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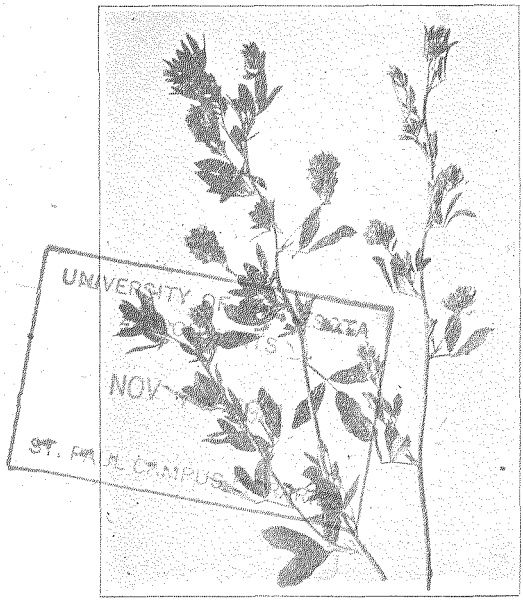

1. ALFALFA, ITS CHEMICAL DEVELOPMENT, FEEDING VALUE AND DIGESTIBILITY.
2. THE DIGESTIBILITY OF HOG MILLET.

ST. ANTHONY PARK, RAMSEY COUNTY, MINNESOTA.

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ALFALFA, ITS CHEMICAL DEVELOPMENT, FEEDING VALUE AND DIGESTIBILITY.

*HARRY SNYDER AND J. A. HUMMEL.

INTRODUCTION.

The interest which has recently been manifested in alfalfa by farmers and stockmen throughout Minnesota has prompted this work. Much encouragement is being given the growth of this great forage plant by the discovery and

Figure 1.—Third crop Alfalfa, Aug. 28, on farm of Mr. A. B. Lyman, Excelsior, Minn.

*The details of this work have been carried out and the results prepared for publication by Mr. J. A. Hummel, Asst. Chemist. There has been a great deal of interest taken in alfalfa and it is believed that this bulletin will answer some of the numerous inquires that have been made regarding this crop.

H. SNYDER, Chemist.

introduction of varieties that seem to be hardy in our severe climate. Some of these varieties have been brought from certain localities in Turkestan, the climate of which resembles that of Minnesota. Alfalfa has been grown without difficulty in the region of Lake Minnetonka in this state, for thirty or more years. The seed of this variety was brought into the state by certain Germans, and is said to have come originally from Norway. This variety has been found to be perfectly hardy in that vicinity, and no doubt, will thrive throughout the state generally excepting possibly certain sections in the northern third of the state. Because of the encouragement thus offered, this work on alfalfa was undertaken with the object of determining its composition and feeding value when grown in Minnesota, its chemical development and draft upon the soil. It was also thought that the work might stimulate the interest already shown and bring before our farmers, the great possibilities of this forage plant.

Alfalfa or lucern, *medicago sativa*, is a native of Western Asia; it was early introduced into Southern Europe and later was taken to South America whence it found its way into Mexico and then to California and other western states. In the region south and west of the Missouri River, it found congenial conditions and has proved of immense value to farmers throughout that country.

Alfalfa belongs to the same family as clover, peas and beans, the legume family. The young plant, at first, has a single stem, but as this is cut off or grows older, it branches and forms a crown with many stems. The plant has a strong tap root with smaller lateral roots as feeders. This tap root goes deeply into the soil and finds moisture even when far below the surface. On the roots are found tubercles, or small nodules, (see figure 2), similar to those found on red clover roots, and by means of these tubercles, which are induced by bacteria, the plant is enabled to gather and use as plant food, free nitrogen of the air, so that in common with red clover and other members of this family, it not only has the power of storing up within itself large quantities of that valuable nitrogenous material protein, but by

Fig. 2.—Alfalfa roots, showing the nodules.

the accumulation of roots, it leaves the soil richer in this element than it was before producing the crop. Professor Davenport, when speaking of the members of this important family, says: "They not only work for nothing and board themselves, but they pay for the privilege." These plants are the only ones of any agricultural importance that can use the atmospheric nitrogen, and they can do it only with the aid of certain bacteria.

Figure 3 is typical of the alfalfa plant in blossom, and shows its peculiar habit of bearing the flowers all along the stem and not simply at the tips as the clover blossoms are borne. The seed is formed in spiral pods as shown in the illustration Fig. 4. Unlike red clover, alfalfa is a perennial and lives for an indefinite period. Near Lake Minnetonka, fields have been producing alfalfa for thirty years continuously.

Seeding.—The young alfalfa plant is rather delicate and a weak feeder consequently the seed bed must be carefully prepared, with a good supply of plant food readily available. The ground should be plowed rather deeply and the surface brought into a fine condition as in the sowing of clover or other small seeds. From ten to fifteen pounds should be sown per acre, preferably without a nurse crop, and as early as possible in the spring without danger of frost which may kill the young plants. As soon as the first blossoms appear or whenever the plant shows signs of losing thriftiness, it should be mowed as this stimulates stronger growth. It can usually be cut three times during the season, and after it has become well established, it will yield from three to five tons of cured hay per acre.

Soil.—Alfalfa seems to do best on sandy loam soils that have a good supply of plant food and are well drained though it has been known to have grown in a heavy clay soil. It will do well on any soil that will produce wheat or corn. The field designed for alfalfa should be selected with the view of leaving it for several years. The plant seems to reach its prime in four years and can as a rule be left in a field profitably for seven or eight years. No difficulty is experienced in getting alfalfa out of a field if it is plowed in mid-summer and kept well cultivated.

Fig. 3.—Alfalfa blossoms, reduced one-half.

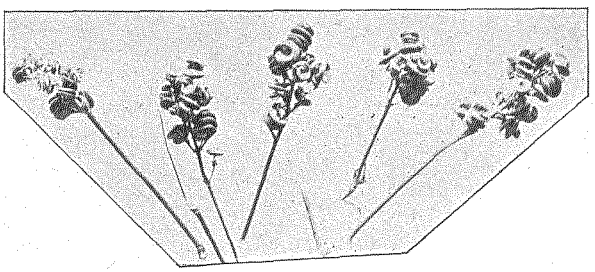

Fig. 4.—Alfalfa Seed Pods.

Harvesting.—Alfalfa for hay should be cut when one-third of the blossoms have appeared, because at this stage it makes the best quality of forage. It should be raked up into windrows when somewhat wilted, and never allowed to dry out before being raked, because then it does not cure so well and most of the leaves will be broken off in handling. It should be handled so as to preserve all the leaves since they are the most valuable part of the plant. In a dry season, it can sometimes be placed in the barn or stack the day after cutting, but it will usually be a better plan to a allow the hay to stand in cocks a few days.

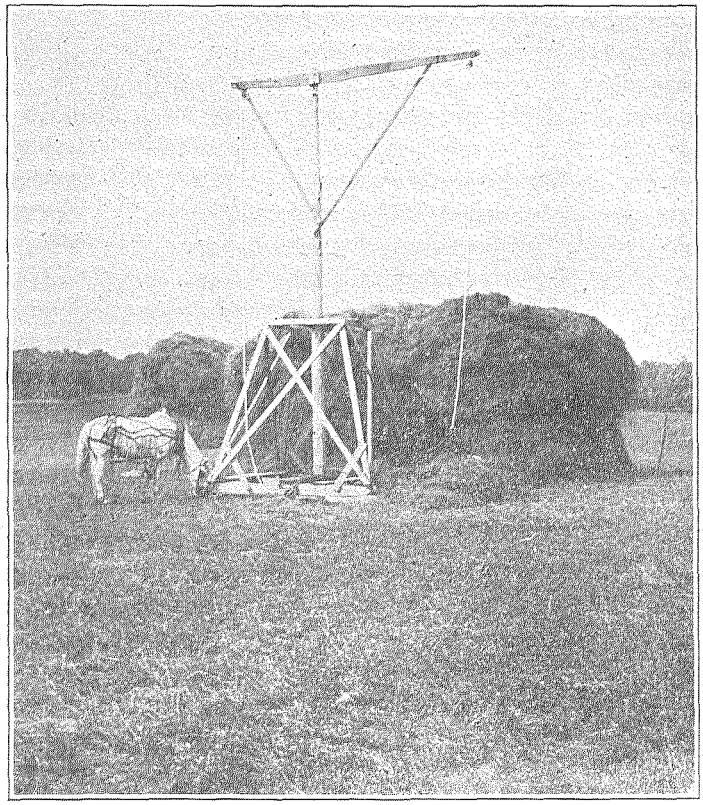

Fig. 5.—Device for stacking Alfalfa hay.

Figure 5 shows the device used for stacking alfalfa on the farm of Mr. A. B. Lyman, Excelsior, Minn. The upright piece is made to turn freely, and the pulley at the base is so placed that as the load is drawn up, the rope pulls the arm around so that the hay is deposited in the center of the stack. Alfalfa seeds rather uncertainly; the second crop is usually better than the first for seed production. For seed it should be cut when the seed pods turn dark, and should be handled in the same way as is clover for seed. The yield is from two to four bushels per acre.

OBSERVATIONS FROM FARMERS.

Before venturing on the chemical study of the crop it was thought best to determine to what extent it was grown in the state and gain some information as to its possibilities. For this purpose letters were sent out early in the summer of 1902 to certain farmers and stockmen throughout the state, requesting them to give any information they could as to the extent to which alfalfa was grown in their vicinity and with what success. Incidentally inquiries were also made to obtain the methods of seeding and handling the crop and other general information. From letters received in reply to these inquiries, it was found that alfalfa has been grown with some success in Freeborn, Carver, Hennepin, Rice, Sherburne, Sibley, Lyon, Watonwan, Scott and Redwood counties. These counties are all situated in the southern and central part of the state. It is possible that successful attempts have been made in many other counties from which we have no reports. Few reports have been received from the northern part of the state. The following are letters received in answer to some of these inquiries:

New Prague, Scott Co.

"In this vicinity, alfalfa does best on black soil on high land. We sowed about 15 lbs. to the acre. We have about one acre which we feed to the hogs. For this purpose it is fine. They seem to like it better than red clover. We cut it from three to four times a year. It can stand a drouth and frost better than clover. I do not think it freezes out at all. I know of no one else around here who has raised it.

Yours truly,

ADOLPH SCHARF.

Excelsior, Hennepin Co.

"My attention was first called to alfalfa in 1881 when my father and I were about ten miles west of here in Lake Town. This was during the month of August, and a field

of alfalfa in full bloom attracted my attention. The German farmer, at whose place we stopped, was pleased when I spoke of the alfalfa and was greatly surprised to learn that we had none in our neighborhood. He told of its great feeding value for all stock and made, as the strongest point, that it was everlasting, while the red clover with him, often killed out the first year. This good report of this great forage crop did not appeal to my father as strongly as it would have later as we were more interested in grain than stock. However, the next spring, we purchased at Minneapolis, a few pounds of alfalfa seed with which we seeded a few rods of land in one end of a field that we seeded down to red clover. We were greatly surprised to find our everlasting clover all killed the next spring, while the red clover was not injured. We did not do anything more with alfalfa for some time.

"Ten years later, in 1890, I taught school about 15 miles from here and found the farmers all growing alfalfa. I noted its great feeding value and also that it *was everlasting*, as the farmers told me how long different fields had been seeded and no one had had it winter killed. Children in school often spoke of "everlasting clover." I reported at home the many advantages of alfalfa over red clover and the next spring we purchased again at Minneapolis ½ bushel alfalfa seed. We seeded about two acres alfalfa in barley and got a fine stand. The Germans often cut or pastured the first year after cutting the grain but we did not. Our alfalfa was about a foot high and went into winter thus. The next summer we cut three crops of hay and there was quite a fourth crop which we didn't cut or pasture. You can guess our surprise at finding the "everlasting (?) clover" all dead the next spring, also our surprise to find that the Germans had not lost a rod by winter killing. About this time there appeared an article in one of the Minneapolis papers stating that alfalta was not a success in Minnesota except that it did well in Carver county. Our experience and observation and this article led me to form the opinion that common alfalfa was not hardy and that these Germans had a variety that was perfectly hardy. Since then, I have seen this proven a hundred times, have seen fields of common alfalfa and our hardy variety

seeded at the same time and separated only by a wire fence, and the alfalfa all kill out on one side of the fence and not on the other. This alfalfa was brought here some forty years ago and is said to have come from Norway. In 1894 we planted 1½ bushels of "everlasting" alfalfa on about seven or eight acres and have had no more trouble with winter killing. We have cut three crops annually except when we left the second crop for seed and have always pastured in the fall.

"I think a good stand can be secured with less seed when planted alone than any other way, yet have got good stands in grain. I consider 12 pounds per acre heavy seeding. The seed is much smaller than common alfalfa. Make a good seed bed and seed in April and harrow the seed in lightly. Cut two or three times the first year. It does well on all soils except meadow land and wet places. The alfalfa fields cut three good crops of hay each season; even during our dry years we cut three good crops when other hay hardly cut one.

"I think it cuts about four tons per acre. This variety of alfalfa cures much quicker than red clover. During a dry season it can be cut and put in the barn the next day. The past season, it needed to be left in shocks a few days. In shocks it turns rain well if put up before it is too dry.

"Some years, it seeds very heavy, while other years there is none all. I think it will average about three bushels per acre. Last year (1901) the seed crop was ruined by the extreme heat and this year (1902) by too much rain.

"We find there is a ready market for the hay. If a man feeds one load he will be sure to want more. One party drove ten miles to our place and purchased fifteen tons when he could have purchased common hay right at home.

"We now have seventy acres of "everlasting clover" and expect to seed about thirty acres in the spring."

Very truly yours,

A. B. LYMAN.

Grand Rapids, Itasca Co.

"Our test of alfalfa last year resulted in winter killing of

the greater part of the stand. We sowed Grimm's* alfalfa. Tests by Warren Pendergast gave similar results. So far we have not shown alfalfa to be hardy in this vicinity."

Yours truly,

H. H. CHAPMAN.
Supt. of N. E. Exp. Station.

Madelia, Watonwan Co.

"I have been raising alfalfa in a small way for about three years. I commenced with two acres and now have seventy seeded. It should be sown on well manured, well drained land. Prepare a good fine seed bed and sow as you would wheat or oats as soon in the spring as danger from heavy frosts is over. I sowed last spring with a common seeder. I mixed ¼ bushel of wheat with 15 pounds alfalfa and set the seeder to sow ½ bushel per acre. It was sown immediately after the spring rains commenced, and I have a very fine stand. I have just completed cutting the crop for hay. It should be mown at this time (August 1st) or earlier to give the alfalfa a better chance.

"I have secured two hay crops from my older fields amounting to about three tons per acre. I shall cut them once or twice more this season. Use any good corn land, sow from 15 to 20 lbs. of seed and do not allow live stock to pasture it the first season.

"I consider the hay to be about equal to red clover. As a soiling crop it will be superior to anything we have. I have given my experience to Mr. O. C. Gregg of the Farmers' Institute who will publish it in his Annual, No. 15." I remain

Yours truly,

JOHN BISBEE.

Belview, Redwood Co.

"In the year 1899, I seeded about 1½ acres of alfalfa with wheat to be used for hog pasture in the future. I used about 10 lbs. of alfalfa seed per acre and ½ bu. of wheat per acre. The wheat stooled remarkably well but when the alfalfa was about 6 inches high, I cut it with a mower. This

*This is the variety grown in the vicinity of Lake Minnetonka, and at the Exp. Station, is known as Minnesota No. 4.

checked the wheat to some extent. It still made a good crop of wheat by harvest. This patch was located in the bottom along the Minnesota River, slightly sloping towards the southwest and bounded on the southeast and southwest by tall timber. About ½ acre of the southwestern as well as the lowest portion was very sandy. The rest was very rich, black loam accustomed to clover. This upper portion seemed very promising the first fall but the sandy lot seemed rather weak. I left the stubble and did not pasture the first fall. In the winter the creek overflowed some of this sandy portion completely and smothered it. The next March, during nice weather, the alfalfa started to grow very nicely but during the alternate cold and warm spells about one-half of the plants seemed to rot off just below the crown, this made a poor stand. However, it made a fair hog pasture that year except the very sandy and poor soil, and I also used it for pasture in the spring and part of the summer of 1901, but as some more of the plants had damped off in the same way that spring, I decided to plough it up and seed to rape.

"The year 1900 I seeded about two acres just on the other side of the timber (southeast side) on quite, if not very sandy, very rich potato land, formerly clover. This time I seeded it alone. It grew very fast. I cut it down when 6 inches high and in addition to that I cut it three times for hay. The first time, it was only alfalfa hay, the next time it was more pigeon grass than alfalfa, and the third time, mostly alfalfa hay.

"During the very shifting weather of the next spring (1901) about one-half of the plants damped off in the same way as described. We therefore seeded about 12 lbs. more to the acre while the first seeding was only 10 lbs. That year, we took one good crop from the patch after which a long velvetish black bug took complete possession of the crop. It was kept eaten down all summer. By the way, this bug also attacked the soy beans and red clover to some extent and also some of the wild leguminous shrubs.

"As the blue grass which had remained in the land had stooled wonderfully during the summer, I thought it best to break it up, which I did last fall. I used the common Utah

grown seed. I found that the hay would cure nicely in cocks when raked rather green. To my judgment, alfalfa grows best on rich sandy loam in this neighborhood."

Yours truly,

G. E. ENESTVEDT.

Crookston, Polk Co.

"We have had considerable experience with alfalfa and there is no crop I have on the farm that has perplexed me more in the past than this. It will neither live nor die. It grows fairly well for one year, then a number of plants die out, but still there is enough growing to make a partial success.

"These struggling plants continue to grow for a long time. I have selected seed from some of these plants and have started to raise some alfalfa in a garden way. I have small garden plots of alfalfa that are doing very well. The Turkestan alfalfa is doing fairly well, but Minn. No. 4* is doing exceedingly well. I have no forage grass planted on the farm that has made such a growth as this one.

"Both these varieties came through the winter uninjured. I have now seed selected for more than one-half an acre which I shall sow this spring. I shall bear in mind to report to you of our success in case you so desire."

Yours truly,

T. A. HOVERSTAD,
Supt. N. W. Exp. Farm.

Faribault, Rice Co.

"I sowed an acre and a half of alfalfa four years ago which I mowed for hay three times a year and got a big crop every time. A year ago last spring, I sowed one-third of an acre which I mixed with Bromus grass. Last fall, I could hardly see any of the Bromus grass, but this year, the Bromus grass has improved greatly. I mowed this mixture four times and got about fifteen hundred pounds of hay every time. I cut it when the blossoms on the alfalfa would appear. This year, I sowed nine bushels of alfalfa on twen-

*This is the variety grown in the vicinity of Lake Minnetonka, sometimes called Grimm's alfalfa.

ty-two acres which is a thick stand. I sowed the alfalfa with oats which I mowed for hay after it was headed out. About four weeks after, I mowed the young alfalfa again and left it on the ground. My soil is a heavy timber clay soil. I believe alfalfa is the most profitable feed we can raise for all kinds of stock.

Yours very truly,
NICHOLAS BECKER.

THE CHEMICAL DEVELOPMENT OF ALFALFA.

Although this work was not undertaken until a few days before the first crop was harvested, it was thought that data of value could be secured. Three samples of one square yard each were taken at weekly interval from a plot of a Western variety, and two samples at weekly intervals from a plot of a Turkestan variety. Both of these plots were in the field used by the Animal Husbandry Division; the Western variety was on range 4, plot 7; the Turkestan variety on range 4, plot 4. The results of the analyses, calculated on a basis of water free substance, are given in Table LXVI.

TABLE LXVI.

	Western			Turkestan	
	Cut June 3.	Cut June 10	Cut June 24	Cut June 3	Cut June 10
	Per Ct.	Per Ct.	Per Ct.	Per Ct.	Per Ct.
Total Nitrogen	3.28	2.85	2.06	3.03	2.67
Proteid Nitrogen	1.93	1.87	1.58	2.24	1.85
Per cent proteid nitrogen to total nitro'n	59.27	65.94	76.65	73.97	69.30
Crude proteid (Total nitrogen X6.25)	20.50	17.81	12.87	18.94	16.68
Ether Extract	2.50	2.48	2.13	2.28	2.26
Fiber	30.70	41.76	43.53	40.59	42.00
Nitrogen-free-extract	36.04	29.55	35.55	30.66	31.52
Ash	10.26	8.40	5.92	7.53	7.54
Lbs. Dry Matter per sq. yd.	265	295.8	362.7	260.4	257.2

The first crop from these two fields was harvested June 9th. It will be observed that on June 3rd, at which time, the first blossoms were appearing, there is the highest percentage of both total nitrogen and proteid nitrogen, and the lowest percentage of fiber for both varieties. This would indicate that the crop should be cut soon after the first

blossoms appear in order to secure, in the cured fodder, the largest percentage of protein, and the smallest percentage of fiber. By cutting as early as possible the growth is stimulated and more time is given for the second and third crops to reach maturity. Table LXVII gives the number of grams (28.3 grams in one ounce) of nutrients yielded by one square yard at the different stages.

TABLE LXVII.

	Western			Turkestan	
	Cut June 3	Cut June 10	Cut June 24	Cut June 3	Cut June 10
	Gms.	Gms.	Gms.	Gms.	Gms.
Total Nitrogen	8.69	8.42	7.47	7.89	6.87
Crude protein (nitrogen X6.25)	54.3	52.6	46,7	49.3	42.9
Ether Extract	6.62	7.34	7.73	5.94	5.81
Fiber	81.36	123.5	157.9	105.7	108.
Nitrogen-free-extract	95.5	87.4	128.9	79.8	81.
Ash	27.19	24.84	21.47	19.6	19.39

On June 30th, a square yard sample was taken of the second crop when it was about six inches high, and four samples were taken thereafter at weekly intervals, the last sample being taken July 29th, five days after the crop was harvested. The first blossoms appeared about July 22nd. These five samples were taken from the field of Turkestan alfalfa mentioned on page 162 and were prepared for analysis in the same way as those from the first crop. Table LXVIII gives the results of the analyses of these five samples.

TABLE LXVIII.

	Time of Cutting Sample				
	June 30	July 7	July 14	July 22	July 29
Total Nitrogen	5.00	4.20	3.62	2.92	2.65
Proteid Nitrogen	3.63	3.18	2.70	2.11	1.98
Per cent proteid to total nitrogen.	71.84	75.60	74.72	72.31	74.72
Crude protein (Total nitrogen X6.25)	31.25	26.25	22.62	18.25	16.56
Ether Extract	4.11	4.18	2.91	3.52	3.22
Fiber	19.32	24.37	30.08	32.41	34.20
Nitrogen-free-extract	34.65	36.61	37.23	39.23	38.77
Ash	10.67	8.59	7.15	6.59	6.62

It will be observed that the total nitrogen and ether-extract decrease regularly as the crop grows and the fiber increases. The dry matter increases rapidly during the flowering period. The nitrogen is assimilated most rapidly in the early stages of growth and after the blossoms appear does not keep pace with the increase of dry matter. During this period, the proteids are being built up in the leaves and transferred to the stem. Table LXIX gives the total number of grams of nutrients yielded by one square yard at the different stages.

TABLE LXIX.

	Time of Cutting Sample				
	June 30	July 7	July 14	July 22	July 29
	Gms.	Gms.	Gms.	Gms.	Gms.
Total Nitrogen	2.05	2.84	5.83	8.60	8.85
Crude protein (nitrogen X6.25)	12.8	17.8	36.4	53.8	55.3
Ether extract	1.68	2.83	4.69	10.36	10.75
Fiber	7.92	16.50	48.49	102.3	114.2
Nitrogen-free-extract	14.20	24.78	60.00	123.8	129.5
Dry Matter	41.00	67.70	161.2	294.5	334.00

In general, the results of the work done on the second crop corroborate that on the first crop. The crop reaches the condition most suitable for cutting at the time when one-third of the blossoms have appeared. After this, a larger amount of much inferior hay is obtained. These results also agree with those obtained by the Kansas Agricultural Experiment Station. The chemical department of that station obtained the following results:

One-tenth in bloom.....18.5 per cent protein.
One-half in bloom.....17.2 per cent protein.
In full bloom.....14.4 per cent protein.

It is stated in the bulletin just referred to that "The late cutting of the first crop seems to injure the plant more than at any other time, and we have found it profitable to cut alfalfa the first time, as soon as one-tenth in bloom, even though the weather was bad and we knew that the crop would spoil in curing. The increased yield from succeeding cuttings over that cut late much more than makes up for

the loss of the first crop. Successful clover-growers the first time they try alfalfa often ruin the stand, so that it has to be plowed up, by waiting to cut until it reaches the stage at which clover is usually cut."*

The Utah Experiment Station for five years cut alfalfa at different stages of maturity and fed the crop in producing beef. The average production per year per acre was as follows:

	Hay.	Beef.
In first bloom	5.35 tons	706 lbs.
In full bloom	4.90 tons	562 lbs.
Half blooms fallen	4.55 tons	490 lbs.

In order to determine the proportion of dry matter in the alfalfa leaves to that in the stems, seven samples were taken at intervals of four days, and the leaves carefully separated from the stems. The leaves and stems were then dried and weighed. The results are given in the following table.

TABLE LXX.

	Dry Matter	
	Leaves	Stems
	Per Cent.	Per Cent.
June 3	42.78	57.22
June 7	38.62	61.38
June 11	40.39	59.61
June 16	36.08	63.92
June 21	36.32	63.68
June 25	34.68	65.32
June 30	36.08	63.92

An examination of the table shows that after the third sample, taken June 11th, which was two days after the crop was harvested, there is a noticeable decrease in the proportion of leaves to stems. Soon after the alfalfa plant begins to blossom, some of the leaves turn yellow and fall to the ground. We find the largest proportion of leaves to stems just before the blossoming period.

An analysis of the dry matter of the leaves, taken at the

* Kansas State Agricultural College, Bulletin No. 114.

Correction to Bulletin No. 80.

Page 165. In the fifth column, nitrogen free extract, read 39.40, not 38.77. Page 172, Table 77, nitrogen free extract, read 37.48, not 37.03.

time the first blossoms appear shows 23.06 per cent of crude protein (Nx6.25). Average wheat bran contains about 16 per cent crude protein. On June 3rd, six days before harvesting the crop, the leaves contained 63 per cent of the total nitrogen of the part of the plant above ground. On June 11th they contained 57 per cent, having lost 6 per cent because of the transfer of nitrogenous material to the stem which was going on quite rapidly at this stage. This shows the great value of the leaves and emphasises the importance of preventing any loss of this material in harvesting and feeding the crop. The results of the analysis of the dry matter of the leaves and stems, taken at the several periods, are given in table LXXI and reveal some interesting data.

TABLE NO. LXXI.

	TIME OF CUTTING SAMPLES.						
	June 3	June 7	June 11	June 16	June 21	June 25	June 30
LEAVES	Pr. Ct.	Pr. Ct.	Pt Ct.	Pt. Ct.	Pr. Ct	Pr. Ct.	Pr. Ct.
Dry Matter.	24.90	30.84	28.36	32.44	34.18	32.70	59.10
Total Nitrogen.....	4.36	3.66	3.73	3.12	2.74	2.74	2.77
Proteid Nitrogen.....	3.69	3.02	3.33	2.51	2.17	2.18	2 17
Per cent Proteid to Total Nitrogen	84.69	82.74	89.20	80.66	78.95	79.44	78.25
Crude Protein (Total Nitrogen X6.25)....	27.25	22.87	23.31	19.50	17.12	17.12	17.31
Ether Extract.....	2.56	4.48	4.48	3.80	6.12	5.45	4 56
Fiber.....	12.76	13.04	17.80	13.37	17.89	18.89	20.05
Ash.....	7.83	6.54	7.31	7.75	8.35	7.66	8.52
STEMS							
Dry Matter.....	.....	25.84	23.66	30.21	32.63	32.84	58.90
Total Nitrogen.....	1.95	1.76	1.88	1.59	1.65	1.60	1.46
Proteid Nitrogen.....	1.32	1.23	1.46	1.24	1.35	1.40	1.28
Per cent Proteid to Total Nitrogen.....	67.77	69.77	77.43	78.00	81.96	88.47	87.60
Crude Protein (Total Nitrogen X6.25)....	12.18	11.00	11.75	9.94	10.31	10.00	9.13
Ether Extract.....	1.19	.78	1.66	1.95	2.53	2.48	3.19
Fiber.....	50.76	48.13	46.69	48.21	48.16	48.12	55.15
Ash.....	6.79	5.56	5.62	5.36	6.00	4.98	4.61

It will be noticed that the percentage of dry matter increases quite regularly in both leaf and stem, being slightly higher at any given period in the leaf at every stage except

one. In the leaf both total and proteid nitrogen decreases as the plant ripens, the proteid nitrogen, however, decreases more rapidly. (The proteid nitrogen is that obtained by the use of Stutzer's method as given in the Methods of Official Agricultural Chemists. This proteid nitrogen has a greater food value than the nitrogenous material that exists in the non-proteid form.) In the stems, the total nitrogen decreases while the proteid nitrogen remains quite stationary which accounts for the increase in the percentage of proteid to total nitrogen. This seems to show that the nitrogen is taken from the soil in non-proteid or amide forms and is changed to proteid forms in the leaves and then transferred to the stems to be finally stored in the seed.

The ether extract increases in both leaves and stems but rather irregularly in the leaves. The fiber increases in the leaves but is almost stationary in the stem.

The percentage of ash or mineral matter remains almost stationary in the leaves but decreases in the stems. We find, as is to be expected, that the leaves contain the most ash, for it is in the leaf that the complex compounds found in the ripened plant are elaborated from simpler materials, and in this work the mineral elements take an important part. An examination of table LXVIII will show that the ash elements are taken up most rapidly during the early stages of growth. The results of the analysis of the ash of the leaves and stems are given in table LXXII.

TABLE NO. LXXII.

	IN 100 POUNDS OF ASH					
	Leaves Cut June 3	Leaves Cut June 16	Leaves Cut June 30	Stems Cut June 3	Stems Cut June 16	Stems Cut June 30
	lbs	lbs	lbs	lbs	lbs	lbs
Phosph't's(P_2O_5)	7.76	5.90	4.20	9.62	10.70	10.63
Potash (K_2O).....	17.17	14.61	11.60	26.68	31.16	27.54
Lime (CaO).....	24.90	24.39	32.41	14.10	13.42	15.98
Magnesia (MgO).	3.88	6.49	3.66	5.26	4.49	4.70

In the leaves, the ash elements are in almost every case found in the greatest abundance during the early stages. In the stems, there seems to be but little variation in the compo-

sition of the ash during this period, but the next table shows that there is a slight decrease in the percentage of the several ash elements owing to a decrease in the percentage of total ash. It must be noted that the blossoms appeared soon after June 3rd, the time the first sample was taken, so that this work represents only the last period of growth. The figures gven in the table following are calculated from the data of the table immediately preceding and the percentage of total ash.

TABLE NO. LXXIII.

	IN 100 POUNDS OF DRY MATTER					
	Leaves Cut June 3	Leaves Cut June 16	Leaves Cut June 30	Stems Cut June 3	Stems Cut June 16	Stems Cut June 30
	lbs	lbs	lbs	lbs	lbs	lbs
Phosph't's(P_2O_5)	.608	.457	.357	.653	.573	.49
Potash (K_2O).....	1.345	1.131	.988	1.812	1.67	1.268
Lime (CaO)	1.949	1.89	2.76	.957	.72	.735
Magnesia (MgO).	.303	.503	.312	.357	.24	.216

The most noticeable feature of the following table is the large amount of phosphates shown to be in the seed and the large amount of potash and lime in the cured hay.

TABLE NO. LXXIV.

	IN 100 POUNDS OF DRY MATTER				
	Alfalfa Cut June 30	Alfalfa Cut July 14	1st Crop Alfalfa Hay	Alfalfa Seed	Alfalfa Roots
	lbs	lbs	lbs	lbs	lbs
Total Ash.....	10.67	7.15	8.30	3.37	4.22
Phosphates (P_2O_5).....	1.10	.69	.61	1.72	.66
Potash (K_2O).....	2.54	1.65	2.99	1.11	.76
Lime (CaO).....	2.07	1.74	1.31	.05	.63
Magnesia (MgO).....	.46	.36	.32	.18	.34

An alfalfa field will yield on an average 8,000 pounds of cured hay per acre in one season. This cured hay will contain about 6,880 pounds of dry matter. The number of pounds of each of the four most important ash constituents removed from an acre by a season's crop of alfalfa hay, as compared with that removed by a crop of clover hay, is given in the following table:

TABLE NO. LXXV.

	POUNDS REMOVED IN AN ACRE CROP			
	Potash (K_2O)	Phosphates (P_2O_5)	Lime (CaO)	Magnesia (MgO)
Alfalfa Hay...	206	58	89	22
Clover Hay.....	66	28	76	17

Alfalfa draws most heavily on the lime and potash, resembling clover in this respect, but because of its heavier yield per season, a greater quantity of these ash constituents is removed. Most of the soil of Minnesota is well supplied with these ash constituents. If the alfalfa is fed on the farm and the manure well preserved and returned to the land, but little fertility is lost. If it happens that soils are poor in these constituents, fertilizers of lime in the form of land plaster and potash in the form of wood ashes can be profitably applied. The ash of alfalfa seed is rich in potash and phosphates; the samples analyzed contained 32.77 per cent potash and 44.29 per cent phosphate. It will be seen that when the seed is sold a considerable amount of this valuable ash material is removed from the farm.

With the aid of nitrogen gathering bacteria, alfalfa, like clover, can use the free nitrogen of the air, still it must not be inferred that a fair supply of nitrogen in the soil is unnecessary or that the application of nitrogenous fertilizers is always wasteful. Professor Bernard Dyer* of England has shown by careful experiments that "The use of moderate quantities of nitrate of soda has been decidedly remunerative." He found that in five years, an annual dressing of 1 cwt. of nitrate of soda per acre gave an increase of nearly three tons of green alfalfa fodder per acre per year, while an annual dressing of 2 cwt. per acre gave an increase of four and a half tons of fodder per acre per year. From this he calculated that there was an annual profit due to the nitrate of a little more than four dollars per acre in the first case and over six dollars per acre in the second case.

* Reprint from the 'Transactions of the Highland and Agricultural Society of Scotland,' Fifth Ser., Vol. XIV, 1902.

TABLE NO. LXXVI.

COMPOSITION OF DRY MATTER.

	Dry Mat'er	Crude Pro-tein	Ether Ex't	Fiber	Nitro-g'n free Ex't	Ash
	Pr. Ct.	Pr. Ct.	Pr. Ct.	Pr. Ct.	Pr Ct	Pr. Ct.
Roots, Cut June 3	27.09	12.75	.78	35.13	46.09	5.25
Roots, Cut June 12	28.97	13.44	1.53	37.05	43.76	4.22
Blossoms, Cut June 12	18.58	19.37	3.28	19.55	52.25	5.55
Alfalfa, 5 months after Seeding	22.64	11.81	3.35	37.84	39.31	7.69
First Crop of Alfalfa Hay	89.71	15.00	3.06	33.27	40.37	8.30
Second Crop of Alfalfa Hay	89.38	17.62	2.08	34.33	40.00	5.97
Alfalfa Seed	93.40	36.94	10.61	13.55	35.29	3.61

The samples of roots and blossoms, as given in the table immediately preceding were taken from the Station plots. The five months old alfalfa was taken from the farm of Mr. Baird, Edina, Minn. The first and second crop alfalfa hay was taken from the farm of Mr. A. B. Lyman, Excelsior, Minn. The alfalfa seed was a sample of a Turkestan variety from the U. S. Department of Agriculture. The small amount of protein in the very young alfalfa is noticeable. The samples of hay from Mr. Lyman's farm are believed to be fairly representative of alfalfa hay produced in Minnesota.

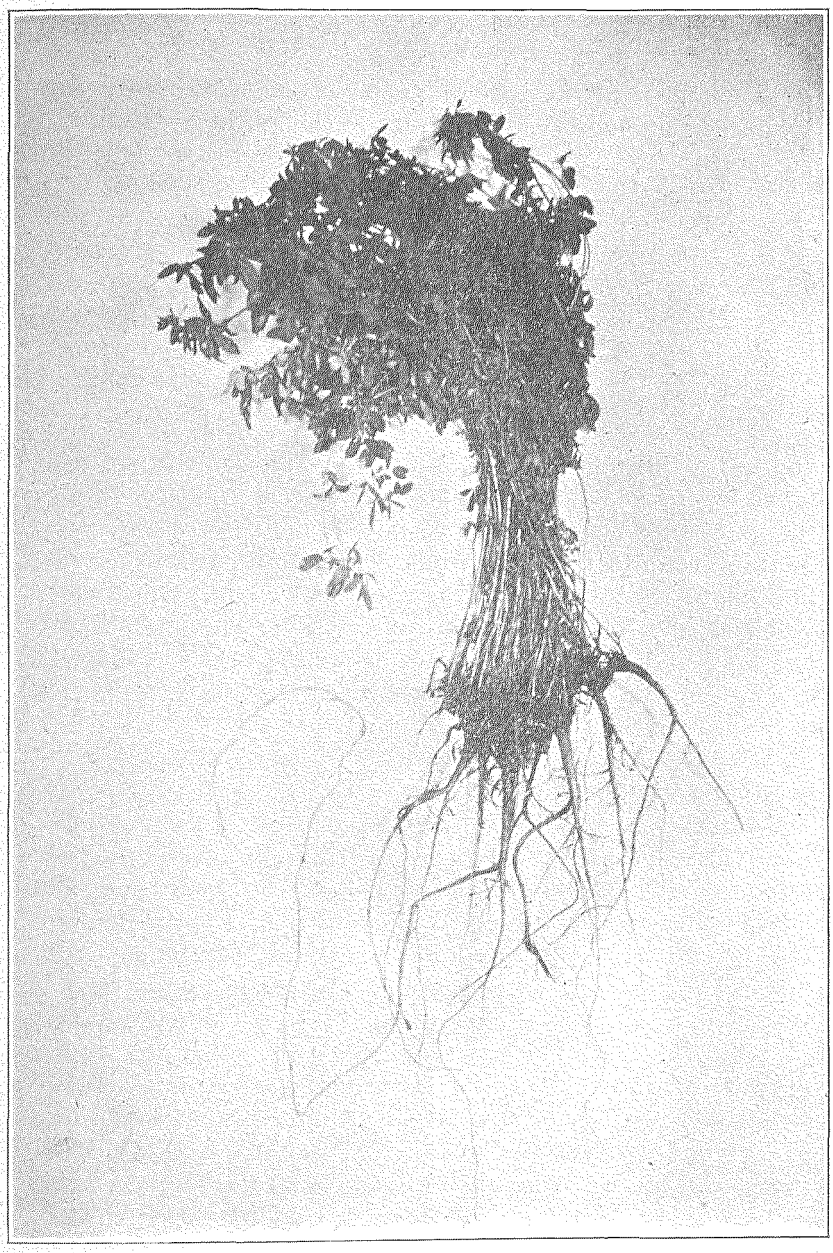

Fig. 6.—Two-year-old Alfalfa plants.

THE FEEDING VALUE OF ALFALFA.

A comparison of the composition of the dry matter of alfalfa hay and clover hay is given in the following table:

TABLE LXXVII.

	Composition of the Dry Matter					
	No. of Samples Analyzed	Protein (Nx6.25)	Ether Extract	Fiber	Nitrogen-Free-Extract	Ash
Alfalfa hay.....	6	17.42	2.62	34.11	37.03	8.37
Red Clover hay...	4	12.97	3.43	26.82	49.95	7.83

The most striking feature shown in this table is the large amount of protein in the alfalfa hay. This substance is always the most valuable constituent of a feeding stuff. It is the substance which enters so largely into the composition of the flesh and the vital fluids of the body, and in a dairy animal, of the milk. Here then we have a source of protein which seems to be far superior to red clover which heretofore has held undisputed the title of being the best nitrogenous forage for Minnesota. With alfalfa as the source of protein and corn as the source of carbohydrates and fat, stockmen of Minnesota can produce cheaply an ideal ration for the production of both milk and meat.

Alfalfa makes a fairly satisfactory pasture for all farm animals but under the continued tramping the plants are often injured. It should not be pastured the first year and never so late in the fall as to force the plants to go through the winter with the crowns exposed, because in this condition they are apt to winter kill. In pasturing cattle and sheep on alfalfa there is some danger of bloat especially when the pasture is wet. Perhaps the better way to feed alfalfa is to mow it and allow it to wilt a short time before feeding. When fed in this way there is a larger yield of forage and no loss from bloat. Alfalfa has a laxative effect especially when fed green and for this reason it always gives best results when fed with some grain or dry fodder. Under these conditions it is also more digestible as is shown by the digestion trials reported in succeeding pages.

DIGESTIBILITY OF ALFALFA.

The value of a feeding stuff does not depend entirely upon the amounts of the several nutrients that enter into its composition, but upon the amounts of these nutrients that the animal can digest and use. In order to determine to what extent the nutrients of alfalfa are digested, several digestion trials were made. For these trials, two steers, weighing about 800 lbs. each, were courteously loaned by the Animal Husbandry Division and fed alfalfa hay for a period of about ten days before the trial proper began in order to accustom the animals to the ration. At the end of the preliminary period, the steers were put into specially constructed stalls as shown in Fig. 7.

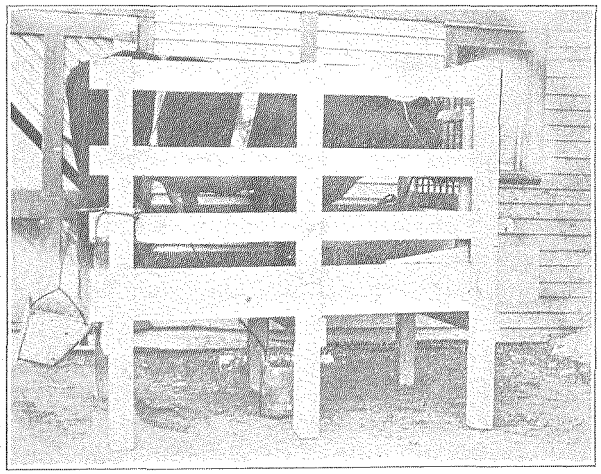

Fig. 7.—Steer in stall for digestion trial.

These stalls were designed by Professor Andrew Boss and built under his direction. The feeding was done under the supervision of Mr. George Craig, of the Animal Husbandry Division. The steers were weighed when put into the stalls and also when removed. The animals were left in the stalls for a period of four days and during that time all the food which they consumed was carefully weighed and samples taken for analysis. The excrements, both solid and liquid, were collected by the devices shown in the illustration.

These were weighed and sampled at the close of each day. The samples of the food and of the excrements were dried and analyzed. The methods of analysis used throughout this work were those adopted by the Association of Official Agricultural Chemists. The calories were determined by combustion in an Atwater-Blakeslee calorimeter. The heat of combustion of the daily samples of urine were determined in all cases except in the fifth trial and in the trial with hog millet. From the composition of the food thus determined and the total weight of food eaten by the animal during the four days, the total amounts of each of the food nutrients consumed were calculated. In the same way, the total amount of nutrients in the dung for the four days was determined. The difference in the amounts found in the dung and that found in the food eaten represents the amounts digested. This difference divided by the total amounts of nutrients consumed and the result multiplied by 100 gives the percentage digested. Five separate trials of four days each were made using in all, the same two steers.

In the first trial, the animals were fed first crop alfalfa hay of fair quality. This was cut in a feed cutter and the steers were fed all that they would eat up clean which amounted to almost 16 pounds of dry matter daily per steer. In the second trial, the daily ration consisted of 16 pounds alfalfa hay from the same lot as that used in the first experiment, and 5 pounds of corn meal. In the third trial, the daily ration consisted of about 42 pounds of green alfalfa, third cutting. In the fourth trial, the daily ration consisted of 16 pounds of alfalfa hay, 5 pounds barley meal and 15 pounds mangels. In the fifth trial, the daily ration was a duplicate of the ration of the second trial, viz.: alfalfa hay and corn meal, with the addition of about two tablespoonfuls of International Stock Food.* The object of this last trial was to determine the effect of a condimental food on the digestibility of a ration. A detailed account of the method of making these digestion trials and calculating the results is given in the Annual Report and also in a supplement to this bulletin. The results of these five trials are given in the following table:

* According to the Connecticut Experiment Station this material contains wheat feed, cayenne pepper, charcoal, salt and a bitter drug resembling gentian.

TABLE LXXVIII.—Coefficients of Digestibity of Alfalfa Hay.

	Dry Matter	Crude Protein	Ether Extr't	Crude Fiber	Nitrogen-free-extract	Ash	Digestible Calories
Alfalfa Hay							
Steer 181	68.60	76.59	57.84	58.23	75.48	54.89	67.15
Steer 184	63.09	74.17	53.92	56.91	68.25	47.92	61.67
Average	65.84	75.38	55.88	57.57	71.86	51.40	64.41
Alfalfa hay fed with corn meal							
Steer 181	71.80	84.02	61.46	64.60	73.64	66.98	70.93
Steer 184	70.16	83.25	60.19	61.98	73.24	62.70	89.26
Average	70.98	83.63	60.82	63.29	73.44	64.84	70.09
Alfalfa hay fed with corn meal and International Stock Food							
Steer 181	61.16	66.70	27.05	47.87	74.18	56.38	60.87
Steer 184	60.24	68.48	28.23	51.27	70.66	43.28	61.53
Average	60.70	67.59	27.64	49.57	72.42	49.83	61.20
Green Alfalfa							
Steer 181	60.62	73.46	37.75	42.17	72.21	40.34	62.46
Steer 184	60.63	74.65	39.08	42.66	71.26	39.66	63.17
Average	60.62	74.05	38.42	42.41	71.73	40.00	62.81
Alfalfa hay fed with barley and mangels							
Steer 181	63.63	74.90	53.29	48.41	73.36	63.22	60.21
Steer 184	63.51	77.56	56.46	49.64	70.68	61.64	60.81
Average	63.57	76.23	53.37	49.02	72.02	62.43	60.51

These trials show that alfalfa hay compares very favorably with that of our other principal forage crops. In considering the nutrients of a feeding stuff we must give the greatest prominence to the crude protein, the nitrogen free extract and the ether extract. Of these the crude protein is by far the most important because it is the nutrient usually lacking in a ration. The column headed Calories gives the percentage of the energy of the food that is digestible. This is determined by the heat given off by burning a certain weight of substance. The table shows that alfalfa hay is the most digestible when fed in a ration with corn meal, and next highest when fed with barley meal and mangels. When fed green, alfalfa shows a slightly lower digestibility than when fed as dry hay. This is probably due to the more laxative effect of the green food, which gives the digestive fluids less time to act on the food. A comparison of the two trials of the digestibility of alfalfa hay when fed with corn meal with the addition of a condimental food in one case, shows a remarkable difference in favor of the ration without the condimental food. The average digestibility of the protein in the two trials without the condimental food is 83.63 per cent, and with the condimental food is 67.59 per cent. With the other nutrients the difference is not as great but still in favor of the ration without the condimental food. The

condimental food seems to have much the same laxative effect as the green alfalfa, but to a greater extent.

Table LXXIX gives the percentage of digestible nutrients of Minnesota grown alfalfa hay as compared with that of some of our other common feeding stuffs.

TABLE LXXIX.

PERCENTAGE OF DIGESTIBLE NUTRIENTS IN DRY MATTER.

	Crude Protein	Ether Extract	Fiber	Nitrogen-free-Extract	Ash
Alfalfa Hay	13.13	1.46	19.64	26.61	4.30
Red Clover	7.52	1.89	14.53	32.13	2.28
*Timothy Hay	3.40	1.30	16.20	27.20	.....
*Corn Fodder	3.90	2.20	14.10	37.10	.....
*Barley	9.10	1.80	2.40	56.60	.....
*Corn Meal	9.00	2.80	1.00	66.40	.....
*Wheat Bran	12.50	3.60	3.60	38.50	.....

* Minnesota Experiment Station, Bulletin No. 36.

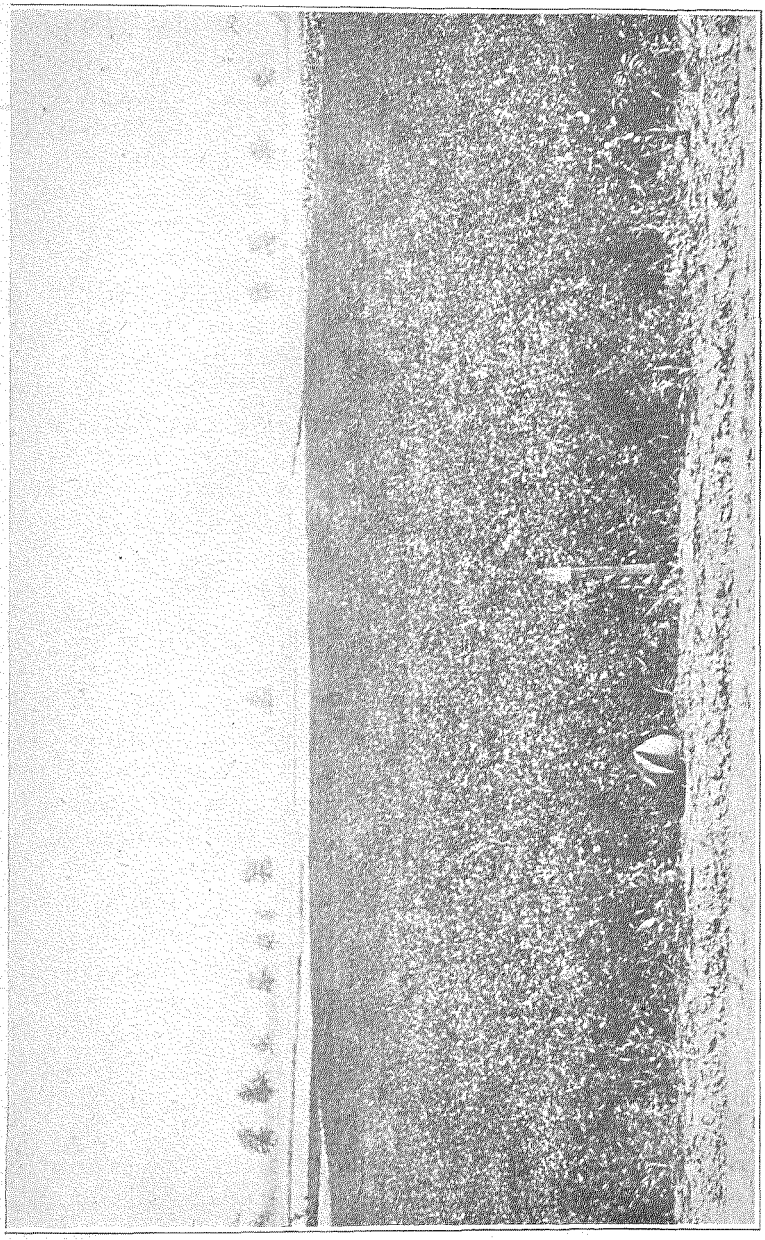

Fig. 8.—Alfalfa plat at Experiment Station; second crop, July 12. From field of Agricultural Division.

FERTILIZING VALUE OF ALFALFA.

Because alfalfa has the power of appropriating for its use the free nitrogen of the air, it has a high fertilizing value. A crop of alfalfa plowed under adds large stores of this most valuable plant food to the soil. The roots when decayed furnish to the soil large amounts of humus which improves it for crop production both chemically and physically. The Wyoming Experiment Station found that when alfalfa land was plowed and planted to wheat, it produced $8 to $12 more value in wheat per acre than the land that had grown potatoes and grain before. Alfalfa land gave $16 worth more of potatoes per acre than was obtained from land that had grown potatoes and grain before.*

In the digestion trial in which green alfalfa was fed, the solid and liquid excrement of the steers contained 94 per cent of the nitrogen consumed in the food. Of this amount nearly 75 per cent was contained in the liquid excrement. This shows the value of the manure, especially the liquid part and the importance of returning it to the land.

THE DIGESTIBILITY OF HOG MILLET.

(*Panicum miliaceum.*)

An examination of American Experiment Station literature fails to disclose any recorded results of work done to determine the feeding value of hog millet. This millet seems to be easily grown and produces seed fairly well in Minnesota, hence this work was undertaken.

For this trial, a hog weighing about 180 pounds was used. During the actual trlal the animal was fed 17 meals and the solid and liquid excrements were collected for a like period. A marker of charcoal was fed to the animal with the first meal and another after the last meal of the period. Only the feces which appeared between these markers was weighed and used for the analysis. Samples were taken at the close of every day, and these were carefully dried and a composite sample for analysis was made of all. The feeding of the animal and the collection of the excrements was done under the supervision of Mr. C. P. Taylor of the Animal

* Wyoming Experiment Station, Bulletin No. 44.

Husbandry Division. The millet was ground and was fed with water.

The following table gives the composition of the hog millet fed and of the composite sample of solid excrement.

TABLE NO. LXXX.

COMPOSITION OF DRY MATTER.

	Dry Mat'er	Crude Pro-tein	Ether Ex't	Fiber	Nitro-g'n free Ex't	Ash	Deter-mined Cal'r's
Hog Millet	87.87	13.40	4.47	19.22	58.71	4.20	4.597
Solid Excrement	.....	15.57	6.75	47.00	18.20	12.48	4.542

The calculation of the per cent digested of the several food nutrients is given in table LXXXI.

TABLE NO. LXXXI.

	Dry Mat'er	Ash	Crude Pro-teid	Ether Ex't	Fiber	Nitro-gen free Ex't	Calories
	Lbs	Lbs	Lbs	Lbs	Lbs	Lbs	
In Food	42.21	1.78	5.658	1.89	8.11	24.78	88.010
In Feces	11.50	1.44	1.79	.78	5.41	2.09	23.690
Digested	30.71	.34	3.87	1.11	2.71	22.69	64.320
Per cent Digested	72.75	19.17	68.36	58.86	33.36	91.56	73.07
Per Cent of Energy Available to Body	.....	.....	.....	.....	.....	.....	70.60

The animal voided in the urine .48 lbs. nitrogen, in feces .29 lbs. and consumed in food .905 lbs., having retained in the body .14 lbs. equivalent to .88 lbs. protein. The animal weighed at the beginning of the trial 181 lbs., at the close 191 lbs.

This trial shows hog millet to be about equal in digestibility to barley, wheat and shorts, but not as digestible as corn meal or oil meal.

The following table gives the digestible nutrients of hog millet along with that of some of our common feeding stuffs used for hogs.

TABLE LXXXII.

POUNDS OF DIGESTIBLE NUTRIENTS IN 100 LBS.

	Dry Matter	Ether Extract	Crude Protein	Nitrogen Free Extract	Fiber
Hog Millet	63.9	2.6	9.2	53.8	6.4
Barley	70.6	1.8	9.1	56.6	2.4
Corn	80.1	3.1	9.2	67.4	1.1
Oats	65.5	3.9	9.2	49.4	1.6
Peas	80.2	.5	19.4	55.1	4.5
Rye	72.9	1.5	10.5	58.0	1.3
Wheat	73.0	1.5	11.0	57.3	1.3
Wheat Shorts	67.0	2.3	10.0	54.4	1.5
Red Dog Flour	78.0	2.0	13.5	60.1	1.2

A comparison of these figures shows that hog millet contains as much digestible nutrients as barley and oats and nearly as much as corn.

CONCLUSIONS.

A variety of alfalfa has been grown in Minnesota for thirty or forty years and has proved to be perfectly hardy wherever tried.

Alfalfa for hay should be cut when one-third of the blossoms have appeared because at this stage it will yield the largest amounts of the several nutrients in the most valuable forms.

Alfalfa produced in Minnesota contains more protein than red clover and has a greater feeding value than wheat bran.

Alfalfa hay contains large amounts of the most valuable fertilizing materials and when fed on the farm the fertility of the soil is increased.

Alfalfa hay is equal in digestibility to red clover. It is more digestible when fed with corn or barley meal than when fed alone.

Hog millet is equal in digestibility to barley, wheat and shorts, but is not as digestible as corn meal or oil meal.

Hog millet contains as much digestible nutrients as barley.