and a good covering for winter protection reduce the risk of loss.

Alfalfa Adapted to Rotations

Growers who know how to secure satisfactory stands of alfalfa are able to work it into their rotations successfully. The fact that alfalfa is a long-lived perennial does not deter them from using it as the regular hay crop in four- or five-year rotations. Yields of alfalfa may increase with successive years of judicious cropping, but this can scarcely serve as an argument against its use in rotations provided the yields secured the first year after planting are as good as those from clover, or better. That good stands of alfalfa produce as satisfactory yields of hay the first year as does clover, has been demonstrated repeatedly. The yields presented in Tables 7 and 8 illustrate this point. Making due allowance for differences in season, on the average, as high yields were secured the first year as in any subsequent year.

Hardy Varieties Needed

Varieties or strains that have shown their ability to thrive under climatic conditions similar to those of Minnesota should always be given the preference, because altho an excellent stand and a thrifty growth the first season may be secured by using good seed of any variety, other conditions being favorable, the varieties usually grown in the milder climates can not be relied on to stand through the winter.

The yields of varieties of alfalfa secured at University Farm over a seven-year period from three different seedings are given in Table 7. There are some variations due to season, but the large differences are due to variety.

Table 7.—Comparison of Yields per Acre of Alfalfa Varieties, 1913-19
University Farm

Yields on a 15 Per Cent Moisture Basis

Variety and year of seeding	1913	1914	1915	1916	1917	1918	1919	Average
	Tons	Tons	Tons	Tons	Tons	Tons	Tons	Tons
1912								
Minn. Grimm	5.78	5.28	5.70	5.28	...	...	...	5.42
Mont. Grimm	5.40	4.97	5.60	5.00	...	...	...	5.19
Turkestan Common ..	5.82	4.73	5.10	4.38	...	...	...	4.74
1913								
Minn. Grimm	...	4.39	5.23	5.43	4.04	...	...	4.77
Mont. Grimm	...	4.31	5.00	5.06	3.71	...	...	4.52
Turkestan Common ..	...	4.50	4.40	3.58	2.55	...	...	3.76
Kansas Common	...	4.00	4.90	4.53	2.16	...	...	3.90
Nebraska Common ...	...	4.50	5.04	4.44	2.71	...	...	4.17
1914								
Minn. Grimm	...	...	4.33	3.73	5.40	2.51	4.20	4.03
Mont. Grimm	...	...	4.64	3.45	5.19	2.16	4.07	3.90
Turkestan Common ..	...	...	4.18	3.04	4.45	1.22	2.80	3.14
Kansas Common	...	...	3.59	3.27	4.69	0.20	...	2.38
Nebraska Common ...	...	...	3.48	3.96	5.28	1.09	...	2.76

Only one common variety was included in the seedings made in 1912. After four years of cropping, Grimm strains were yielding about as high as in the first season and Turkestan about half a ton lower. Three common alfalfas were included in the 1913 seedings. The first two years they yielded at the same rate as the Grimm strains; the fourth year they averaged about a ton and a half of hay per acre less than the best Grimm.

Considerable winter killing of the common alfalfa sown in 1913 occurred during the winter of 1917, and the season was unfavorable for growth. All the common alfalfas yielded from 1.25 to 1.5 tons less than the highest yielding Grimm strain.

All the varieties sown in 1914 yielded well for three years. In the winter of 1917 considerable winter killing took place, and Kansas Common yielded only 0.2 ton. In 1919 the yields from the two Grimm strains were about equal to the average for the years 1915-17, inclusive. The plantings from Turkestan seed gave fair yields, and the other two were not worth cutting. As an average for the five-year period, the Grimm strains sown in 1914 yielded 3.96 tons of hay per acre; the three strains of common, 2.76 tons, an advantage in favor of the Grimm strains of 1.2 tons per acre per year, sufficient to pay many times over for the small additional cost of Grimm seed.

None Better Than Grimm

In another trial carried out at three locations in the state, there have been no differences in the yields of Grimm, Cossack, and northern grown common in three years, as shown in Table 8. Differences in winter hardiness may develop later. There is the possibility that the seed which was purchased for northern grown was largely Grimm.

Table 8.—Yields per Acre of Alfalfa Varieties on a 15 Per Cent Moisture Basis, Minnesota

Location and variety	Yields per acre			
	1925	1924	1923	Average
	Tons	Tons	Tons	Tons
University Farm				
Grimm	2.80	4.93	2.46	3.40
Cossack	2.93	4.94	2.68	3.52
Northern Grown Common	2.97	4.75	2.43	3.38
Waseca				
Grimm	5.28	4.80	3.11	4.40
Cossack	5.28	5.04	3.20	4.51
Northern Grown Common	5.15	4.98	3.08	4.40
Crookston				
Grimm	3.07	4.47	2.71	3.42
Cossack	2.80	4.36	3.11	3.42
Northern Grown Common	3.34	4.21	3.31	3.62

Fig. 2. When Common Alfalfa Is Killed Out, Weeds Take Its Place

Left, Grimm with no winter killing and no weeds. Right, common alfalfa more than 50 per cent winter killed in the winter of 1916-17. Dandelions have taken the place of the alfalfa that was killed—1913 seedings, the yields of which are given in Table 7.

From the results given in Table 8, it appears reasonably certain that Cossack is not higher yielding than Grimm. It lodges to a greater extent and has no higher percentage of leaves in the hay than Grimm. From the tests conducted, Cossack appears to be about equal to Grimm in winter hardiness. Tests over a longer time are necessary before this may be considered an established fact.

Common Alfalfa May Be Killed Any Winter

In another test conducted at University Farm, plantings from southern grown common seed were killed the second year from seeding.

Table 9.—Alfalfa Hay Yields per Acre on 15 Per Cent Moisture Basis

Variety	Source of seed	1924	1925	Total
Grimm	Minnesota	5.05	2.55	7.60
Common	Idaho	4.98	2.30	7.28
Common	New Mexico	5.35	2.30	7.65
Common	Kansas	4.97	1.96	5.93
Common	Argentine, S. A.	5.36	0.90	6.26

Fig. 3. Even Grimm Is Sometimes Winter Killed
When an ice sheet forms over alfalfa, it is smothered out. Areas in this field were killed from this cause.

In this test the common alfalfa from Idaho showed some winter killing, but not enough to reduce the yields in 1925. Alfalfa from the Kansas grown seed was killed during the second winter so that it yielded considerably less than Grimm. So high a percentage of the plants from the Argentine seed was killed during the second winter, that it did not pay to let it stand in hay during the summer of 1925.

Based on the results given in Tables 7, 8, and 9, and other data which are available but not included in this bulletin, the following recommendations are made regarding the use of seed of the different varieties of alfalfa in Minnesota.

Recommendations Regarding Alfalfa Varieties

1. Use Grimm seed for all plantings in the seed-producing areas of the state. This includes the west central and the northwestern parts and the sandy areas in central Minnesota. By using Grimm only in these areas, crossing of varieties and mechanical mixtures will be avoided.

2. In southern Minnesota, where seed production is unusual, use Grimm for all locations where conditions during the winter are exceptionally severe and where soil conditions are somewhat unfavorable for alfalfa growing.

Under favorable conditions in southern Minnesota, particularly when alfalfa is grown in four- or five-year rotations, northern grown common alfalfa seed may be used with less risk of loss through winter killing than is taken in sowing red clover. Where greater certainty of a stand is required than this, the use of certified Grimm seed is the way to secure it.

3. The suitability of southwestern grown common alfalfa seed for use in Minnesota has not yet been determined.

4. Seed imported from South America, Italy, or France is not suitable for use in Minnesota.

Use Certified Grimm Seed

Minnesota does not produce enough Grimm seed to meet its own needs. Therefore Grimm seed grown in states farther west, where conditions for seed production are more favorable, must be used in order that the increase in acreage may go forward as rapidly as it should. If stands in these western states have been secured from genuine Grimm seed that can be traced by short pedigree back to the original fields in Carver County, there appears to be no good reason why seed from these fields should not be satisfactory in Minnesota. It is necessary that the seed be certified as genuine Grimm and that it be sold in sealed bags. Purchase of Grimm seed certified by the state or other reliable authority and sold in sealed bags is the only safe method of procedure for the Minnesota grower who must depend on the western grown product. Growers can not afford to pay Grimm prices for seed unless it is so handled.

Good Seed Essential

Being certain of the variety is only one of the essentials. Freedom from seeds of noxious weeds is of prime importance. Alfalfa seed in which are found the seeds of dodder, Canada thistle, sow thistle, quack grass, or other noxious or troublesome weed pests, should not be sown under any circumstances. Particular precautions should be taken to use dodder-free seed in sections of the state where alfalfa seed is produced.

Purchase Seed Early

More alfalfa seed is being used each year. The best seed is usually purchased early in the winter by discriminating buyers. Unless there is enough certified seed in sealed bags to go around, much of the poorer grades of seed is on the market in the spring and summer. This finds its way into the hands of growers who put off buying until just before they are ready to sow. Considerable certified seed is being distributed through farm bureau organizations.

Amount of Seed to Purchase

On well prepared seedbeds, 12 pounds of good scarified seed germinating from 90 to 95 per cent per acre is ample. If seed grown on the farm is used, it should either be scarified or additional seed used to make 12 pounds per acre of seed that will germinate. If the seedbed is not in proper condition, the additional work necessary to make it right should be put on it rather than to use more seed per acre.

Fig. 4. A Well Inoculated Alfalfa Plant

Note the large bunches of nodules on the fleshy roots. The bacteria that enable the alfalfa plant to use the nitrogen of the air live in these nodules.

Particularly on sandy lands, where Grimm seed should be used, it is often necessary, because the young plants are killed by blowing sand, to sow the second time. Under such circumstances, it is far better to

sow 10 to 12 pounds of seed per acre the first time, retaining sufficient for a second planting if that becomes necessary, rather than to sow 18 to 20 pounds per acre at one seeding.

Why Inoculation Is Necessary

Alfalfa needs inoculation to make its best development. Grain and root crops draw on the soil for all the nitrogen they use in their growth. Even if these crops are fed to livestock and the manure returned to the soil, there is a loss of nitrogen. The leguminous crops—clovers, alfalfa, beans, and peas—are rich in nitrogen. They use the nitrogen in the soil as do the other crops, but they also have the power, through the bacteria which live in the nodules on their roots, to obtain the larger part of the nitrogen needed in their growth from the air. If the right bacteria are not present, the legumes are soil robbers, as are grains, grasses, and root crops. When properly inoculated, leguminous crops may leave in the soil as much nitrogen as was there before they were grown, or more. If the leguminous crop is removed from the field and sold, or fed and the manure not returned to the field, the nitrogen is usually maintained by the roots and stubble, but not increased. On the other hand, if the leguminous crop is fed and the manure returned to the same field, or if the crop is pastured off, the nitrogen supply in the soil is usually increased considerably.

In most cases leguminous crops are not able to secure from the soil all the nitrogen needed in their growth, hence the hay is not as rich in nitrogen as it would be if the bacteria were present. In order that these crops may maintain or increase the supply of nitrogen in the soil and that the hay made from them may be as rich in nitrogen as possible, it is highly important that they be inoculated.

Results from Inoculation

In Table 10 are given the weights of hay and roots to a depth of ten inches from fields where the plants were inoculated and uninoculated.

Table 10.—*Effect of Inoculation of Alfalfa on Weight of Dry Matter and Nitrogen per Acre in Tops and in Roots to a Depth of Ten Inches.*
Two-year average, first cutting one year from seeding. University Farm, St. Paul

Part of plant	Seed treatment		Increase due to inoculation	
	Inoculated	Not inoculated		
	Lbs.	Lbs.	Lbs.	Per cent
Dry matter				
Tops	3818.0	667.0	3151.0	472.4
Roots	1556.0	439.0	1117.0	254.4
Total	5374.0	1106.0	4268.0	385.9
Nitrogen				
Tops	97.2	11.3	85.9	760.2
Roots	30.9	3.6	27.3	758.3
Total	128.1	14.9	113.2	759.7

Inoculation increased the dry weight per acre of the hay 472 per cent and of the roots in the upper 10 inches of soil, 254 per cent.

The amount of nitrogen in the dry hay was increased 760 per cent and that in the roots, 758 per cent.

The inoculated plants were dark green and thrifty, producing a successful stand. The uninoculated plants were very light green and weak in growth and the stand was not worth retaining.

Methods of Inoculation

Soil cultures.—Carefully carried out experiments on black loam, light sand, and peat show the following results. The plants were dug and examined approximately a month from planting time.

Inoculation by the glue or the sugar method was not satisfactory. Careful determinations showed that by these methods only 8.2 pounds of soil adhered to each bushel of seed. This is not enough for efficient inoculation. It is recommended that at least as many pounds of dry inoculated soil as of seed be used. Soil taken from the upper three or four inches of a vigorous sweet clover patch will usually be found more efficient than that taken from a well inoculated alfalfa field. The soil is taken under cover, sifted to make it very fine, and then dried gradually in the shade. This may be done several days before seeding if more convenient. When ready to sow, the seed is moistened and as many pounds of the dry soil are mixed in as there are pounds of seed. If the soil is sifted and dried as directed, there will be no difficulty in the mixture going through the seeding machinery.

Table 11.—Percentage of Plants Bearing Nodules on Roots from Various Methods of Inoculation

Methods of inoculation	Percentage of plants inoculated		
	Black loam soil	Peat soil	Sandy soil
None	0.0	0.0	0
Glue solution and soil	31.3	15 5	0
Sugar solution and soil	28.0	46.7	0
Same weight dry soil as seed	80.5	81.7	50

Scattering broadcast before the seed is sown 200 pounds per acre or more of soil from an inoculated sweet clover or alfalfa field and harrowing it in has been found effective.

While thoro inoculation can be secured most easily at the time the seed is sown, occasional failures occur. In such cases, broadcasting the inoculated soil at the rate of 200 pounds per acre and harrowing it in immediately should accomplish the desired results.

Commercial cultures.—Several brands of pure cultures are now available. Directions for use are provided on each container. In order to be effective, these inoculants should be fresh. The date up to which

the contents of the container are supposed to be effective is stamped on the wrapper. Look this up when making the purchase.

Thoro Inoculation Pays

Particularly on sandy lands, thoro inoculation often makes the difference between securing a really successful stand and one that is scarcely worth retaining. On heavier soils the need for thoro inoculation is just as great, but the immediate effects of inoculation are not so easily seen.

In order to be certain of very thoro inoculation, it is advisable to use a good commercial culture at the rate given on the container, and in addition ten pounds of finely sifted soil from a sweet clover or alfalfa field known to be well inoculated, mixed as directed above with the seed for each acre. Extra effort to secure thoro inoculation is well expended.

If, after the seed is inoculated, weather conditions make it impossible to sow immediately, the treatment will remain effective for a week or two under ordinary conditions. After several weeks have elapsed, reinoculation is always advisable.

Alfalfa Has Wide Adaptation

The deep rooting habit of alfalfa plants and their ability to grow downward very rapidly, particularly during the first few months of growth, make it possible to secure satisfactory stands and good crops on widely different soil types. Poorly drained fields or low areas in otherwise well drained fields where water stands on the surface from a week to ten days in spring or after heavy rains, are not suited to alfalfa growing. Low areas in an alfalfa field may be sown to timothy and alsike clover. Alfalfa does not usually do well on peat. These exceptions form only a small part of the total cultivated area of the state. This leaves by far the largest part of the state, including the central sandy areas and the Red River Valley, where red clover is not a success, adapted to alfalfa growing.

On most of the fields in nine of the counties of southeastern Minnesota and the sandy lands of the central and northeastern counties, liming is necessary for success with alfalfa. Where, when, and how to lime are discussed in Special Bulletin 107, "Liming for Alfalfa in Southeastern Minnesota."

Clover Fails—Alfalfa Succeeds

On sandy lands it is difficult to secure successful stands of red clover, and when occasional stands are secured they produce hay for only one season. While clover plants have tap roots that grow downward to considerable depths, their progress is too slow to keep the ends of the roots where they can secure sufficient moisture to thrive.

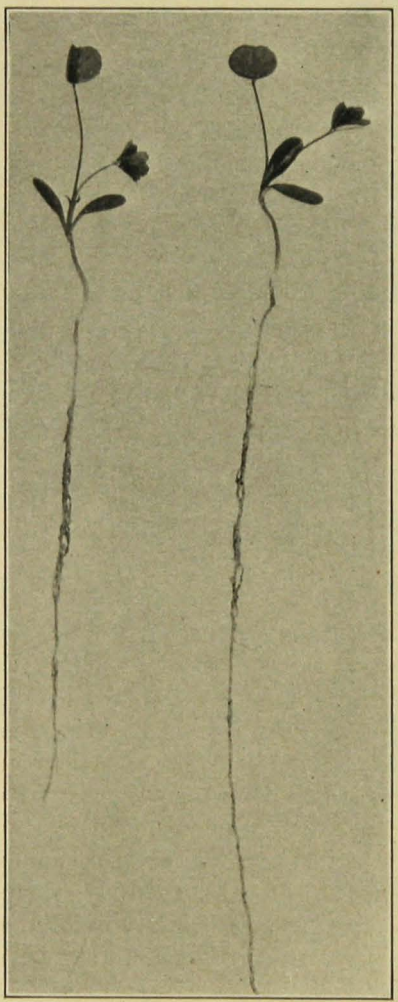

Fig. 5. Roots of Young Alfalfa Plants Penetrate the Soil Rapidly
These are two weeks old and the roots are from 8 to 10 inches long.

When dry weather occurs, the young clover plants use up the available moisture in the upper two or three feet of the sandy soil more rapidly than the roots grow downward to additional supplies of moisture. The result is that the young clover plants die out for lack of water. Even if light rains wet the ground to a depth of a few inches, this moisture disappears rapidly and therefore does not save the plants.

The roots of young alfalfa plants, on the other hand, force their way downward rapidly. Using the water as they go, the lower parts of the roots are maintained in moist soil and the young plants are able to withstand the prolonged drouths which often prevail on these sandy lands during the summer.

Alfalfa roots from seedings made in July on sandy land have been found with their tips from 3½ to 4½ feet deep by October. During much of the last half of the period between seeding and the examination of the roots, the sand was dry to a depth of from 1½ to 3 feet. These plants with the ends of their roots in moist soil did not lack water, while shallower rooted plants had stopped growth or were dead. Year old plants had penetrated to a depth of from 5 to 5½ feet and older plants were down to the water table 12 feet below the surface.

Alfalfa roots grow downward rapidly the first season and continue downward as the plants become older. This makes it possible for alfalfa to make a successful stand on sandy lands where clover fails and to make some growth even when drouths are so severe as to make clover fail. This habit of growth, together with the fact that the plants are perennial, adapts alfalfa to sandy land where the water table is not too far beneath the surface.

Seeding Alfalfa with a Grain Crop

In practically all except the sandy lands of the state the supply of moisture is sufficiently dependable that alfalfa may be planted with a grain crop in spring as is clover. When this method is followed, the grain crop should be sown at about half the usual rate or not more than one bushel by weight for barley, wheat, and oats. On fields fairly free from weeds, flax is an excellent crop with which to sow alfalfa, using 42 pounds of flax seed per acre and sowing in April or the first few days of May. Sowing the flax early prevents very largely the growth of such weeds as foxtail, barnyard grass, and pigweed. If the fields are not ready for the flax and alfalfa by the first week in May, better results will be secured by cultivating until the middle of June and then sowing the alfalfa alone.

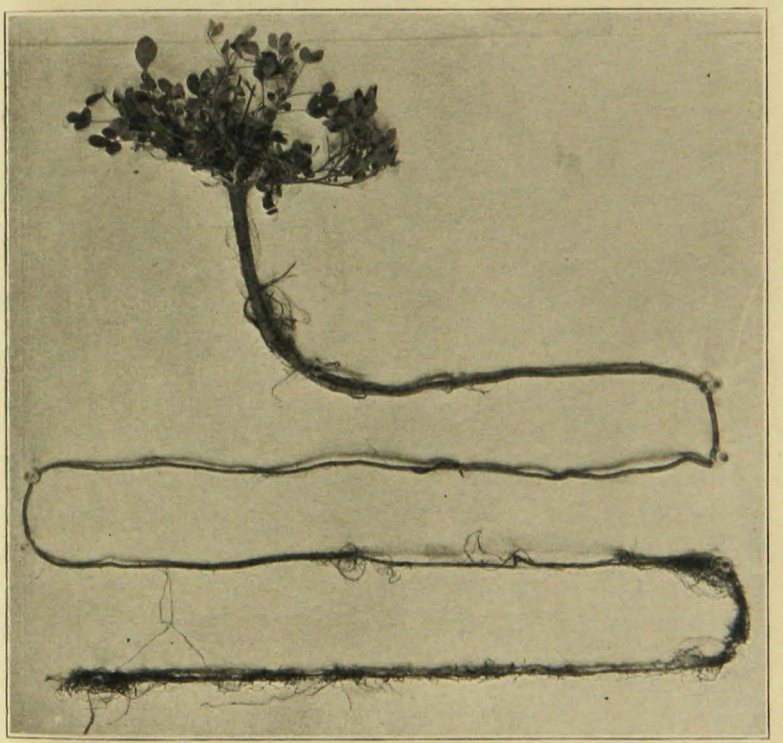

Fig. 6. Alfalfa Plant One Year Old, 5 Feet 6 Inches Long
From sandy land in Sherburne county

If drouth occurs at any time during the growing season and it appears that there will not be sufficient moisture for both the grain and the alfalfa, the grain crop, except flax, may be cut for hay, leaving a stubble from 5 to 6 inches high.

If the grain crop is permitted to grow to maturity, the shocks should not be left in the field so long that the alfalfa plants are killed out under them.

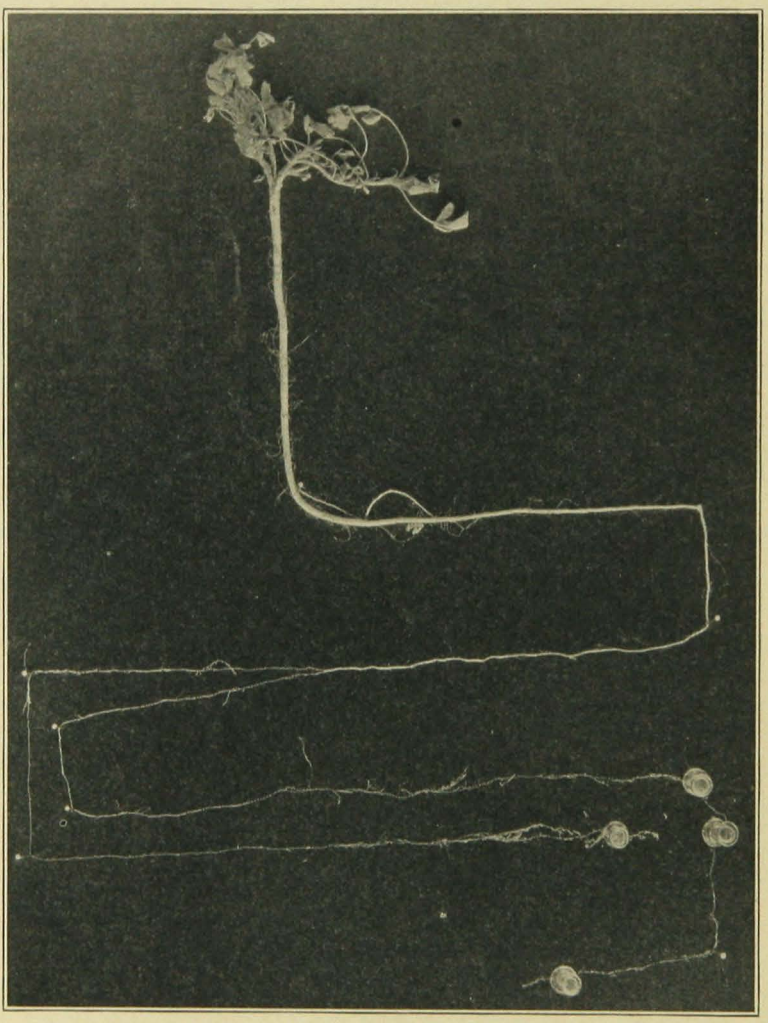

Fig. 7. Root of Alfalfa Plant from Seed Sown in July, Dug in October, 42 Inches Long From sandy land in Sherburne county

There is no advantage in seeding alfalfa alone in early spring. Unless the land is exceptionally free from weed seeds, the weeds that spring up will crowd the alfalfa as much as a grain crop does or more, and there is the labor of clipping the weeds several times during the season with no return from the land.

Summer Seeding Without a Grain Crop

On sandy lands, on other lands that lie high and are liable to lack moisture, and on fields on which for other reasons conditions for securing a stand of alfalfa are not favorable, summer seeding without a grain crop is advisable. Summer seeding has the following advantages:

Fig. 8. Alfalfa Sown August 15 on Black Loan Soil

Many of the plants were heaved out during the winter, leaving a poor stand of very weak plants. On sandy lands alfalfa sown after August is not heaved out but is frequently winter killed, particularly where there is no snow covering.

(1) The weeds may be killed out practically completely by disking as often as necessary to keep the surface free from all green growth. (2) None of the moisture in the soil is used by plants before the alfalfa is sown, if the fields are kept free from weeds. (3) The seedbed may be kept ready for sowing the alfalfa at the time when moisture conditions are most favorable. This is following a good rain. (4) If a successful stand is not secured from the first planting, the seedbed may be put in shape quickly so that a second seeding may be made the same season, before it is too late.

Preparation of the Seedbed and Time of Seeding

Special care should be used to have a firm seedbed where alfalfa is sown with grain early in the spring. Fall-plowed land well prepared by the use of the disk and the harrow usually provides this. If spring-plowed land is used, it should be made firm by the use of a corrugated roller.

When the alfalfa is to be sown in the summer, the disk should be used systematically as often as is necessary to keep the surface of the fields entirely free from all weed growth. It is especially desirable to

get rid of all quack grass and Kentucky bluegrass before seeding alfalfa. These are two of the most undesirable plants in alfalfa fields. Usually by the end of the first or second week of June most of the weed seed in the ground will have germinated and the seedlings have been killed by subsequent diskings.

Successful stands of alfalfa may usually be secured by seeding up to and including the last week in July. Sowing later than this is attended by considerable risk of having the plants killed during the following winter. On heavy soil there will usually be enough moisture that the seed may be sown at any time in June or July that the seedbed is free from weeds. However, on sandy lands it pays to wait until the first good rain. In order to make the most of the rain, the land should be rolled with the corrugated roller as soon after the rain ceases as possible and the alfalfa sown and covered. Practically nothing else should be allowed to interfere with prompt use of the corrugated roller,

Fig. 9. Alfalfa in Corn at Last Cultivation

Sowing alfalfa in corn at the last cultivation is not a dependable way of securing a successful stand. Note the uneven stand. On left, alfalfa sown without grain, June 15; on right, alfalfa sown with grain in the spring.

followed immediately by the planting of the seed. The sooner this can be done after the first or second week in June the better, as if a successful stand is not secured the first time, there will still be time to replant before the last week in July.

Depth of Seeding

On heavy soils, sowing the seed broadcast and harrowing to cover is the best practice. If a drill is used, much of the seed is likely to be put in so deep that it will be difficult for the seedlings to push up through the covering.

On sandy lands it is better to plant the seed from one to one and a fourth inches deep in the openings made by the corrugated roller in order to get the seed in a favorable position as far as moisture is concerned and to avoid blowing out, particularly on the higher places in the fields.

Method of Seeding

When alfalfa is sown with the grain, the usual method is to broadcast the seed from the grass seed attachment to the drill. After the seeding is completed, the smoothing harrow is used crosswise of the

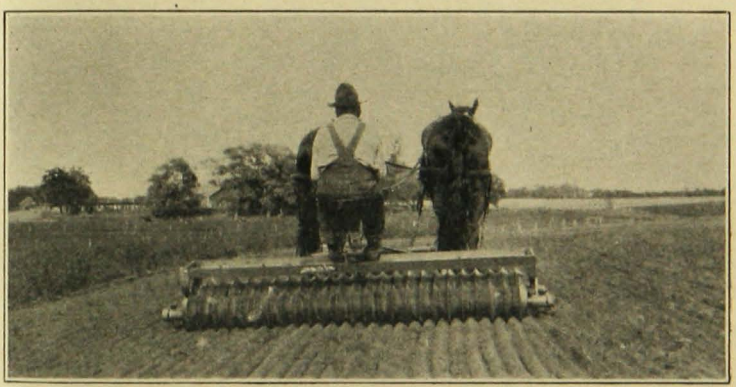

Fig. 10. Preparing the Seedbed

The corrugated roller packs the seedbed and at the same time leaves openings of uniform depth into which the broadcast seed falls.

direction of the drilling. Another method is to broadcast the seed with a wheelbarrow seeder either before or after the grain is drilled, and cover with the smoothing harrow.

When the alfalfa is sown alone, the best method is to broadcast with a wheelbarrow seeder or other device that will distribute the seed evenly over the seedbed. If the seedbed has been prepared by using a corrugated roller, most of the seed falls or rolls from the ridges down into the shallow, hard-packed openings made by the roller. The use of a weeder or a light smoothing harrow crosswise of the roller openings drags the seed left on the ridges down into the depressions and closes the openings, thus covering the seed at a fairly even depth.

The corrugated roller should be used following the harrowing and in the same direction, crosswise of the previous rolling, to pack the ground above the seeds. No further harrowing is necessary or desirable on sandy lands. With the surface uneven, as left by the corrugated roller, the sand blows less than where the surface is left smooth by the harrow.

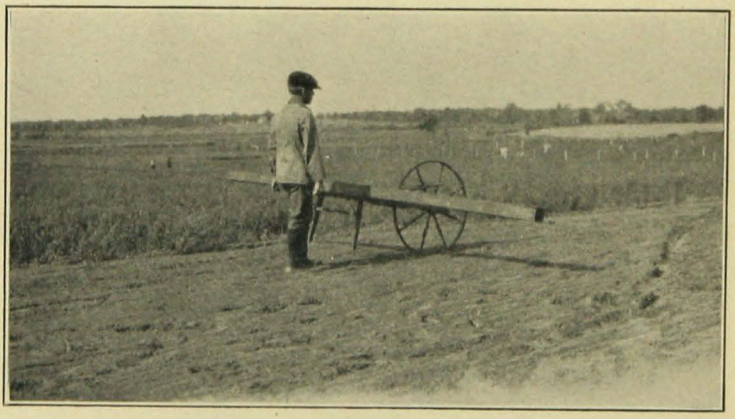

Fig. 11. Using the Wheelbarrow Seeder

Alfalfa seed can be broadcast fairly evenly by hand, with care, but an even distribution is more easily secured by using the wheelbarrow seeder.

Care During the First Season

The few weeds that usually develop after the seedbed has been kept clean through the first or second week in June, or longer if necessary, do the alfalfa no harm and hence need not be cut. After a good stand is secured it should be so handled that the plants will remain vigorous as long as desired. Usually alfalfa should not be cut the same season as sown. Under no circumstances should new seedings or old stands be pastured close late in the fall. The growth the next

year will be more vigorous if all of the growth of the first season and from 6 to 8 inches in succeeding seasons is left for winter protection.

Alfalfa Hay Making

The main purpose of growing alfalfa is to secure a dependable supply of high protein hay of good quality.

In order to secure these results it is necessary (1) to cut the alfalfa before the stems become large and hard and before the leaves have dropped; and (2) to leave a growth of from 6 to 8 inches in the fall for winter protection where it is desired to have the alfalfa live through the winter. The reasons for leaving a good winter covering are discussed later.

Good quality alfalfa hay is made up of 50 per cent or more of green leaves and the stems are pliable. In order to secure hay of this kind it is necessary to begin cutting before the plants have reached the full bloom stage of development.

Where alfalfa is left until it is in full bloom or nearly so before cutting is started, all of the hay will be coarse stemmed and if rains prevent cutting promptly, many of the leaves will be lost. In Minnesota it is not necessary to let alfalfa come to full bloom regularly before cutting in order to maintain vigorous stands.

Time of Cutting

The roots of alfalfa plants serve two purposes: (1) They hold the plant in place and take up water and other materials from the soil in the same way as do the roots of wheat and corn. (2) They serve as storage organs for such reserve food supplies as starch and protein, that are necessary to make rapid growth of stems and leaves in spring and after each cutting. Knowing how reserve foods are stored in the roots aids materially in understanding how to handle alfalfa successfully as a hay and pasture crop.

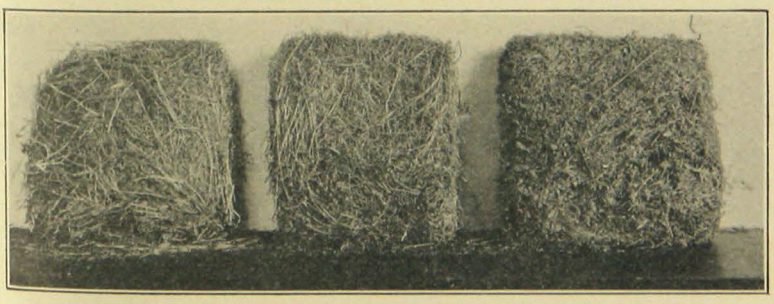

Fig. 12. Alfalfa Hay Cut at Various Stages

Right, cut at tenth-bloom stage and cured without loss of leaves. Over 50 per cent leaves, fine texture, soft, and bright green; high in feeding value. Center, cut in full bloom, many leaves lost, and somewhat discolored; medium feeding value. Left, about the same as that in the center but much more bleached; of low feeding value.

Almost every one has had experience with a battery used in starting and lighting a car. When the battery is new it is fully charged. When the engine is cranked or the lights are used, the energy in the battery is drawn on and consequently the amount in the battery is lowered. When the car is run at a fair speed without the lights on, the battery is recharged slowly. If more energy is used out of the battery in starting and lighting than is put back by running the car with the lights off, the battery grows weaker and weaker until it will not turn the engine over. The battery is then taken to a garage and recharged. If recharging is neglected, it soon becomes dead.

The reserve plant food in the alfalfa roots acts in much the same way as the reserve energy in the battery. In order to have a good supply of reserve food in the alfalfa roots by the time growth stops in the fall, which is comparable to a well-charged battery, it is necessary to let a good growth develop on the field during September and October. Usually no hay should be removed from alfalfa fields later than September 10. Unless the alfalfa fields have been misused earlier in the season by too frequent cutting or too close pasturing, sufficient reserve food will be stored in the roots during September and October that a vigorous rapid growth of stems and leaves can be made in spring.

In the spring the reserve food stored in the roots is drawn on entirely for material out of which to build the first stems and leaves. As soon as some of the stems and leaves are formed, they make food material, but not in sufficient quantities to take care of the rapid growth. Therefore the reserve supplies in the roots are being constantly lowered.

As the stems and leaves continue to develop they reach a point where they are able to make all the food that is needed for growth and finally where they can make more than is used in daily growth. This is when a refilling of roots with reserve foods begins. It is not known at what stage in the development of the plant this occurs. It continues until the crop is cut again, or until the roots are filled if the crop is left standing that long. The only way that the alfalfa roots can be refilled with reserve foods is through their manufacture by the leaves and stems. Reserve food can not be supplied from some outside source as can be done with the energy in a battery.

As soon as the second cutting of hay is removed, the reserve food in the roots is again drawn on for materials to make new growth, and the same lowering of the reserves followed by filling them in again occurs as took place following the first cutting.

Just as a battery may be used too often to start a car and finally, if not recharged, becomes weak or dead, so cutting alfalfa too often or pasturing it too close lowers the reserve foods in the roots to the

point where the plants are unable to produce more new stems and leaves and they die.

How Often Should Alfalfa Be Cut

It is known that cutting alfalfa every ten days or pasturing it close throughout one season will kill out 80 per cent or more of the plants. The supply of reserve plant food in the roots is lowered to the point where no more is available to produce new stems and leaves and the plants must die. Cutting alfalfa as a regular practice as often as it comes to the bud stage of development, that is, before blossoming has started, keeps the reserve foods in the roots at too low a level for the plant to be vigorous. However, an occasional cutting before blossoming begins will do no permanent injury provided the following cuttings are made at a more mature stage of development.

Leaving a good growth during September and October enables the roots of alfalfa that have been cut too often during the season to refill with reserve food to a considerable extent.

Under Minnesota conditions, there is ample evidence that cutting alfalfa as often as it comes into the tenth to quarter bloom stage of development keeps the level of the reserve foods in the roots high enough to maintain a satisfactory stand of plants in a vigorous condition over a considerable period of years. In order to leave a good winter covering, this means usually three cuttings in the central and southern parts of the state and two cuttings in northern Minnesota with the last one removed about September 1 to 10. All of the yields given in Table 7 and 9 and those in Table 8 from University Farm and part of those from Waseca are from three cuttings per year in tenth bloom.

It is of considerable importance to know this, as cutting at from tenth to quarter bloom has been found to give as large yields of hay as cutting in full bloom, and the hay is usually leafier and the stems are smaller and softer.

On sandy lands two cuttings in from tenth to quarter bloom may be made each year, and during years of abundant moisture, three cuttings, provided always that the last one can be removed about September 1 to 10 and the conditions look favorable for a good growth before winter sets in.

Altho letting alfalfa stand until it has come to the full bloom stage usually keeps the food reserves in the roots at a somewhat higher level than cutting at tenth to quarter bloom, this difference is not great enough to warrant a general practice of putting off the beginning of cutting until this advanced stage. When the alfalfa on large fields is left until the full bloom stage before the mower is started, much of it

will be far beyond that stage before the haying operations are completed. Many of the leaves are dropped as the alfalfa comes to the full bloom stage and passes beyond that, and the result is a low leaf percentage and coarse hard stems, particularly from the first cutting of the season.

The second and third cuttings are not so likely to be coarse and may become more mature before cutting with less lowering of the quality of the hay.

If for any reason alfalfa stands have become weakened by too frequent cutting or too close pasturing, it is advisable to remove one less cutting per season until the reserves in the roots again reach the level where the plants will be vigorous.

Alfalfa is most vigorous when it stands until it has produced seed. Except in the seed-producing areas of the state, this is not a practical method of handling any part of the season's crop.

Cut Lodged Alfalfa Before Leaves Fall

In central and southern Minnesota the first crop of alfalfa very often is of rank growth and lodges during wet weather, often before the crop has begun to flower. Within a very few days after lodging, the leaves that are shaded turn yellow and drop off.

Fig. 13. Alfalfa Seed Crop Cut with the Binder, and Shocked

As shown in Table 12, lodging caused a loss of 12 per cent of the leaves in one year and 18 per cent the next year. Hay with only 41 per cent of leaves is medium in quality and when the percentage of leaves is as low as 30 the quality is very poor.

In order to secure a good quality of hay from lodged alfalfa, it should be cut as soon as the weather becomes favorable regardless of the stage of development it has reached.

Table 12.—Effect of Lodging of Alfalfa on Percentage of Leaves in the Hay Crop University Farm

Condition of crop at harvest	1925		1924	
	Leaves	Stems	Leaves	Stems
	Per cent	Per cent	Per cent	Per cent
Erect	53.75	46.25	48.50	51.50
Lodged	41.63	58.37	29.62	70.38
Differences	12.12	....	18.88	....

Curing Alfalfa Hay

Leafiness, green color, soft stems, and freedom from weeds and trash are the best indications of high feeding value in alfalfa hay. If it is to be baled and sold on the market, it may be advisable to mow the winter covering in the spring and rake the field clean in order to keep trash out of the hay.

It is important to keep in mind that rain or dew does little damage to green hay, but after it is partly dry rain leaches the valuable materials out of it rapidly. Keep rain and dew off of partly cured or cured hay in order to secure the best quality.

One of the best methods of curing alfalfa hay is to cut it after the dew is off in the morning, windrow it with the side delivery rake within an hour or two, and get it into cocks before the day is over.

Only small acreages can be cured in this way. Large acreages can be handled to best advantage by windrowing with the side delivery rake soon after cutting, turning as needed with the same implement, and getting the hay into the stack or mow before the leaves have become so brittle that they drop off.

Growing Alfalfa Eliminates Canada Thistles

Vigorous alfalfa grows more rapidly than Canada thistles and therefore shades them. This, together with the cutting of the hay regularly for a number of years, weakens the thistles and they finally disappear. Alfalfa will not eliminate quack grass.

Alfalfa Seed Production

Each year some alfalfa seed is produced in Minnesota, mostly in the west central and northwestern parts of the state and on the central sandy land areas. The west central and northwestern parts of the state are comparatively low in rainfall, averaging from 24 to 26 inches annually. The eastern and southern parts of the state have from 28 to 30 inches. On the sandy lands seed is often produced even if the rainfall is higher than in the western part of the state. This is due to the fact that they retain less of the water that falls.

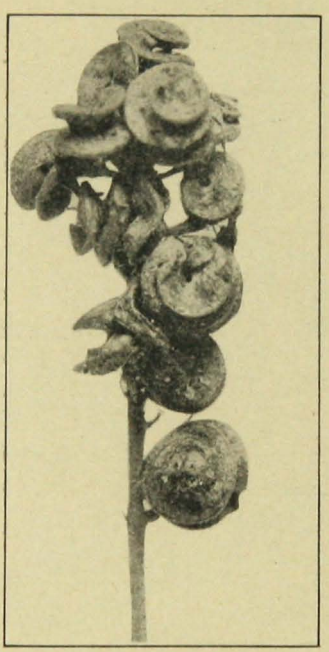

Fig. 14. Alfalfa Seed Pods

When the majority of the pods have turned dark brown or black, the crop is ready to cut.

In the west central and northwestern regions it is usual to leave the second cutting for seed production. In order to give the seed crop ample time to mature before frost, it is necessary to cut the first crop for hay early.

Where the second crop is allowed to go to seed, there need be no hesitancy in cutting the first crop in the bud stage or before, if necessary. Leaving the second crop for seed allows the alfalfa to replenish the food reserves in the roots, which are lowered by cutting the first crop early. When left for seed production, alfalfa stores up in its roots the largest amounts of reserve food and hence is in the most vigorous condition. Close watch should be kept on it as it comes into full bloom. If there is much wet weather during this time, few pods will set and the crop may as well be cut for hay before most of the leaves have dropped and it has become of little worth as feed.

Alfalfa for Pasture

Sweet clover is a more practical pasture crop for cattle than alfalfa. However, alfalfa may be pastured if used judiciously. The oldest stands that are about ready to be plowed up should be used for this purpose. When it is sown for pasture rather than for hay, 4 to 6 pounds of timothy or meadow fescue should be included with the alfalfa seed. These grasses in the alfalfa reduce somewhat the danger from bloat. In order to reduce bloating to a minimum, the animals should have some dry feed, as hay or straw, to eat before going to the pasture in the morning. If the stands of alfalfa are to be retained it should not be pastured close during any part of the year.

For hogs, alfalfa is one of the best pastures known. If handled rightly, alfalfa produces tender green feed from May until September. In order to maintain a stand, the hogs must not be allowed to pasture it down closer than from 6 to 8 inches at any time unless they can be taken off while the alfalfa recuperates. Alternating the hogs in two

alfalfa fields is the best arrangement. When this plan is followed, one field may be allowed to grow up to the blossoming stage while the other is being pastured.

Whether alfalfa is pastured by cattle or hogs, it is necessary to have a growth of from 6 to 8 inches for winter protection.

Fig. 15. Care Needs To Be Exercised in Pasturing Cattle on Alfalfa

Care of Alfalfa Fields

Besides limiting the number of cuttings each year to the number that can be removed and still keep the alfalfa in a vigorous condition, it is necessary to leave a good growth in the fall for winter protection.

How Winter Protection Helps Maintain Stands

A growth of from 6 to 8 inches in autumn to hold the snow and aid in maintaining a more uniform temperature for the plants during the winter appears to be one of the most important considerations in maintaining a good stand. A good growth holds the snow and prevents rapid alternate thawing and freezing.

Fig. 16. Alfalfa Holds Snow and Helps To Prevent Thawing

Note the good snow covering on the right. On the left some of the snow was blown off and what remained melted.

In Figure 17 is shown the temperature range for two weeks underneath 8 inches of snow and in the air above the snow. The comparatively straight line starting at the upper left hand side varying from 28° F. at the beginning to 23° F. at the end, is the record of the temperature beneath 8 inches of snow. This is a variation of only 5 degrees for the fourteen days. The irregular line beginning at about 30° F. in the upper left-hand corner is a record of the temperatures of the air in the shade about two feet above where the record was taken beneath the snow. Here the temperature went up to 40° F. on Tuesday noon of the first week and down to 22° below zero Monday morning of the next week and back up to 38° F. by the next Friday noon. Alfalfa in a field without a good fall growth and with no snow

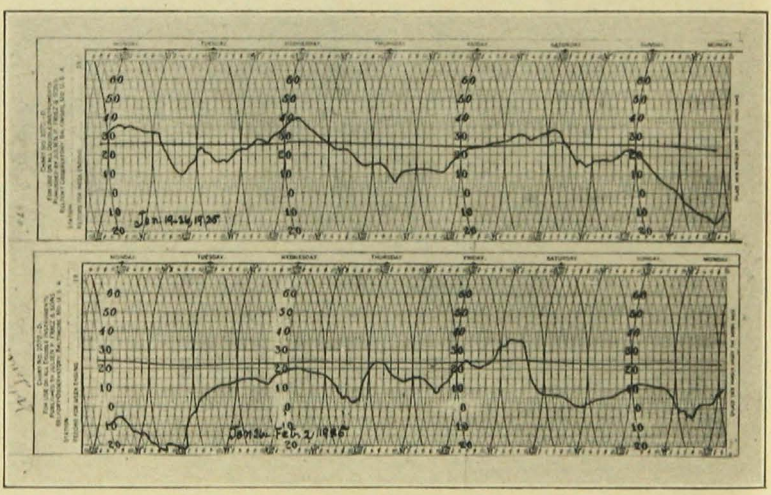

Fig. 17. Variations in Temperature

Underneath the snow, during two weeks, alfalfa plants experienced a variation in temperature from 28 to 22 degrees, F., while the air above varied from 10 degrees above zero to 22 degrees below. With no snow covering the plants would be subjected to about the same temperature as the air.

for a covering would be subject to about the same changes in temperature as the air above it. Thawing starts growth and severe freezing following it can do more damage to the plants than if the slight thawing and growth had not taken place. Leaving a good growth for winter protection when maintaining stands is important.

Cultivation Eliminates Grasses

If bluegrass or quack grass appears in alfalfa fields it may be eliminated by using the spring-tooth harrow in June as soon as the first cutting has been removed. The harrow should be set at a depth

of from three to four inches and used vigorously in both directions until the field looks black. This treatment will not injure the alfalfa if the work is done at the right time.

It is not advisable to use the spring tooth harrow on alfalfa fields in early spring on heavy land until it is in good physical condition. Very often the land is too wet and weather conditions are unfavorable for eradicating bluegrass or quack grass. If land is worked when it is too wet it is left in poor physical condition. The use of the smoothing harrow following the spring tooth puts the fields in better condition for mowing.

Whether any increase in yields may be secured by cultivating alfalfa fields with the spring tooth harrow when no bluegrass or quack grass is present, has not been determined.

Eliminate Pocket Gophers

Pocket gophers do considerable damage in alfalfa fields. Methods of killing them by the use of poisoned bait are explained in detail in Circular 14, published by the Agricultural Extension Division, University of Minnesota. As soon as gophers are known to be present they should be killed by this simple and highly efficient method.