T H E S I S

SUNFLOWER SILAGE AS COMPARED WITH CORN SILAGE FOR FATTENING STEERS AND LAMBS

Submitted by

Martin Adkisson Alexander

for the Degree of Master of Science

Colorado Agricultural College

Fort Collins, Colorado

July 1, 1924

378.788
A.D.
1925
6

THIS THESIS HAS BEEN READ

APPROVED AND RECOMMENDED

FOR CREDIT

Fred B. Morton

Head of the Department of Animal Husbandry

Colorado Agricultural College

Fort Collins, Colorado

July 1, 1924

46560

THIS THESIS HAS BEEN APPROVED AND RECOMMENDED FOR

THE DEGREE OF MASTER OF SCIENCE

C. R. Gillett

Chairman and Professor of Zoology

E. P. Sandsten

Professor of Horticulture

I. E. Newsom

Professor of Veterinary Pathology

Committee on Advanced Degrees
Colorado Agricultural College
Fort Collins, Colorado

TABLE OF CONTENTS

(continued)

(continued)

SUNFLOWER SILAGE AS COMPARED WITH CORN SILAGE FOR FATTENING STEERS AND LAMBS

INTRODUCTION

The sunflower plant gives promise of satisfying the needs of farmers for a profitable ensilage where corn is a poor ensilage yielder.

Sunflower silage is filling the succulent feed need for farmers in the east where successful growth of corn for silage is limited either by climatic conditions or by improper soil adaptation. It is used in the West to fill the silo where the altitude is too high, the frost too injurious, the season too short, the moisture too scant, or the soil too poor for corn to give a satisfactory and profitable yield of silage.

In Colorado the production of sunflowers is very small, but this does not mean that there is not a place for them in the state. The San Luis Valley and similar high valleys of Colorado have too short and too cold a season for corn to be a profitable ensilage crop. There are dry land areas in the state where sunflowers would perhaps give a good yield of ensilage, judging from the Montana Experiment Station results.

The Rocky Mountain states are in need of a high yielding plant for ensilage and one with a good feeding value. With the feeding value of sunflowers in mind, we have the express purpose of this paper. It seems advisable, however, in order to make the article more complete, to give a short review of the sunflower as a plant in comparison with the corn plant.

Following this review a detailed report will be made of three feeding experiments in which a comparison is made of the feeding value of corn ensilage and sunflower ensilage. The experiments were carried on at the Colorado Agricultural Experiment Station and are ones which the writer has assisted with.

In the comparison of sunflower ensilage with corn ensilage it must be kept in mind that the comparison is not made with the idea in mind of sunflowers competing with corn in a corn district where corn can be grown successfully. In the comparison it is hoped to bring out the importance of sunflowers where corn can not be successfully and profitably grown as an ensilage crop for the feeding of live stock.

(All figures in parentheses refer to authorities in the bibliography.)

PART I

THE SUNFLOWER PLANT

(a) Early History.

The wild sunflower (Helianghus Annus) is the plant from which the cultivated Mammoth Russian variety was developed. (1) It is a native of North America, being used in early days as food for the Indians and oil dressing for their hair. The Indians were known to cultivate this plant in the vicinity of Georgian Bay as early as 1615. (2)

Crawford, in 1892, gave an account of the sunflower industry in Russia. (1) He states that many Russian farmers secured a better field of wheat following sunflowers than when following any other crop grown there. The leaves stay green even after the seeds are ripe. Another claim of the plant is that its cultivation in low, unhealthy swamps or malarious districts will prevent the spreading of miasmatic diseases.

The early experimental work with sunflowers in the United States was along the seed production line with the oil content in mind.

(b) Distribution.

The sunflower plant is grown throughout North America from the southern provinces of Canada to the Canal Zone. It is to be found also in most parts of South America, but more especially along the west coast from Colombia to Chile. In Australia, New Zealand, South Africa, Egypt, the Mediterranean

region of Europe, India, and China the sunflower is grown to a limited extent. It has reached its highest development and its greatest usefulness in Russia, where several important varieties have been developed. It is grown extensively there for its seeds and oil therefrom, both being consumed as food, and the stalks are utilized as fuel by the peasants. Next to Russia, Hungary was perhaps the largest producer of sunflowers. There were many mills in that country which were equipped especially for extracting the oil from sunflower seeds, and the oil content of the Hungarian seed was higher on the average than that of seed grown in Russia. (2)

(c) Localities in United States for Sunflower Production.

The areas of production for sunflowers in the United States are determined more by the crops it has to compete with than its adaptability to the climate and the soil. By this it can be seen that sunflowers will perhaps never invade the corn belt district, or where corn and the sorghums will give a better yield per acre of silage or a more economical silage. Sunflowers will be grown for silage, not where they will grow the best and make the largest yield, but they will be grown where they will give more economical returns than other silage crops.

The areas in the United States where the sunflower will figure largely as a silage crop are in the extreme northern part of the United States (2) or at high altitudes in the western states, in the New England states, northern New York, Michigan, Wisconsin, and Minnesota, in North Dakota, Montana, Washington, and Oregon, and in the high valleys of the Rocky

Mountain region, especially the San Luis Valley of Colorado.

The ability of the sunflower to resist quite a cold temperature and especially killing frosts for corn, has given it an important place in the mentioned areas. It is stated by a Michigan observer that they will "push back the frost line three weeks" in that state. Personal observation at the Experiment Station at Pullman, Washington showed that sunflowers were still green and retained their leaves from two to three weeks after corn had been killed by a fall frost. Similar results were reported by a New York correspondent for the state of New York. (2)

(d) Why Sunflowers Figure as a Promising Silage Crop.

Leaving the feeding value of sunflowers until the latter part of this paper and discussing it under the results of the experiments, will leave an abundance of facts which are in support of the sunflower.

"Corn, the great grain and forage crop of the middle west, is not such a good yielder in the Rocky Mountain region where the high altitudes shorten the growing season. The man who wishes to use a silo in order that he may save more of his feed for winter use, finds the corn plant a low yielder. What he wants is a high yielding crop with good feeding value. The one that seems to come the nearest to fulfilling these requirements is the sunflower. It is the best yielder of any crop grown for silage in the West." (1)

"The sunflower is an exceedingly quick and heavy growing crop having an advantage in this respect over corn. It can be planted from ten days to three weeks later than corn and still mature in good shape for silage. It is also a very sturdy grower and may be planted on foul or weedy land which is unsuited to other crops. Sunflowers also can be used as a last resort when a failure has occurred with the silage corn planting. The crop is resistant to drought. Its greatest advantage over corn, however, seems to be in the tonnage secured per acre. A yield of eighteen tons, weighed, per acre, was secured at the West Virginia Experiment Station in 1919, on a late planting and on very poor ground, as compared to eight and one-half tons per acre for corn under earlier planting and better soil conditions." (3)

In the state of Washington it was found sunflowers are not easily affected by cold and do not suffer from light frosts after they are up in the spring. Areas that were found lacking in sufficient moisture for corn production often gave satisfactory sunflower yields. (4)

In the dry land areas where the growing season is fairly long and warm, the sorghums enter into competition with the sunflower. However the dry districts that have a low growing temperature and short seasons give good returns in yield per acre as stated at the Montana Station. The average yield of silage on thirteen different farms in eight

counties was ten and three-tenths tons per acre.

At the Government dry-land station near Dubois, Idaho, (2) in 1920 sunflowers yielded four and one-half to five tons of silage per acre when it was so dry that the wheat crop on adjacent land was a complete failure.

The ability of the sunflower plant to produce good yields where the corn plant will not do well, and its adaptability to various climatic and soil conditions has caused comments by the farmer and feeder without considering its feeding value.

(e) Sunflower Production for Silage

1. Soil Treatment

The soil treatment for sunflowers here at the Colorado Experiment Station is practically the same as for corn production. It has been the practice here to have a fine, well-firmed seed bed. The best yields of course are received from fertile soil rich in humus. (5) The plant will respond readily to increased fertility by the application of manure.

The best results were obtained at the Washington Station when the ground was plowed in the fall with early spring cultivation as disking or by early spring plowing with immediate cultivation. This same method was used in preparing the soil for corn.

The New Mexico Station found that sunflowers could be grown on soil on which the water level is too high for the

cereals and many other plants to make a paying crop, provided the soil is warm and the water level does not fluctuate excessively or become stagnant on the growing roots. In the same bulletin a statement is made that sunflowers proved to be more successful than any other crop when used to eradicate noxious weeds. They grow so rapidly they shade and starve out the weeds. Preliminary trials point to the possibility of the sunflower being an eradicator for the troublesome Johnson grass. (6)

In their Bulletin on sunflower production the United States Department of Agriculture found there was no difference in methods used for preparing the soil for sunflower production, from preparing it for corn production.

(2) Time of Planting

The time for planting the sunflower seed is as difficult to name as the best breed of beef cattle. The date all depends upon the locality, the climate, and the moisture. Sunflowers may be planted before the time or after the time for usual corn planting. At the Colorado Station the corn crop and sunflower crop in 1923 were seeded May tenth. At the Wyoming Station it is recommended that sunflowers be planted several weeks earlier than corn. This is the factor that makes them superior to corn on both the dry-land and high-altitude farms. (1)

The Washington Station plants its sunflowers early in

the spring, two or three weeks before safe planting for corn.

The seeding at the New Mexico Station is done at least ten days earlier than corn. They often use the plant as an emergency crop in case some of the cereals mature early and the growing season permits of a late planting. Good yields have been secured from such planting. (6)

The West Virginia Station plants its sunflowers about June fifth, receiving their best yields from such planting. (3)

The Montana Station has perhaps carried on the most extensive experiment on time of seeding as affecting the yield. Their best results came when seeding was the earliest, about April twenty-ninth. The yields decreased as later seeding dates were used. Recommendations of the station are to defer seeding in the higher altitudes until the ground is warm and in good condition.

From the experience of other stations that have grown the sunflower it is found to be safe to always plant before the safe time of planting corn. The ability of the sunflower to resist a killing corn frost makes this possible.

3. Seeding, Method Used, and Amount.

The seeding at the Colorado Station differs from corn seeding only in distance between plants in the row. For the 1923 crop eight pounds of seed were used for sunflowers and the same amount per acre for corn.. The distance between rows was three and one-half feet.. The sunflower plants were four to six inches apart in rows while the corn was twelve

to fifteen inches . The corn planter was used to plant each crop, the planter being set to plant two and one-half to three inches deep.

An ordinary grain drill may be used for planting the sunflower seed if holes are stopped up to give proper distance between rows. The distance between plants in the row can be regulated by mechanical adjustments.

Best results were secured at the Experiment Farm, Huntley, Montana, when the rows were twenty inches apart and the plants three inches apart in the rows. This method of planting gave a yield of thirty-seven and six-tenths tons to the acre. The planting distance recommended by the Montana Station however is twenty-four to thirty inch rows and three to four inch intervals between plants.

A rich soil will stand thicker planting than a dry-land soil. The reason for such close planting is to prevent the sunflower stalk from growing so large and becoming woody. The thick planting also requires less cultivation to kill the weeds as the thick foliage will soon cover and shade the ground, starving out the weeds in this way.

The Wyoming Station has carried out a "rate of seeding" test which shows very conclusively the effects of different rates of seeding as affecting the yield. The table as presented by them is as follows on the next page:

The Rate of Seeding Sunflowers as Affecting the Yield Per Acre. (1)

Width of Rows in Inches	Interval Between Plants in Rows Inches	Yield per Acre in Tons
30	3	32.2
30	6	28.8
30	9	24.0
30	12	22.3
36	3	23.6
36	6	22.8
36	9	19.9
36	12	19.7
42	3	23.8
42	6	21.0
42	9	16.9
42	12	16.7

As the width of the rows and the distance between plants in the rows increased, the yield in tons per acre decreased. Not only did they receive a greater yield by thicker seeding but they claim a better quality of silage because the plants did not have such large stalks and did

not show so much fiber or woodiness..

There are some records of where sunflowers were planted in hills instead of in rows. Montana Station records show better yields by row planting and find it an easier method. More work will have to be done along this particular line before definite conclusions can be drawn. The general practice by different Experiment Stations is to row plant.

Eight pounds of seed per acre for planting is given by the New Mexico and Washington Stations. The amount varies from five to eight pounds, depending upon the size of the seed, the kind of soil, and the moisture.

A high percent germination test in a lot of sunflower seeds runs more uniformly thruought than in many kinds of seeds. That is , a low test is always dangerous because the natural vitality of the seed should nearly approach one-hundred per cent. Factors affecting one portion of a lot of seeds is very liable to affect the whole lot proportionately.

4. Cultivation and Irrigation

The same machinery for cultivating corn was used for cultivating sunflowers at the Colorado Station. The first cultivation is given soon after the plants are up and then every week or two to keep down the weeds until the plants are three or four feet high. At this height the ground is quite well shaded and weeds will not give much trouble.

The New Mexico Station gives an early cultivation and

perhaps another with the straddle row cultivator before the plants are so tall as to be hurt with such a cultivator. They use a one row cultivator to clean out between the rows where there is grass or if the land is badly infested with Johnson grass. The grass and Johnson grass give very little trouble after the sunflower is three or four feet high. The first cultivation, as given by the Wyoming and Washington stations, is deeper than the following cultivations, as there is not so much danger of injuring the roots when the plant is small. The cultivations are given for the same purpose as in case of the corn plant, namely to conserve moisture, make more plant food available and destroy weeds.

The irrigation of sunflowers has not been made a study as yet in convincing results by any station. Some localities require an irrigation to bring up the plants. The crop here was not irrigated until about six weeks after planting. Quoting the New Mexico st tion gives good information on this subject: "Where irrigation is followed, water should be applied as soon as the plants show signs of wilting, but never allowed to stand on the soil. No plant will die sooner than the cultivated sunflower when water is allowed to stand on it for any length of time. In all places at the Station where water stood for one entire day and heated on the heavy soils, the sunflowers were killed."(6)

An interesting discovery was made at the Montana Station (8) with their work on "Quality in Sunflower Silage." The silage

at the Huntley Station was always of poor quality and unsatisfactory. The crop at this place was grown under irrigation and upon chemical analysis of the plant, the sugar content was only .3 per cent. At the same station only on dry land plots an analysis showed a sugar content of 2 per cent. This is only one test and will not justify the drawing of conclusions, but it seems as though the irrigation may have some part in determining the sugar content of the sunflower, thereby affecting the quality of the silage. The silage at Huntley was habitually from plants grown on irrigated land since the yield was low on dry land localities. It always failed to make good silage, even when handled under the best known methods. This silage from irrigated land showed the presence of large quantities of butyric acid which is the wrong kind for silage preservation, and indicates putrefaction. Analyses of other plants that make good silage shows a large sugar content which later makes the lactic and acetic acid that preserves the silage.

Sunflowers from the non-irrigated land always made a good quality silage.

5. Harvesting Methods.

The ordinary corn harvesting machinery may be used to harvest the sunflower crop when the growth is not too rank and the rows are not too badly tangled. The corn binder may be used with less trouble on the dry-land sunflower crop as the stalks as a general rule, do not grow so large in diameter and tangling of rows is not so common.

The Dubois (Idaho) sheep station devised an elevator to carry the bundles from the binder into a wagon and thus save time and labor. The sunflowers in this case ranged from 8 to 9 feet in length and passed up the elevator giving no trouble. (2) The rows, as seen in a picture, were not tangled with each other, but the plants in the row were close together.

Where the crop has lodged, or is too heavy for a corn binder or a corn row binder is not available, the sunflower crop may be harvested by using a sled towhich a knife has been attached.

The 1923 sunflower crop at the Colorado Station was harvested with the sled method. At the beginning of the work only one sled was used. Three horses were required to pull the sled and one man to drive. There were four men in the field to help load, two men working while the other two rested. Four teams and four drivers hauled the sunflowers from the field to the silo. Two men were used in the silo to pack the silage, one man to feed the cutter, one man to tend tractor and help feed cutter, and one man to help the drivers unload.

This system of harvesting was changed in a day or so by using another sled cutter and letting the four men in the field to help load, work all the time, two loaders to each sled. This was a saving of time and no harder on the loaders as they did not have to work so fast to keep the ensilage cutter going as when one sled was used.

The latter arrangement of workmen has proven to be the most economical method, thus far used for harvesting sunflowers here at the Station.

The plants here grow rapidly and to an average size of 3.7" in diameter and an average height of 10' 4". The rows were badly tangled, which made harvesting more difficult. On account of sunflowers being hard to handle, it is generally reported necessary to pay farm laborers an increased wage during this kind of work. (2)

The general practice is to haul the sunflowers to the cutter as they are cut in the field. If they are allowed to be left piled up, heating will soon start, as there is a large per cent of moisture in sunflowers. The Montana Station, however, has offered an exception to this general statement. In 1921 they carried on an experiment to determine quality in sunflower silage. One of the objects of the experiment was to determine the effect of wilting of sunflowers before ensiling. Part of their 1923 crop was wilted before being run thru the cutter. The results of this method will be brought out under the next heading, "Time of Cutting for Ensilage."

A good quality of silage was made from frozen plants at an advanced stage of maturity at Montana. (8) The material made an excellent quality of silage. This method is not advocated or practiced, but is mentioned to show that the crop need not be wasted should it be frozen.

6. Time of Cutting for Ensilage.

The stage of maturity at which we wish to cut the sunflower for ensilage is very obvious; that stage at which it will produce a good quality of silage with a maximum saving of actual digestible food constituents in the plant. This theoretical stage as yet has not been agreed upon by all the experiment stations. Some stations get best results at one stage of growth, while another station will get best results at an entirely different maturity.

The West Virginia Station (3) cut their sunflowers with a corn binder at the light dough stage, making a yield of 18 tons to the acre. The binder cut them easily and no difficulty was experienced with ensiling. The sunflowers made a silage of excellent quality, being eaten by dairy cows as readily as the corn silage.

By experimental results, the Wyoming Station has stated the best time to ensile is at the dough stage or when the rays are dry and falling. (1) When cut too early, the moisture content is high and the results will be a water-logged, high acid silage of very poor quality. They state that about 75 per cent moisture content gives best results. When the seeds mature, the silage will be woody and most of the leaves will have fallen to the ground, causing a loss in tonnage and feeding value.

The New Mexico Station starts harvesting when the plants are about 25 per cent in bloom, claiming a maximum weight of

of good silage will be secured. (6) The late milk stage is recommended by the Nevada Station (5)

Here at the Colorado Station, the 1920 - 1922 crops of sunflowers were harvested when the plants were approximately 50 per cent in bloom. The silage these years was of the best quality so far produced here.

The Montana Station carried on an extensive experiment trying to determine the following points: (8)

1st. "Effects of cutting at different stages of maturity on the appearance, taste, odor, and other properties that have to do with the quality of the silage."

2nd. "Effects on quality of silage of certain methods of handling after cutting, such as wilting the sunflowers before putting them in the silo."

3rd. "Effects of time of cutting and of various methods of handling sunflowers on chemical composition and on losses -- drainage and otherwise -- which occur during the curing processes."

Their fourth point was brought out under the heading of irrigation in this paper.

In this experiment six silos were used and filled with one of the following materials:

1st. Plants in the bud stage; 2nd, plants just in bloom; 3rd, plants whose seeds were forming on the outside margin of the head, and 4th, plants whose seeds were fully formed except in the center of the head, while some were hardened. A fifth silo was filled with sunflowers of the

same stage as in silo three, but no facilities were made for drainage at the bottom. Silo six was filled with material of the same stage of maturity as silo three, only the plants were allowed to wilt in the field three days after cutting, before being ensiled. The silos were of 1000 pound capacity with enough weight on top to make about the same pressure as in large silos.

The results of the Montana experiments are as follows:

1st. Up to and including the stage of maturity where the seeds were fully formed and partially hardened, nearly 10 per cent of the original weight of the green material was lost in the form of juice, provided drainage was allowed. Unless drainage was allowed, a poor silage resulted. There was no drainage from the wilted plants.

2nd. When sunflowers are ensiled at an early stage, there are more losses than juice. Very immature green plants contain active life processes which will liberate, probably carbon dioxide and nitrogen. The losses in dry matter from the silos filled with immature plants were 17 and 15 per cent respectively, whereas the silos filled with more mature plants lost about 7 to 8 per cent of their total dry matter. The protein loss from plants ensiled at the bud stage was 30 per cent; from plants beginning to bloom, 23 per cent; where seeds were forming, 17 per cent; seeds fully formed and beginning to harden, 7 per cent; and the silage from wilted plants lost only 6 per cent.

3rd. From the above facts it is evident that there is a greater loss of actual food constituents from silage made of immature plants than from plants cut when the seeds are formed.

4th. The silage from the wilted plants was of excellent appearance and of good palatability. Because of its lower moisture content, this silage contained from 60 to 75 per cent more dry matter per unit weight than the average sample of silage made in the usual manner. This also results in a marked saving of labor.

A table of analyses as prepared by the Montana station is as follows:

FOOD CONSTITUENTS 1919

Composition of Sunflower Silage (8)

Silo No.	Stage of Growth	Dry Matter	Ash	Protein	Fiber	Dig. Carbohydrates	Acid Value
		Per Cent	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent
1.	Bud stage	16.64	1.80	1.24	5.42	7.69	160
2.	Just in bloom	16.68	1.74	1.32	5.36	7.75	152
3.	Seeds forming	18.51	1.84	1.41	5.88	8.83	137
4	Seeds formed	18.27	1.68	1.43	5.72	8.72	100
5	Same as 3, no drainage allowed	17.36	1.50	1.26	5.22	8.94	100
6	Wilted	27.76	2.41	2.50	6.64	15.31	98

From the above table it can be seen that food constituents do not differ greatly in sunflowers until the stage of seeds forming or partially hardened. With advancing maturity, other things being equal, (8) there is a slight increase in dry matter, protein, fiber, and digestible carbohydrates. The fiber content of wilted silage was lower in proportion to dry matter than that in any other samples. The acidity increased as the immaturity of the plant. Silage made from plants in the bud stage was dark in color, sour, and inferior in quality to that made from plants cut at a later stage of growth.

A study of the composition of sunflower and corn plants at various stages of growth was made (9) by R. H. Shaw, Chemist and P. A. Wright, Assistant Chemist, Dairy Division of the Bureau of Animal Industry. The sunflower and corn crops were grown at the Dairy Division Experiment Farm at Beltsville, Md., a district usually devoted to silage corn. A study of their results will help in selecting the proper stage of maturity for ensiling sunflowers. The sunflowers were the Giant Russian variety, being commonly called the Mammoth Russian. The corn was Boone County White. The tables of results are as follows:

Table I -- Composition of sunflower plant at different stages of growth.

Stage of maturity	Moist. in fresh mat.	Dry Matter	Moisture--free basis				
			Total Protein	Albuminoid Protein	Reducing Sugars	Non-reducing Sugars	Starch
	P.ct.	P.ct.	P.ct.	P.ct.	P.ct.	P.ct.	P.ct.
3 ft.high	84.87	15.13	8.59	8.00	12.36	19.08	.63
6 ft.high	86.02	13.98	8.01	7.37	18.95	15.63	4.61
First flower	84.09	15.91	7.04	6.35	15.96	8.43	4.34
Rays ready to fall	83.90	16.10	9.44	7.89	13.23	3.01	.20
Rays dry and partly fallen	75.58	24.42	6.80	6.22	8.96	1.40	.84
Rays all fallen	74.37	25.63	7.03	6.09	6.99	.89	1.66
Seeds hard and mature	69.68	30.32	5.90	5.04	4.15	1.47	1.90

Table II -- Composition of corn plant at different stages of growth.

Stage of maturity	Moist. in fresh mat.	Dry Matter	Moisture--free basis				
			Total Protein	Albuminoid Protein	Reducing Sugars	Non reducing Sugars	Starch
	P.ct.	P.ct.	P.ct.	P.ct.	P.ct.	P.ct.	P.ct.
3 ft.high	84.21	15.79	11.14	10.26	14.69	2.73	1.52
4½ to 5 ft. high	85.14	14.86	9.42	8.14	16.69	3.23	1.66
Just tasselling	81.65	18.35	9.90	6.59	13.13	1.85	1.29
Just silking	81.56	18.44	8.95	6.73	18.23	1.30	.86
Kernels forming	81.20	18.80	8.99	6.38	20.37	5.44	3.45
Milk stage	77.60	22.40	8.97	6.30	17.59	4.51	2.87
Silage stage	68.69	31.31	7.31	6.23	10.03	2.81	24.00
All glazed	64.22	35.78	6.32	5.62	8.50	5.39	24.78
Ready to shock	59.79	40.21	7.09	6.14	7.71	2.73	21.66

Comparing table one and two it will be noted the chief difference is in the carbohydrate content and their character. In this experiment silage was not made of the sunflower plant at all stages but was made of the plant at the stage when the rays were dry and partly fallen. The silage was of excellent quality. Comparing the sunflower plant at this stage with the corn plant at its silage stage, it will be noticed that the starches and sugars combined constitute 11.2 per cent of the dry matter in the former, of which only about one-fifteenth is starch, while the combined starch and sugars in the dry matter of the latter constitute nearly 37 per cent, two-thirds of which is starch. (9)

The percentage of protein in the two plants in the dry matter is slightly in favor of the corn.

In drawing conslusions as to the time of cutting sunflowers for ensilage, one must keep in mind that the stage selected must be that which gives the largest yield of digestible food constituents in the silage. Points to consider in getting the maximum food constituents in the silage are; (first), the moisture content, as high moisture causes a loss of food material and produces a high acid silage or a waterlogged condition in the bottom, while plants low in moisture are hard to pack and keep from spoiling; (second), the yield per acre should be considered as this point alone would bar out the earlier stages disregarding the moisture

content; (third), from the moisture standpoint the sunflower at the late stage of maturity would make the best silage but at this time we find the leaves have started to fall and the outer layer of the stalk has become hard and woody, so much so that the cut plants would not pack tight enough in the silo to insure good keeping.

According to the before mentioned considerations in determining the time to cut sunflowers for silage, there are but two stages left, the one when the rays are dry and falling and the other when all the rays have fallen. These two stages are so close together that for all practical purposes they my be considered as one.

The protein content at these stages is approximately the same as the protein in the corn plant at the silage stage. The chief difference between the two plants at this time, as stated before, is in the carbohydrate content.

From a summary of the studies made it seems apparent that the best time to cut sunflowers for silage, and get a maximum amount of food constituents in a good quality of silage, is when the rays are dry and partly fallen until the rays have all fallen. This stage is spoken of sometimes as the light dough or dough stage of the seeds.

7. Ensiling

The same wagon used for hauling corn to the ensilage cutter may be used for sunflowers. A very convenient wagon however is one with a low rack. The sunflowers are

quite heavy and the elimination of any unnecessary lifting will be a labor saver as well as a cost saver in putting up sunflowers. The flat topped hay racks were used at the Station here for hauling in from the field.

The sunflower at the light dough or dough stage is a little harder and more woody than the corn plant at the silage state, thus requiring more power to run the ensilage cutter. It takes a little more time to cut the sunflowers than corn but if the sunflowers are put into the cutter heads first there will be a saving in time than if placed butts first.

When ensiled at the light dough or dough state the sunflower does not require the addition of water. If ensiled later some water will need to be added.

The ensilage cutter is set to cut the plant into pieces about one-half inch long. Two men are usually used in the silo to insure good packing.

The sunflower will pack much closer in the silo than corn, giving more pressure on the silo than in case of corn. Mr. Rommel, United States Department of Agriculture, (2) states that a 200 ton corn silo will hold 300 tons of sunflower silage. He also states that a new Monolithic concrete silo 14 feet in diameter and 50 feet high was built with six inch walls and the ordinary quantity of metal reinforcements, on the United States Sheep Experiment

Station near Dubois, Idaho, in 1920, but that this silo began to crack from the pressure when about half filled with the sunflower crop. The Huntley Station at Montana had a hoop on their wooden silo burst while the silo was being filled with sunflowers. This trouble does not seem to be very general, not enough so as to cause any published data on the pressure exerted on silos by sunflowers and the necessary reinforcements over corn silos.

8. Yields.

The yield comparison of sunflowers and corn for silage has been made mostly in those districts where corn does not do well. Under these circumstances sunflowers have always out yielded the corn. Calgary, Alberta, Canada, under irrigation reports a yield of 39 tons per acre, while Bozeman, Montana, under similar conditions reports a yield of 33 tons. Under dry-land conditions with an average yearly rain fall of about 18 inches, the Washington Station at Pullman, Washington received an average yield for 1919-and 1920 of 11.6 tons for sunflowers and 6 tons for corn.

A direct comparison of the yield per acre of the two silage crops at the Colorado Station shows for sunflowers in 1921 a yield of 15.37 tons. No corn was grown this year. For the year 1922 the yield in tons per acre were 17.2 for sunflowers as compared to 6.5 for the corn. The 1923 results show the sunflowers with an advantage in yield of 19.2 tons as compared wih 10.9 tons for the corn.

The Michigan Agricultural College in their survey of eight farms in four different counties, found that the sunflowers on an average gave a 20 per cent greater yield than the corn grown in the same fields.

The Washington Experiment Station in 1919 and 1920 noted that the outside rows of the sunflower plats next to the corn made a more vigorous growth than rows in the centers of the plats. Conversely, the corn rows next the sunflower plats were less vigorous than the rows in the centers of the plats. This seemed to indicate an ability on the part of the sunflowers to obtain a greater portion of the plant food and soil moisture than corn when grown in competition with that crop. The plats which produced corn and sunflowers in 1919 were seeded to wheat in 1920. The average yield of wheat on the corn plats was 33.78 bushels and on the sunflower plats 28.36 bushels per acre. These results at the Washington station indicate that sunflowers are more exhaustive of the plant food and moisture in the soil than corn. This can be accounted for in most part by the larger tonnage obtained from the sunflowers. (2)

9. Cost Comparisons in Colorado.

Records were kept of the different field operations necessary in producing the corn and sunflower crops, also a labor record was kept of the ensiling process.

All operations up to the harvesting time, except

cultivation, required practically the same number of man and horse hours per acre of crop. The man hours required for irrigating the two crops was less in the case of the sunflowers than for the corn. Sunflowers do not need as heavy an irrigation as the corn and in many instances not so many irrigations, as the sunflower will produce a foliage in a short time which will so shade the ground that moisture evaporation is considerably reduced. Due to this rapid growing nature of the sunflower, the man and horse hours for cultivating one acre of sunflowers for the season 1923 was 10.8 man hours and 13 horse hours as compared to 16.5 man hours and 17 horse hours for one acre of corn. The shading of the ground keeps sunlight from striking the young weeds and consequently the pest is starved out because of not being able to manufacture the proper food.

The cutting of the sunflower crop is the one item which runs up the cost in making sunflower silage. From the records on cutting the crop it is found that four times as many man and horse hours are required to cut an acre of sunflowers as to cut an acre of corn. Of course there was twice the yield of sunflowers per acre to cut.

The time required to haul in an acre of sunflowers was longer than for corn but the time required to haul in a ton of sunflowers was slightly less than a ton of corn. The heavy yield of sunflowers made this possible.

During the ensiling period of the crops there was some delay in filling the sunflower silo due to the ensilage cutter breaking down several times. In spite of this fact, using the actual man hours charged, it took on the average for the season, twelve minutes to cut a ton of sunflowers, and ten minutes to cut a ton of corn silage. There were no break downs during the ensiling of the corn crop.

Using the actual labor charges against the sunflower and corn silage, we get a cost of $4.71 per ton for sunflowers and $5.11 for corn. The time lost in ensiling due to break downs ran up the cost of cutting the sunflowers as well as the ensiling at the silo. Eliminating all trouble there perhaps would have been a spread of at least a dollar per ton in favor of the sunflower cost.

For 1922 the actual labor cost charged to the sunflower silage was $4.80 per ton, while for corn it was $7.42. Sunflower silage in 1921 cost $5.34, corn silage for 1920 was charged $6.44 for labor.

PART II

EXPERIMENT ONE

PRELIMINARY STEER FEEDING EXPERIMENT OF FORTY DAYS

Objects of the Experiment.

1. To study the comparative feeding value of corn silage and sunflower silage with alfalfa hay when fed for a short time, allowing the steers a heavy feed of silage.

2. To get the steers on feed, filled, and gaining steadily before starting the main feeding experiment which will follow this one.

METHOD OF PROCEDURE

(a) Animals Used

Sixty-six head of high grade Hereford yearling steers were purchased in the southern part of the state in the Spring of 1923. The steers were thin, averaging 450 pounds. During the summer of 1923 the yearlings were run on the College Foot-hill Range, and were taken off the twenty-eighth of October averaging approximately 720 pounds.

The steers at the beginning of this test were costing $38.90 per head.

(b) Allotment Considerations.

The steers were weighed October twenty-ninth, graded according to their type as feeders and according to condition. The grades for type and condition were good, medium, and fair.

The six poorest steers as to type and condition were taken out, leaving sixty steers to be divided into six lots of ten steers each. Although there were only two rations to be fed the steers had to be divided into six lots as there were no two lots large enough to hold thirty steers each. Hereafter in this preliminary test the lots will, however, be considered as lots one and two of thirty steers each.

The factor of weight was taken into consideration trying to divide the heavy and light steers as nearly equal as possible between the two lots. There were five steers showing strong as Brockles, that were divided as nearly as possible between the two lots.

The previous treatment of the steers was not used as a factor, as the range experiment they were on subjected them to similar conditions, due to the fact that there was plenty of grass for all the steers even though the range pastures were under a different system of management.

In the following allotment sheet under type and condition the letters G, M, and F stand for the grades good, medium, and fair respectively. The weights secured are not used to get the initial weight for the beginning of the experiment, but are used as a guide in dividing the steers according to weight.

The allotment sheet is on the following page.

Allotment Sheet

Lot I (corn silage)				Lot II (sunflower silage)			
Number of Steer	Weight	Condition	Type	Number of Steer	Weight	Condition	Type
1	835	M	M	10	780	G	G
11	625	M	M	14	725	M	M
12	640	F	M	17	680	M	F
24	715	M	M	22	685	M	G
46	695	M	G	31	635	F	M
49	655	F	G	34	655	M	M
59	730	G	F	43	730	G	G
60	710	G	G	45	740	G	G
63	665	M	G	51	655	F	M
64	720	G	G	58	705	M	G
2	680	M	G	5	760	M	M
6	795	G	G	18	700	G	G
9	715	M	G	20	640	F	F
13	710	G	G	25	720	M	F
16	715	G	M	29	670	M	G
26	720	G	M	32	665	F	G
42	700	M	G	35	750	G	G
50	650	F	G	52	675	M	M
61	640	F	M	53	730	G	G
66	660	M	F	65	680	M	M
4	695	G	G	19	655	M	M
7	670	M	G	21	725	M	M
8	660	M	M	27	685	F	F
23	635	M	G	37	730	G	G
33	715	M	M	40	705	G	G
36	730	F	G	44	735	M	G
38	745	G	F	47	705	G	G
39	705	G	M	54	750	G	G
48	750	M	G	57	690	M	M
56	680	F	G	62	610	M	F
Av. Wt.	698.7			Av. Wt.	699.0		

(c) Feeds Used and Rations.

Lot one was fed on corn silage and alfalfa while lot two was fed on sunflower silage and alfalfa hay.

The corn silage was cut at a stage slightly less immature than the recommended silage stage for corn.

The sunflower silage was made when the seeds were in the light dough stage or when the rays were beginning to fall.

The alfalfa hay used was of good quality, first and second cuttings being used, Each lot was receiving the same cutting of hay at the same time.

Chemical Analyses of Feeds Used.

The chemical analyses used, comparing corn silage and sunflower silage, are analyses taken from reports only where the two silages were grown under similar and comparable conditions.

The table on the following page will show the chemical composition of the two silages in different parts of the United States.

Table III. Comparison of the Composition of Sunflower Silage and Corn Silage at Different Experiment Stations.

Kind of Silage	Constituents (per cent)						Year	Authority
	Water	Ash	Crude Prot.	Crude Fiber	N. Free Ext.	Ether Ext.		
Sunfl.	77.62	1.55	2.24	6.22	11.52	.85	1920	Ore. (10)
"	81.34	2.15	1.87	5.58	7.71	1.35	1922	" "
Corn	73.00	1.39	2.64	4.45	17.55	.97	1920	" "
"	76.38	1.30	1.89	6.08	13.93	.42	1922	" "
Sunfl.	76.20	2.33	1.86	7.45	18.43	1.18	1920	W. Vir. (3)
Corn	73.60	2.10	2.70	7.80	20.70	.90	1920	" "
Sunfl.	71.96	3.23	2.96	8.67	12.36	.81	1921	Okla. (11)
Corn	73.70	1.70	2.10	6.30	15.40	.80	1921	" "
Sunfl.	77.88	2.16	1.72	6.52	9.96	1.76	1921	Wash. (12)
Corn	71.60	1.98	1.99	5.94	17.58	.91	1921	" "
Sunfl.	83.20	2.39	2.22	3.38	8.29	1.52	1922	Colo. O.L. Osburn
Corn	76.30	2.02	3.50	7.55	9.44	1.19	1922	" "
Sunfl.	81.20	2.25	2.39	5.35	9.11	.70	1923	" "
Corn	80.70	1.35	1.86	5.10	10.75	.54	1923	" "
Aver. Sunfl.	78.48	2.29	2.18	6.17	11.05	1.16		
Aver. Corn	75.04	1.69	2.38	6.17	15.05	.82		

The analyses reported in table III for Colorado in 1923, represents the composition of the silage used in the feeding experiments for 1923 and 1924 at this station. These analyses agree with the average of all the stations quoted in table III except in the per cent of protein content in the two silages. The protein in the sunflowers was a little higher than in the corn silage. The nitrogen free extracts are quite similar in per cent content, closer than the average for the two silages. The rather immature stage of the corn at the time it was ensiled will account for the low per cent of carbohydrates in the corn silage, also for the low protein content.

The ether extract or fat is generally always higher in the sunflower silage than in the corn silage, while the crude fiber is about the same.

A fair representative sample was taken of the alfalfa hay used. Upon chemical analysis the following results were obtained.

Table IV. Chemical Composition of Alfalfa Hay Used.

Alfalfa Hay	Constituents (per cent)						Authority
	Water	Ash	Crude Prot.	Crude Fiber	N,Free Ext.	Ether Ext.	
	8.6	8.04	13.79	33.50	34.07	2.00	O. L. Osburn Chemist
	8.6	8.6	14.90	28.30	37.30	2.30	Henry&Morrison

From the table of analysis ,the alfalfa hay used was high in crude fiber and nitrogen free extracts as compared to the analysis given by Henry and Morrison. The steers were allowed all the alfalfa hay they would clean up well in the feed racks.

Digestible Nutrients in Corn Silage and in Sunflower Silage.

A digestion trial was not conducted with the two silages used, therefore work along this line will have to be gathered from other sources.

Digestion Trials with Cattle and Sheep.

It was impossible to secure digestion trials with corn and sunflower silage at the same station for the same year. In view of this fact a table will be made showing the digestible nutrients in sunflower silage as determined at different stations. Feeds and Feeding by Henry and Morrison will be used as an authority for the corn silage.

Table V. Digestible Nutrients in 100 Pounds of Corn Silage and Sunflower Silage.

Kind of Silage	Animal Used	Digestible Nutrients: lbs. Crude Prot.	Crude Fiber	N.Free Ext.	Ether Ext.	N. R.	Authority
Sunfl.	3 steers	1.24	2.87	7.25	.35	8.8	Mont.(2)
"	3 cows	.97	2.34	5.38	.91	10.1	Idaho(13)
"	3 sheep	1.10	2.94	6.68	.95	10.6	" "
"	2 lambs	1.00	2.50	5.79	1.45	11.55	Wash. (120
"		1.00	3.00	6.83	.80	11.60	Henry&
Corn		1.10	4.09	10.9	.70	15.10	Morrison

The rather immature stage of the Montana sunflower silage accounts for the low amount of digestible fat due to a small percent of fat in the plant at the ensiling period.

The Idaho experimenters found the nutritive ratio narrower in sunflower silage than in either immature or mature corn silage. Another conclusion to be drawn from their work is that the sheep utilized slightly more nutrients in the sunflower silage than did cows under the same conditions.

Conclusions drawn by J. Sotola, of the Washington Experiment Station,(12) from his trials on digestion of sunflower silage with lambs are; ...

1. Sunflower silage is a palatable, succulent roughage adapted to feeding lambs.

2. Sunflower silage from rather mature plants had a nutritive ratio of 1 to 11.5 for lambs as compared to an average for all classed of livestock , of 1 to 17.9 for corn silage.

3. In 100 pounds of the sunflower silage there were 12.55 pounds of digestible nutrients, as compared to 19.04 pounds of digestible matter for each 100 pounds of corn silage.

4. Sunflower silage had 66per cent of the value of corn silage, when comparing the content of digestible nutrients.

5. Sunflower silage proved to have a crude protein 12.4 per cent more digestible than the crude protein of corn silage; the crude fiber of sunflower silage was about 40 percent less digestible. The nitrogen free extract was 18 per cent less digestible in sunflower than in corn silage.

The digestion results given in the Montana Bulletin 134, shows that the digestible protein in sunflowers exceeds that in corn by approximately the same per cent as determined at the Washington Station.

The digestible nutrients in the silages fed and the alfalfa hay used are computed in the following table by using the coefficients of digestibility as given by Henry and Morrison in their text on Feeds and Feeding and applying them to the chemical composition of the silages as determined, in table III, by O.L. Osburn for 1923; also for the alfalfa hay analysis in table IV.

Table VI. Composition, Coefficient of Digestibility, and Digestible Nutrients in the Sunflower Silage, Corn Silage, and Alfalfa Hay Used in the Experiment.

		Dry Mat.	Crude Prot.	Crude Fat	N.Free Ext.	Crude Ash	Crude Fiber	Total Diges. Nutr.	N. R.
Chemical Analyses in Per Cent	Corn Silage	19.30	1.86	.54	10.75	1.35	5.10		
	Sunf. Sil.	18.80	2.39	.70	9.11	2.25	5.35		
	Alf. Hay	91.40	13.79	2.00	34.07	8.04	33.50		
Coefficients of Digestibility	Corn Silage		51	82	71		65		
	Sunf. Sil.		49	75	67		47		
	Alf. Hay		71	38	72		43		
Digestible Nutrients In 100 lbs.	Corn Silage		.95	.44	7.63		3.32	12,89	12.57
	Sunf. Sil.		1.17	.53	6.10		2.51	10.97	8.38
	Alf. Hay		9.79	.76	24.53		14.41	50.44	4.15

The total digestible nutrients in 100 pounds of the sunflower and corn silage is less in each case by three pounds, than the total given by Henry and Morrison. The nutritive ratio in each silage is 12.57 for corn and 8.38 for sunflowers as compared to 15.1 and 11.6 respectively in Henry and Morrison's table.

The digestible nitrients in the alfalfa compare very favorably to those given in Henry and Morrison.

(f) Weights

To arrive at an initial weight on which to base the experiment, the steers were weighed individually for three consecutive days. The three weights were averaged and the weight secured was called the initial weight, being dated the day of the second weighing.

Group weights were taken every ten days of each lot at seven o'clock before feeding time in the morning.

The final weight was secured by the same method as the initial weight, calling the day of the second weight as the date ending the experiment.

(g) Feed Lots and Housing.

There were six feed lots all equipped with the same kind of hay racks, feed bunks, and a shed on the north end open to the south. Each lot would nicely accommodate ten steers. An over head track was used to convey the silage to the lots by means of a feed carrier. The hay was exposed to the weather all the time and replenished as needed, by

hauling from the stack in the field.

(h) Water

The animals had access to hydrant water in troughs all the time.

(i) Salt

Block sulfur salt was kept in each pen all the time.

(j) Bedding

Baled wheat straw was used for bedding, The steers never ate any of the straw because alfalfa hay was always before them at bedding time.

(k) Disposal of Manure.

The college farm department hauled the manure for its value.

(l) Records

Careful and accurate records were kept all the time. The daily feed was recorded in a feed book with duplicate sheets, two entries being made each day, one for the morning feed and one for the evening feed. The hay was weighed as the pens needed refilling and at the end of the experiment a weigh-back was made to determine the hay consumption for the period.

The weights of the animals were recorded in a weight book in duplicate form.

EXPERIMENTAL RESULTS

Table VII

40 Day Preliminary Steer Feeding Test With Corn Silage, Sunflower Silage, and Alfalfa Hay.

Nov. 2, 1923 to Dec. 12, 1923. Thirty Steers Per Lot All weights in pounds.	Lot I Corn Sil. Alf.	Lot II Sunf. Sil. Alf.
Average initial weight	721.4	719.6
Average final weight	758.3	756.6
Total gain per steer	36.9	37.0
Average daily gain	.92	.93
Average daily feed:		
Corn silage	28.3	
Sunflower silage		27.0
Alfalfa hay	12.57	13.53
Feed consumed for 100 lbs. gain:		
Corn silage	3064.02	
Sunflower silage		2919.62
Alfalfa hay	1360.2	1461.75
Total dry matter	1834.61	1884.93
Feed cost for 100 lbs. gain:*		
Corn silage	9.96	
Sunflower silage		6.57
Alfalfa hay	8.84	9.50
Total cost	18.80	16.07
Feed cost per steer	6.95	5.95

*Feed price: Corn sil.$6.50; Sunfl.$4.50 ; Alf. $13.00

Discussion.

The initial weight of the two lots is practically the same. The final weights are very near the same and the average daily gain is the same in each case, when it is considered that a hundredth of a pound daily gain could be accounted for by experimental error.

Considering the feed consumed one finds that the corn silage lot ate 1.29 pounds more of the silage per day than lot two ate of the sunflower silage. The corn silage lot ate 12.57 pounds of alfalfa per day as compared to 13.53 pounds per day for the sunflower lot, there being 1.04 pounds difference per day in favor of the corn silage lot. Figuring on the basis of feed required for 100 pounds gain, the corn silage lot required 144.4 pounds more of silage, and 101.52 pounds less of hay. The dry matter consumed per 100 pounds gain was 50.32 pounds less in the corn silage lot than in the sunflower lot.

Thus far there has been very little difference between the two silages. In computing the feed cost for 100 pounds gain, there is a difference of one dollar in favor of the sunflower lot. The double yield of sunflowers per acre to that of corn, accounts for the lower charge.

At the beginning of the test the corn silage lot took to their feed a little quicker but after the third day all steers were eating and showing a good appetite. The corn silage lot would clean up a little quicker and stood a more

rapid increase in daily ration.

A careful observation of the animals at the close of the forty days showed no visible difference between the two lots. There were no changes whereby the animals of one lot could be detected from those of the other lot.

The Washington Experiment Station conducted a seventy-five day feeding test comparing a ration of sunflower silage, cottonseed cake, and alfalfa with corn silage, cottonseed-cake, and alfalfa. The steers in this case were two years old. The average daily gain of 1.9 pounds for each lot is one pound greater daily gain than secured with the yearlings here, both gains being figured on feed lot weights. The average daily rations were 43 pounds silage, 12.5 pounds alfalfa, 2.1 pounds cottonseed cake for the sunflower lot and 39.6 pounds silage, 13.2 pounds alfalfa, 2.0 pounds cottonseed cake for the corn silage lot.

A summary of their test shows the sunflower lot ate more silage and slightly less hay than the corn silage lot. The sunflower lot showed exactly the same gains as the corn silage lots and at a cost of $2.47 per steer cheaper.

EXPERIMENT TWO

One Hundred Eighty-six Day Steer Feeding Experiment

Object of the Experiment

1. To compare corn silage and sunflower silage when fed in a grain and alfalfa hay ration for fattening steers.

METHOD OF PROCEDURE

The sixty steers used in the preceding experiment were realloted into six pens of ten steers each. The various factors as previous treatment, condition, weight and etc., were taken into consideration and balanced between the six lots so that each lot was uniform. Two of these lots of ten steers each were used for the corn silage-sunflower silage test. The other lots were on different rations and will not be discussed in this paper.

Feeds Used and Rations.

In this test lot one received barley, corn silage, and alfalfa hay while lot two received barley, sunflower silage, and alfalfa hay. The silages and hay were taken from the same silos and hay field as discussed in experiment one.

The barley was California Feed, good grade, and was ground before feeding. It was fed with the silage in feed bunks.

A small feed of barley was used to start with and gradually increased until at about the one-hundred thirty day period the steers were getting all the barley they would take which was sixteen pounds per head per day.

The daily ration of silage to start with was twenty-five pounds per steer. This amount was cut down when the steers refused to eat it. No silage was refused until after the steers had been on fourteen pounds of barley per head per day for a period of eight days. As the barley was increased the silage was decreased to an amount which the steers would clean up.

The alfalfa was fed in the racks at the amount the steers would consume without waste.

The feed lots, shelter, water, salt, bedding, manure, and records were all taken care of the same as in experiment one. The weights were secured the same, initial and final, and ten day group weights were taken of each lot as well as an individual weight of each steer every thirty days.

Observations.

The steers in each lot were started out on a small feed of barley and gradually increased so that the fourth day they were getting six pounds per head per day. They were held here for a week then raised up to seven pounds and increased thereafter as seemed advisable until one-hundred forty days were up, at which time the steers were getting sixteen pounds of barley, about all they would take.

Within three days the steers were getting twenty-five pounds of silage per head per day at which they were held until they would not clean up their daily ration.

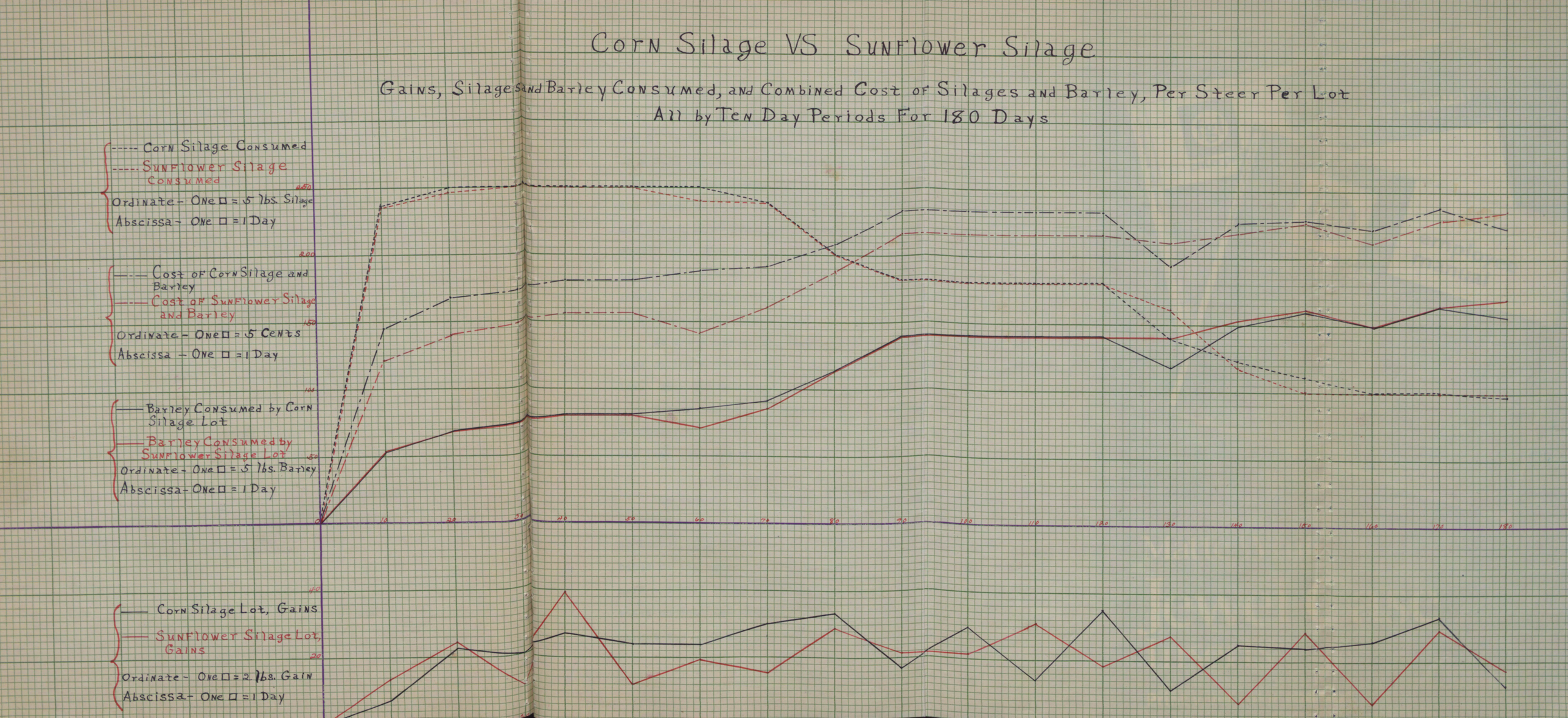
At the end of seventy days both lots were cut down on silage to twenty pounds per head. At the beginning of the ninety day period both lots were cut down to eighteen pounds. The next decrease in silage was at the end of one-hundred thirty-five days when the lots were cut down to fifteen pounds per head per day. Ten days later the cut was made down to ten pounds per steer per day. At this time the steers were starting on sixteen pounds of barley per head per day. Lot one on corn silage was only cut to twelve pounds as they would clean up this amount with the heavy feed of barley.

Steer number 48 in pen two died the night of December 30,1923 of bloat. This was the only case of bloat in the lot. Before this time one or two animals in a lot getting just barley and alfalfa, the check lot, were bothered with bloat.

Lot two was carried on a nine steer basis until Jan. 26,1924 when steer number 9 was taken out because of symptoms indicating a foreign body in the stomach. At this time two cull steers were used to replace those taken out of lot two. The difference in weight was carried so that the two lots would still be comparable. The sunflower silage is not held responsible for the illness of steer number nine because there was a steer in another lot on corn silage that was taken out later showing symptoms like those of steer nine. Steer nine was later returned to lot two and one of the culls substituted was taken out.

Corn Silage VS Sunflower Silage

Gains, Silage and Barley Consumed, and Combined Cost of Silages and Barley, Per Steer Per Lot
All by Ten Day Periods For 180 Days



No more trouble was experienced with the sunflower lot.

Lot one, corn silage lot, went off feed April 12 and May 9, taking about three days each time to get them back on a full ration. From the 120 day period to the 160 day period the corn silage lot would not take as much silage and barley as would the sunflower silage lot. The corn silage steers shed their winter coat earlier in the spring and showed as a thriftier lot although they did not weigh heavier or make any heavier gains up to this time of the experiment. The sunflower steers never did show the sleekness as a whole, as lot one.

At the close of the experiment the steers in lot two were eating and cleaning up just as well as the corn silage lot. Each lot was receiving the same amount of silage.

During the test it was a noticeable fact that the sunflower silage steers ate a little more hay during the day than the corn silage steers.

Termination of the Experiment.

The experimental results were figured from the data received after the steers had been shipped to the market at Denver. The feed required for one-hundred pounds gain based on the weight of the steers at market will mean more and will be of more value to the farmer than amounts based on feed lot weights. Also the accurate shrink to market for each lot and the correlation of shrink with

ration fed can be made if there is any marked difference.

After the steers were sold and butchered the dressing percent and grade of carcass was obtained for each steer. A close examination of the carcasses in the cooler showed there was no means of telling the corn silage fed ones from the sunflower silage fed one. As will be shown later the two lots graded exactly the same as to quality of carcass.

Table VIII EXPERIMENTAL RESULTS

Sunflower Silage VS Corn Silage for Fattening Steers.

186 Day Period, Dec. 12,1923 to June 15, 1924

10 steers per lot All figures based on one steer All weights in pounds	Lot I Barley Corn Sil. Alf.	Lot II Barley Sunfl. Sil. Alf.	Check Barley Alf.
Average initial weight	756.8	759.8	757.5
Average final weight, Denver	1135.0	1125.5	1080.0
Total gain per steer , Denver	378.2	365.7	330.5
Daily gain, Denver	2.03	2.03	1.7
Per cent shrink,Ft. Collins-Denver	3.65	2.76	3.2
Average daily feed:			
Ground barley	11.81	12.12	11.64
Corn silage	18.17		
Sunflower silage		17.94	
Alfalfa hay	8.09	10.86	15.32
Feed consumed for 100 lbs. gain,Denver:			
Ground barley	580.92	597.92	653.12
Corn silage	893.39		
Sunflower silage		884.95	
Alfalfa hay	397.94	535.63	859.76

(continued on following page)

Table VIII (concluded)

Feed cost for 100 lbs. gain:*	Lot I	Lot II	Check
Barley	7.26	7.47	8.16
Corn silage	2.90		
Sunflower silage		1.99	
Alfalfa hay	2.59	3.48	5.59
Total cost	12.75	12.94	13.75
Selling price, Denver	9.61	9.53	9.16
Gross return	109.07	107.26	99.66
Total cost at Denver	105.36	104.63	102.45
Labor return	3.71	2.63	—2.79
Dressing per cent, warm	62.51	61.26	62.08
Grade of carcass and number of each gradeper lot:			
Choice	4	4	4
Good	6	6	4
Medium	0	0	2

* Price of feed

Barley	$25.00
Corn silage	6.50
Sunflower silage	4.50
Alfalfa hay	13.00

Discussion of Results

The average daily gain made by lot one and two was the same, namely 2.03 pounds. By referring to the total gain made by each lot, a larger gain is recorded for lot one, but due to having a less number of steer days in lot two because of one steer dying and another being out for a while , the daily gain figures out just the same,

For the sunflower lot to produce 100 pounds gain it took 17 pounds more of barley or 2.93 %; 8.44 pounds less of silage or .94 %; and 137.69 pounds more of alfalfa or 34.6 % than required by the corn silage lot to put on the same amount of gain.

By using the barley-alfalfa lot as a check lot in determining the replacement value of the silages, one will find that the sunflower silage has 71.15 % the value of corn silage to replace alfalfa, and 75 % the value of corn silage to replace barley in a barley-alfalfa ration for fattening steers.

The cost for 100 pounds of gain in the two silage lots was $12.94 for the sunflower steers and $12.75 for the corn silage steers, a difference of 19 cents. The greater yield of sunflowers per acre gave a cheaper silage per ton; therefore the reason for the cost of 100 pounds gain so nearly approaching the cost of the same gain for the corn silage lot.

Comparing the sunflower lot with the barley-alfalfa lot

one finds that 884.95 pounds of sunflower silage saved 324.13 pounds of alfalfa and 55.2 pounds of barley for every 100 pounds gain besides 81 cents in cost for the one-hundred pounds of gain.

The lot one steers outsold the lot two steers 8 cents per hundred weight, realizing a profit of $3.71 per head as compared to $2.63 profit per head for the sunflower steers. The check lot of steers made a loss of $2.79 per head. With the existing spread in return between lot two and the check lot it seems advisable to feed sunflower silage in place of a straight grain and hay ration.

Table IX. Summary of Corn Silage-Sunflower Silage Ration Comparisons for Fattening Steers in Colorado.

Market returns based on one average steer.

Year---	Corn Sil. D.Mol-B-Pulp C.S.C. Alf. '21-22	Sunf.* Sil. D.Mol-B.Pulp C.S.C. Alf. '21-22	Corn Sil. D.Mol-B.Pulp C.S.C. Alf. '22-23	Sunf. Sil. D.Mol-B.Pulp C.S.C. Alf. '22-23	Corn Sil. Beet-Mol. Barley Alf. '23-24	Sunf. Sil. Beet-Mol. Barley Alf. '22-23	Corn Sil. Barley Alf. '23-24	Sunf. Sil. Barley Alf. '23-24	Barley Alf '23-24
Initial weight	1053.7	1051.8	708.7	722.7	758.2	715.7	756.8	759.8	757.5
Final weight	1292.0	1253.0	1081.0	1064.0	1144.0	1081.0	1135.0	1125.5	1088.0
Days on test	150	150	190	190	186	190	186	186	186
Shipping shrink %	6.3	6.5	6.0	6.1	3.05	6.0	3.65	2.76	3.2
Av. daily gain, Denver	1.59	1.35	1.96	1.80	2.07	1.92	2.03	2.03	1.78
Feed Required for 100 pounds gain:									
Corn silage	1515.5		664.3		881.9		893.4		
Sunf. silage		1794.0		859.2		783.6		884.9	
Dried-Mol.-P.	725.0	859.4	528.0	606.2					
C.S. Cake	163.1	192.5	110.5	120.5					
Beet Mol.					186.0	198.5			
Barley					557.7	542.4	580.9	597.9	653.1
Alfalfa	432.2	704.0	380.4	432.6	347.9	416.8	397.9	535.6	859.8
Selling price, Denver	8.25	8.25	10.33	10.35	9.62	9.99	9.61	9.53	9.16

* Two year old steers were fed, all other years, yearlings were fed.

Summary of Work With Sunflower

Silage at the Colorado Experiment Station.

For the year 1921-22 two year old steers were used to compare a ration of corn silage, dried-molasses-beet-pulp, cottonseed cake and alfalfa, with sunflower silage, dried-molasses-beet-pulp, cottonseed cake, and alfalfa. Figured on a market return basis the corn silage lot made .14 pounds greater daily gain. The sunflower lot consumed more of each feed than the corn silage lot.

The feeding experiment for 1922-23 was conducted with yearling steers, comparing the same two rations. Again the corn silage lot out gained the sunflower lot by a margin of .16pounds daily gain. An interesting fact to note in the table is the economy of the yearling steers over the two year olds to put on 100 pounds gain. In the corn silage lot the two year old steers required over twice as much silage, 197 pounds more of dried-molasses-beet-pulp, 52.6 pounds more of cake, and 51.8 pounds more of hay to put on 100 pounds gain than the yearling steers. Practically the same difference exists in the sunflower lots when comparing the feed required for the two ages of steers.

Comparing the ration of sunflower silage, beet molasses, barley, and alfalfa, fed in 1923 with the ration of corn silage, beet molasses, barley, and alfalfa, fed in 1924, one finds the corn silage lot made .15 pounds greater daily gain. The sunflower lot ate 98.3 pounds less silage, 12.5

pounds more of molasses, 15.27 pounds less of barley, and 68.9 pounds more of alfalfa for 100 pounds gain than the corn silage lot.

The rations for 1923-24 have been discussed under experiment two, but one should note that the check lot of barley and alfalfa made the smallest daily gain, except for the two year old steers, and required in each case more barley and alfalfa than any of the sunflower rations, to put on 100 pounds gain.

Table X. Summary Comparing Efficiency of Sunflower Silage Fattening Rations for Steers at the Colorado Station.

Based on one average steer at Denver.

Year--	'21-22*	'22-23*	'21-22*	'21-22*	'21-22*	'22-23*	'#	'#	'23-24
10 steers per lot Rations--	Sunf. Sil. D.Mol-B.Pulp C.S.C. Alf.	Sunf. Sil. D.Mol-B.Pulp C.S.C. Alf.	Sunf. Sil. Molas. C.S.C. Alf.	Sunf. Sil. C.S.C. Barley Alf.	Sunf. Sil. C.S.C. Corn Alf.	Sunf. Sil. Molas. Barley Alf.	Sunf. Sil. C.S.C. Barley Alf.	Sunf. Sil. Barley Alf.	Barley Alf. (Check Lot)
Initial weight	1051.0	722.7	1051.7	1054.5	715.7	735.1	738.1	757.5	
Final weight	1253.0	1064.0	1222.0	1256.0	1081.0	1097.5	1085.8	1088.0	
Shipping shrink %	6.5	6;1	5.8	4.2	6.0	4.37	3.78	3.2	
Days on test	150	190	150	150	190	188	188	186	
Av. daily gain	1.35	1.80	1.14	1.35	1.92	1.94	1.87	1.78	
Feed required for 100 pounds gain:									
Sunf. silage	1794.0	859.2	2120.1	1779.2	783.6	870.6	960.9		
Dried-Mol.-Pulp	859.4	606.2							
C. S. Cake	192.5	120.5	205.8	172.7		97.6			
Barley			921.9		542.4	584.5	617.4	653.1	
Corn				772.3					
Alfalfa	704.0	432.6	844.4	883.6	416.8	408.2	523.6	859.7	
Beet Molasses					198.5				

* Two year old steers, others yearlings. # A two year average for the ration

The table showing the efficiency of the various sunflower rations to put on gain shows sunflower silage, molasses, cottonseed cake, and alfalfa as being a very poor combination of feeds. Corn was added the last fifty days to improve the ration and give the steers a little finish. The addition of cottonseed cake did not increase the gains enough, neither did it put on a superior quality of finish to pay for the cake. Two of the best rations were sunflower silage, barley, molasses, and alfalfa and a ration of just sunflower silage, barley, and alfalfa hay. When a good quality of alfalfa hay is used the expensive protein supplements are useless and are an unnecessary expense to the fattening ration for commercial cattle.

Due to the large tonnage of sunflowers to the acre which gives a comparatively cheap silage, the check lot of barley and alfalfa has not been able to compete with a ration containing sunflower silage and no protein supplement. In the trial this year with barley at $25 per ton, and alfalfa at $13 per ton, a feeder could pay $6. 32 for a ton of sunflower silage and put on 100 pounds gain in a ration of sunflow- silage, barley, and alfalfa hay for the same cost as 100 pounds in a ration of barley and alfalfa.

Conclusions drawn by the Oklahoma Station from their feeding test are that sunflower silage for fattening calves gave better results than the corn silage. The average daily gain for the calves getting corn, cottonseed cake, sunflower

silage, and alfalfa was 2.13 pounds while for the lot getting corn silage in place of the sunflower silage made 2.08 pounds gain per day. For the two year test the sunflower lot showed the smaller shrink as well as a higher dressing per cent. The calves had a good appetite throughout the test for the two years work with sunflower silage but showed a slight tendency to scouring when crowded, and a heavy excretion of urine.

EXPERIMENT III

124 Day Lamb Feeding Experiment

December 18, 1923 to April 20, 1924

Objects of the Experiment

1. To compare sunflower silage and corn silage when placed in a fattening ration for lambs.

Method of Procedure

(a) Animals Used.

Fifty-six grade Rambouillet lambs were used. They were shipped direct from a southern Wyoming range to the feed lots at the College. At the shipping point these lambs averaged 54 pounds and cost 11.25 cents per pound.

(b) Allotment Considerations.

The lambs were fed alfalfa hay for about ten days then they were allotted into two groups of twenty-eight lambs each. The factors of sex, weight, condition, type and fleece were all taken into consideration and balanced as nearly as possible between the two lots.

(c) Feeds Used and Rations.

Number one yellow Nebraska corn whole, was fed to each lot along with linseed oil meal. Each lot received alfalfa hay in the rack. Lot one received corn silage in addition while lot two received sunflower silage. The corn, linseed oil meal, and silages were fed together in a trough morning and evening. The sunflower silage and corn silage was

taken from the same silos as the ensilage fed the steers in experiment one and two, and has the same chemical composition as given in table III. The digestible nutrients in the two silages for sheep can be found by referring to table V.

Weights

(d) The initial weight was found by taking individual weights of the lambs for three consecutive days, calling the second day the beginning of the experiment. Each ten days group weights were taken of each lot until a thirty day period was reached, at which time an individual weight was taken again of each lamb. The final weight at the end of the experiment was secured in the same manner as the initial weight.

(e) Feed Lots.

The lots were in the open, enclosed by a tight board fence for a wind break. The lambs had a foot space per head at the grain trough and the same at the hay rack.

(f) Water and Salt.

The lambs had free access to water and salt at all times. Granulated number 4 stock salt was used. Water was drawn from the city hydrant.

(g) Bedding.

Baled wheat straw was used for bedding. The pens were kept as dry as possible but one heavy snow storm came which later made the pens quite wet.

Records

(b) Careful and accurate records were kept all the time. All records were kept in duplicate. The feed fed was recorded in the morning and evening of each day. The weight records were kept in a weight record book and placed in a safe.

The hay fed was recorded by taking the weight of hay used to refill the racks and at the end of the experiment weighing back what was left. The difference would give the amount of hay consumed.

(i) Termination of Experiment.

At the close of the experiment the lambs were shipped to Denver and sold. Each lot was sold separate and killed separate so that the carcasses could be identified and scored later.

All figures in the following table, Table XI, are therefore based on one average lamb at Denver on the market. This was thought to be the best way to figure up the results as the farmer wants to know the gains he has put on the lambs after they have been shipped and ready to sell. He is paid for what they weigh at the market and not for what they weigh in the feed lot.

Table XI. EXPERIMENTAL RESULTS.

Sunflower Silage vs Corn Silage

in a Fattening Ration for Lambs.

124 Day Period, Dec. 18,1923, to Apr. 20,1924

Based on one average lamb at the Denver market.

28 lambs per lot All weights in pounds	Lot I Corn L. O.- Meal Corn Sil; Alf.	Lot II Corn L. O.- Meal Sunf.Sil. Alf.
Average initial weight	57.39	57.64
Average final weight, Denver	91.07	93.30
Total gain per lamb, Denver	33.68	35.66
Average daily gain, Denver	.27	.29
Per cent shrink, Ft. Collins to Denver	5.70	6.20
Average daily feed:		
Corn,whole	.92	.93
L.O. Meal	.15	.15
Corn silage	.98	
Sunflower silage		1.01
Alfalfa hay	1.60	1.67
Feed consumed for 100 lbs. gain:		
Corn	337.26	322.13
L.O. Meal	56.20	53.44
Sunflower silage		350.95
Corn silage	361.29	
Alfalfa hay	589.08	581.50

(continued)

Table XI. (concluded)

	Lot I	Lot II
Feed cost for 100 pounds gain: *		
Corn	4.32	4.12
L. O. Meal	1.97	1.87
Corn silage	1.17	
Sunflower silage		.79
Aflalfa hay	3.83	3.79
Total cost per cwt. gain	11.29	10.56
Selling price per cwt. Denver	15.50	15.50
Gross return per lamb	14.12	14.46
Total cost per lamb at Denver	10.95	10.93
Labor return per lamb	3.17	3.53
Dressing per cent , warm weight	47.7	47.2
Grade of carcass, number per grade		
No. S (first)	1	7
No. R (second)	23	14
No. M (third)	0	0
No. D (same as S but too heavy)	4	4
No. X (inferior)	0	0
Average dressed weight	43	44
Average weight of pelt	9.1	9.4

*Price of feed: Corn $25.60; L.O.M.$70; Corn sil.$6.50; Sunflower sil. $4.50; Alfalfa $13.00

DISCUSSION

One lamb died in lot one early in the experiment due to pneumonia and was replaced by another lamb.

Two lambs in lot two died during the latter part of the experiment but were not replaced. The cause of their death was pneumonia also. During the shipping to Denver of the lambs, one was unaccounted for in lot two in the stock yards. He was never located. This explains the reason for there being twenty-eight lambs in lot one and only twenty-five in lot two, at the time of slaughtering.

Considering the gains made in each lot, we find that lot two made 1.98 pounds greater gain per lamb during the test than did the lambs in lot one receiving the corn silage. The average daily gain per lamb was .02 of a pound daily, greater in lot two than in lot one.

The sunflower lot consumed .01 of a pound of corn, .03 of a pound of silage, and .07 of a pound of alfalfa per lamb daily, more than did lot one. The feed required to make one hundred pounds gain in each lot shows that of each feed used, more was required to make the gain in the corn silage lot than in the sunflower. The table shows the difference being 15.13 lbs. of corn, 2.76 lbs. linseed oil meal, 10.35 lbs. of silage, and 7.58 lbs. of alfalfa hay. The cost for this one hundred pound gain was 73 cents cheaper in the sunflower lot than in the corn silage lot. This does not seem like a very great saving but

suppose a feeder had 2500 lambs and put a 30 pound gain on each lamb. The sunflower silage would have saved him $547.50.

The selling price per pound at the yards was the same in each lot, but the labor return or net return was 36 cents greater per lamb in the sunflower lot. On the 2500 lambs just spoken of this would have made a saving of $900 even.

Considering the dressed lamb, there was very little difference in the dressing per cent, .5 of one per cent in favor of the corn silage lots. When the carcasses were graded there were more good ones in the sunflower lot than in the corn silage lot.

For the year 1922-1923 a very similar experiment was conducted only the linseed oil meal was omitted. Practically the identical results were secured as this year, as regards the comparative value of the two silages. The sunflower lot required less corn and less silage but more hay, to make the same gains as the corn silage lambs. The profit was 29 cents per head greater for the sunflower fed lambs. They brought the same price on the market at Denver.

The University of Wyoming carried on some feeding investigations with sunflower silage to fatten lambs but not in comparison to corn silage. Their results show that the ration of corn, sunflower silage and alfalfa was more economical than the ration of corn and alfalfa. They make

the statement that sunflower silage will economically replace half the normal amount of alfalfa hay required and still not affect the rate of gain. In their trial 1.2 pounds of sunflower silage replaced one pound of alfalfa hay.

Sunflower silage and corn silage fed with pea straw were compared as rations for wintering ewes by the Washington station. The sixty day test showed the two rations to be equal. The conclusions were that one silage was practically as efficient as the other in maintaining pregnant ewes, there being no difference detectable either in the shearing or quality of the ewes wool or in the lamb crop of the ewes of the two lots.

SUMMARY

1. There are specific localities in the United States without a profitable ensilage crop, where sunflowers may be profitably and successfully grown.

2. The hardiness of the sunflower plant gives it a wide range of adaptability, more so than corn. Its quick and heavy growing property is an advantage over corn.

3. The practice and method used to produce the corn crop may be used for sunflower production.

4. Sunflowers may be planted earlier than corn and will withstand a corn killing frost.

5. The yield per acre remaining the same, it will cost more to harvest sunflower than corn ensilage. The greater yield per acre of sunflowers, however, has made it a cheaper silage. For the two years 1922 and 1923 at the Colorado station a sixty to seventy per cent greater yield was needed from sunflowers to give a silage at the same cost per ton as the corn silage. The sunflowers have always made a greater yield than this. It is of the opinion, where the sunflower crop can be harvested with a corn harvester, a sixty to seventy per cent greater yield will not be needed.

6. Sunflowers cut when the rays are starting to fall until they have about all fallen or when the seed is in the light dough or dough stage will give the greatest yield of palatable and nutritious silage.

7. A more palatable silage is secured when the sunflower plants are close enough together in the rows to prevent a large woody growth of the stalk. The distance depends upon the type and fertility of the soil.

8. Sunflower silage has a nutritive ratio of 11.6 as compared to 15.1 for corn silage. Sheep tend to utilize more nutrients in sunflower silage than cattle.

9. In a roughage ration for steers sunflower silage and alfalfa gave the same gains as corn silage and alfalfa. The identical relation was secured at the Washington station when cottonseed cake was added to each ration. In each test the sunflower ration was the cheaper.

10. A steer feeding test of 186 days proved sunflower silage to not be equal to corn silage but that it was 71.15% as valuable as corn silage in replacing alfalfa in a barley-alfalfa ration and 75% as valuable in replacing barley in the same kind of a ration and produced the same daily gain as the corn silage steers.

11. In a 186 day steer feeding test a ration of sunflower silage, alfalfa and barley gave 2.03 lb. daily gain and a profit of $2.63 per head as compared to a daily gain of 1.7 lbs. and a loss of $2.79 per head for a ration of barley and alfalfa.

12. The addition of cottonseed cake to a sunflower ration that contains a good quality of alfalfa hay does not pay when feeding steers.

13. At the end of a 186 day test the lot of steers on the sunflower, barley, alfalfa ration were eating as much silage as the steers on a corn silage, barley, and alfalfa ration.

14. The daily gain made by a lot of lambs on sunflower silage, linseed oil meal, corn, and alfalfa was .02 of a pound greater than for a lot of lambs on the same kind of a ration only corn silage was substituted for sunflower silage. In this same comparison the cost of 100 pounds gain was 73 cents cheaper in the sunflower lot.

15. Sunflower silage fed lambs make as good a carcass as corn silage fed lambs.

BIBLIOGRAPHY

1. Sunflowers, Their Culture and Use
   Wyo. Exp. Station, Bul. 129
2. The Sunflower as a Silage Crop
   U.S.D.A. Bul. 1045
3. Sunflowers vs Corn for Silage
   W. Va. Exp. Station, Circular 32
4. Sunflower Production for Silage
   Wash. Exp. Station, Bul. 162
5. Sunflowers for Silage
   Colo. Exp. Station, Extension Bul. 158
6. "The Culture and Feeding of Russian Sunflowers"
   N. Mex. Exp. Station, Bul. 126
7. Growing and Feeding Sunflowers in Montana.
   Mont. Exp. Station Bul. 131
8. Quality in Sunflower Silage
   Mont. Exp. Station, Circular 96
9. A Comparative Study of the Composition of the Sunflower and Corn Plants at Different Stages of Growth

   by

   R. H. Shaw and P. A. Wright
   Journal of Agricultural Research
   Volume XX No. 10
10. Oats and Vetch Versus Corn or Sunflowers for Silage
    Ore. Exp. Station, Bul. 194

11. Cattle Feeding Investigations
Oklahoma Exp. Station, Bul. 139

12. Studies on Digestibility of Sunflower Silage Fed to Sheep
Wash. Exp. Station, Bul. 161

13. Sunflower Silage Digestion Experiment with Cattle and Sheep
Journal of Agricultural Research
Volume XX No. 11

14. Native Feeds for Fattening Lambs
University of Wyo. Exp. Station, Bul. 130