Volume 17
Number 212 *A comparison of roughages for milk production*
Article 1

2017

A comparison of roughages for milk production

A. C. McCandlish
Iowa State College

Earl Weaver
Iowa State College

March, 1923 Bulletin No. 212

A Comparison of Roughages for Milk Production

AGRICULTURAL EXPERIMENT STATION
IOWA STATE COLLEGE OF AGRICULTURE
AND MECHANIC ARTS

ANIMAL HUSBANDRY
Dairy Husbandry Section

Ames, Iowa

SUMMARY

The trials reported here appear to indicate that:

1. The use of corn fodder instead of corn silage reduces milk production 6 percent and fat production 3 percent.

2. When the value of dry matter in silage was worth 66 cents per 100 pounds that in corn fodder was worth 32½ cents.

3. With silage valued at $4.50 per ton, an acre of corn yielding 8 tons of green feed and converted into silage will yield $36.00 worth of feed, whereas, if converted into fodder the value of the crop will be reduced to $16.21 per acre.

4. When timothy hay is used to replace alfalfa hay in a good dairy ration the production of milk and butterfat is reduced 7 percent.

5. With alfalfa hay at $15.00 per ton timothy hay is worth 86 cents per ton for feeding producing cows.

6. When corn fodder and timothy hay are introduced in a ration in place of corn silage and alfalfa hay there is a decrease of 18 percent in milk and 14 percent in fat production.

7. When the two poor roughages, corn fodder and timothy hay, are fed together, this combination gives to them a slightly higher value individually than where one is fed with a good roughage, but good production or economical returns from the feeds can not be obtained.

8. Corn silage and a legume hay (alfalfa) are the best roughages for dairy cattle, while corn fodder and timothy hay are poor.

9. If the corn crop is all to be fed to the cows it should be put in the silo On the dairy farm hays such as timothy should be sold and legume hays purchased in their stead.

A COMPARISON OF ROUGHAGES FOR MILK PRODUCTION

By A. C. McCandlish and Earl Weaver

Altho dairy cows are especially adapted to the consumption of various roughages and tho they utilize more profitably than other livestock many such feeds which cannot be marketed directly, yet there is a marked difference in the values of roughages when considered from the standpoint of milk and butterfat production.

That fact is emphasized in the results of the dairy feeding trials with Iowa's standard roughages, corn silage, corn fodder and timothy and legume hays, reported in this bulletin. In the three tests, alfalfa was the legume hay used, tho clover could have been used in its place. Corn silage has a decided advantage over corn fodder in the ration, and its dry matter seems to be worth about again as much as that of the fodder. Alfalfa hay was shown to have 20 times greater feeding value than timothy hay.

Three distinct problems were worked on in these experiments with roughages. Corn silage was compared with corn fodder, alfalfa hay with timothy hay, and corn silage and alfalfa hay with corn fodder and timothy hay.

RESUME OF PREVIOUS WORK

There is record of a number of experiments dealing with the first problem, comparing corn silage and corn fodder, but of only one on the second and none on the third. No other recent work has been reported, comparing the values of corn silage and fodder, all the trials here referred to having been conducted from 30 to 40 years ago. The conclusions reached are conflicting.

The first trial on record was carried out by Henry (5) who, on comparing the relative values of corn silage and dry corn fodder for milk cows, found the silage increased the production by 10 percent in milk and 11 percent in butterfat over that obtained with the fodder ration. In a later trial Henry (6) compared the two feeds on the basis of their dry matter content and found that one pound of butter was produced from 16.11 pounds of dry matter in corn fodder against 15.69 pounds of dry matter in corn silage. On repeating the experiment the following year, Henry (8) concluded that the dry matter of silage had not a higher value than the dry matter of carefully

cured corn fodder, and that fodder allowed to stand in the field for one month lost as much feeding value as the corn that was ensiled.

In a comparison of silage and corn fodder for milk production, Woll (14) found that the quantity of milk and fat produced was lower during the silage than during the fodder feeding periods, altho the digestibility of the silage ration was somewhat higher than the fodder ration. The experiment was continued the next year, when the cows produced slightly more milk and butterfat per pound of digestible dry matter eaten in the fodder ration than in the silage ration, and Woll (15) concluded that the digestible nutrients of the two feeds were practically of equal value for milk production. The digestibility of the corn silage, however, was somewhat higher than that of the dry corn fodder of the same variety and maturity. Another trial was reported by Short (12), who stated that there was little difference in the feeding value of the dry matter of ensilage and corn fodder when preserved under equally favorable conditions. The small difference was in favor of the silage. It was reported by Hills (10), working with milk cows, that corn fodder and corn silage from the same source had almost equal feeding value when compared on the basis of their dry matter content.

Further work by Woll (16) and a consideration of all previous trials at the Wisconsin Station, lead him to the conclusion that properly cured corn fodder and corn silage of similar variety and maturity are of equal value for milk and butter production. Armsby (1) found a greater yield of milk on the silage ration but stated that there was no material advantage on the side of either corn silage or corn fodder when fed in corresponding quantities other than that arising from the greater digestibility of the silage compared to the poorly cured corn fodder used in his work.

In another piece of work by Woll (17) corn fodder and corn silage from equal areas of land were fed to cows, with a three percent gain in milk and fat production in favor of the silage. Cooke and Hills (2) obtained nine percent more milk and five percent more fat with corn silage than with corn fodder, but in a later trial they (3) concluded that when the two feeds were fed at will the cows produced equal quantities of milk and fat in equal periods of time, but in the case of the corn fodder they consumed nine percent more corn dry matter. This difference in the dry matter of corn silage and corn fodder was brought out by Voorhees and Lane (13) who obtained an increase of 13 percent in milk and 10 percent in fat production in favor of the silage dry matter.

It may be noted that Henry (7) found quite a difference in production value between cut and uncut corn fodder, due largely to the fact that the cut fodder was consumed without waste, whereas, 18 percent of the uncut fodder was refused. Shelton (11) reported an average waste of 31 percent in feeding corn fodder of varying lengths.

Several investigators have measured the losses occurring in the ensiling and field curing of the corn crop, and their results have been tabulated by Henry and Morrison (9). This evidence shows that the loss of nutrients occurring in the silo is not so great as the loss occasioned in the field curing of corn fodder.

The only comparison of alfalfa and timothy hays was made by Frasher and Hayden (4) who found an increase of 17.7 percent in milk production in favor of the alfalfa hay.

THE EXPERIMENTS

The three trials reported in this bulletin consisted of comparisons of the following roughages:

Trial I.—Corn silage and corn fodder.

Trial II.—Alfalfa hay and timothy hay.

Trial III.—Corn silage and alfalfa hay versus corn fodder and timothy hay.

These tests give a comparison between the two pairs of roughages that are quite commonly used, altho clover hay could have been used in place of alfalfa; in addition, it compares what are supposed to be the best and poorest roughage rations for dairy cows in Iowa.

Each trial consisted of three periods of 30 days each but the first 10 days of each period was eliminated in determining the results as they constituted a transition period. There were five cows in each trial except Trial I, where only four cows were used. In table II there is given information concerning the cows and where necessary it is calculated to the day on which

TABLE I—LOSSES IN ENSILED AND FIELD CURED CORN FODDER
After Henry and Morrison (9)

Station	Corn Silage		Corn Fodder	
	Dry matter %	Crude protein %	Dry matter %	Crude protein %
Vermont, av. 4 yrs.	18.2	12.0	17.7	12.7
New Jersey, 1 yr.	18.0	----	17.3	----
Pennsylvania, 1 yr.	10.8	4.4	21.0	11.6
Wisconsin, av. 4 yrs.	15.6	16.8	23.8	24.3
Average at 4 stations	15.7	11.1	20.0	16.2

TABLE II—ANIMALS USED

Cow No.	Breed	Age (years, months, days)	Fresh days	Bred days	Previous lactations
Trial I. Corn silage vs. corn fodder					
161	Holstein	11- 6- 3	53	--	7
399	Grade Holstein	4- 2- 6	15	--	1
414	Holstein	3- 9- 6	361	--	0
477	Holstein	4- 5- 6	101	--	1
Trial II. Alfalfa hay vs. timothy hay					
249	Jersey	7- 9-28	143	--	4
290	Jersey	6-10-25	125	25	4
342	Jersey	5- 7-24	449	82	1
348	Grade Jersey	5- 6-15	111	--	2
398	Grade Jersey	4- 5-24	6	--	1
Trial III. Alfalfa hay and corn silage vs. timothy hay and corn fodder					
391	Grade Guernsey	4- 7-19	178	58	1
414	Holstein	3-11-11	469	--	0
454	Ayrshire	3- 0- 4	159	--	0
464	Grade Guernsey	2-11- 2	119	--	0
485	Grade Holstein	2- 4-28	19	--	0

the trials started. Trial I started on October 30, 1921, and the others on February 5, 1922.

In all the trials the roughages and grains were fed twice daily. The cows were watered morning and evening and were weighed before and after watering. The morning weights, after feeding hay and before watering, were used in determining the average live weights of the animals. They had access to salt at all times while in the barn and were allowed out for exercise daily when the weather conditions permitted. The cows were milked twice daily and the milk was weighed at each milking. A composite sample was kept for each cow, with corrosive sublimate as a preservative, and the samples were tested for butterfat by the Babcock method at the end of each 10-day period. An effort was made to keep each cow consuming a uniform amount of feed thruout each trial but this was not always possible.

Prices of some of the feeds that were used had to be fixed so that the value of other feeds could be determined. The prices used were the average current market prices during the time the trials lasted. The prices used have been tabulated for the feeds that were considered as the standard feeds, corn silage, alfalfa hay and the grains, and the values of the other feeds have been determined by comparison with these.

TABLE III—PRICE OF FEEDS

Feed	Price per ton
Alfalfa hay	$ 15.00
Corn silage	4.50
Cracked corn	14.29
Ground oats	18.75
Wheat bran	25.00
Linseed oil meal—O. P.	40.00

TRIAL I—CORN SILAGE VERSUS CORN FODDER

Thruout this experiment the cows were fed a grain ration consisting of cracked corn, ground oats, wheat bran and old process linseed oil meal in the proportions of 2:1:1:1, by weight. The amount of grain fed was governed by the individual production of the cows. Alfalfa hay was fed to each cow in all periods at the rate of six pounds per cow per day. The amounts of corn fodder and corn silage fed in their respective periods were determined by the capacity of the animals. The corn fodder was of good quality, well matured and well eared, and was fed long. The silage also was of good quality, made from the same variety of corn as the fodder and grown in the same field. The experimental roughages, consisting of the corn fodder and the corn silage, were sampled on the middle day of each twenty-day period in which they were being fed, and a moisture determination made for each sample.

The corn fodder was fed in the first and third periods and the corn silage in the second period. The average of the results obtained in the first and last periods were used as a basis with which to compare the results obtained when silage was fed.

The general results obtained on the feeding of corn fodder or corn silage to the cows in this experiment are summarized in table IV, where it is seen that on the silage ration the cows produced six percent more milk and three percent more butterfat than when fed corn fodder. This result, however, does not in itself form a true basis of comparison of the values of the two feeds for milk production; there are other factors which must be considered. The average live weight of the cows remained practically the same thruout the experiment, the slight increase of one percent during the silage period being of no significance. The slightly greater amounts of hay and grain consumed in Period II are also insignificant. So far as production is concerned, an increase of six per cent in milk and three percent in butterfat was obtained during the silage feeding period. It will be noticed, however, in table IV that the cows

TABLE IV—SUMMARY OF MILK AND BUTTERFAT PRODUCTION AND FEED CONSUMPTION IN TRIAL I

Period	Average live weight	Production		Feed consumed		
		Milk	Fat	Corn roughage	Alfalfa hay	Grain mixture
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
Corn fodder	1,123	2,273	72.3	1,785	468	771
Corn silage	1,137	2,399	74.1	2,745	478	780
Increase	14	126	1.8	960	10	9
Increase percent	1	6	2.5	54	2	1

TABLE V—WASTE OF CORN FODDER

Period	Offered			Refused			Consumed		Percentage loss	
	Fodder	Dry matter		Fodder	Dry matter		Fodder	Dry matter	Fodder	Dry matter
	lbs.	%	lbs.	lbs.	%	lbs.	lbs.	lbs.	%	%
I	2,212	77	1,703	207	70	146	2,005	1,557	9.4	8.6
III	1,758	82	1,440	192	73	139	1,566	1,301	10.9	9.7
Total	3,970	------	3,143	399	------	285	3,571	2,858	10.1	9.1

consumed a greater weight of silage than of fodder, the figures representing an average daily consumption per cow of 34 pounds of corn silage and 22 pounds of corn fodder.

In the feeding of corn fodder there was always a certain amount of waste or refused feed, consisting of the coarser stalks. This waste varied in amount with the individual cows, some apparently finding the coarser portions of the corn fodder less palatable than did others. The amount of corn fodder dry matter that was lost in this way was nine percent, while the loss in fodder was ten percent. This is an appreciable loss, especially when it is noted that the corn silage was fed without waste. In addition, this loss can not be attributed to overfeeding as the fodder ration was varied to suit the needs of each cow. In some cases where the stalks were being refused additional fodder had to be provided to satisfy the appetite of the cow for the portions of the fodder that she would eat.

As the moisture content of silage and fodder is widely different, it becomes apparent that a comparison of the values of the two feeds for milk production must be on a dry matter basis. The total dry matter in the corn fodder and corn silage consumed has been calculated and shown in table VI. In the silage period the cows consumed 35 percent or 504 pounds less corn dry matter than in the average of the fodder periods, while, as already noted, the production of milk and butterfat was increased during the silage feeding period. This would indicate that the dry matter of corn silage has a higher value for milk production than the dry matter of field cured corn fodder, in addition to there being a 10 percent loss in the fodder due to the material the animals refused.

TABLE VI—CORN DRY MATTER CONSUMED

Experimental roughage	Total consumed	Dry matter content	Dry matter consumed
	lbs.	%	lbs.
Corn fodder	1,785	80	1,429
Corn silage	2,745	34	925
Increase	960	—46	—504
Increase percent	54	—57	—35

The difference in value of corn fodder and corn silage is well expressed in terms of the relative values of equal weights of dry matter and of equal weights as fed. Giving corn silage a value of $4.50 per ton and using the costs for the other feeds as given in table III, the feed cost of production on the silage ration was found to be 77 cents per 100 pounds of milk or 25 cents per pound of butterfat. The relative value of corn fodder for production was found to be $5.61 per ton, if milk and butterfat were to be produced at the same cost as when silage was fed. At these values, 100 pounds of dry matter in corn silage and corn fodder is worth 66 cents and 35 cents respectively. However, when allowance is made for the 10 percent loss that occurred in the feeding of the fodder its value is only $5.05 per ton, and the value of all the dry matter in the fodder as fed would be reduced to 32½ cents per 100 pounds.

The value of the silage from one acre producing eight tons of silage would be $36.00, while the same crop made into fodder would have a corresponding yield of 3.4 tons, when the yields are calculated on the relative moisture contents found in this trial. The value of this corn fodder based on the amount fed would be $19.07, whereas its value on the basis of the amount consumed would be $17.17 or less than half the value of the silage. In addition, if the average losses in curing, given by Henry & Morrison (9), be taken into consideration it will be found that there is an additional loss of five percent in the dry matter of the fodder as compared with the silage and this would bring the value of the corn fodder to $16.21 per acre as compared with $36.00 per acre for silage for feeding dairy cows. In other words, an acre of corn if used in the form of fodder has a value of only 45 percent of what it would have if it were made into silage and used for feeding dairy cows.

TABLE VII—RELATIVE VALUES OF CORN SILAGE AND CORN FODDER

Basis of comparison	Corn silage	Corn fodder
On basis of what is fed:		
Value per ton	$4.50	$5.61
Dry matter per ton	680 lbs.	1,600 lbs.
Value of 100 lbs. dry matter	$0.66	$0.35
On basis of what is consumed:		
Value per ton	$4.50	$5.05
Value of 100 lbs. dry matter	$0.66	$0.32½
On basis of production:		
Value per acre	$36.00	$16.21

TRIAL II—ALFALFA HAY VERSUS TIMOTHY HAY

All of the feeds used in this trial were of the same origin as those used in Trial I except that the timothy hay was purchased, tho it had been grown at but a small distance from the other roughages. Both the alfalfa hay and the timothy hay were of good quality.

Thruout the trial corn silage and a grain mixture of cracked corn, ground oats and oil meal in the ratio of 4:4:1 by weight were fed. The alfalfa hay was fed in the first and third periods and the average of the results obtained was used as a check for the second period in which timothy hay was fed.

The method of dividing the periods and arranging other details has already been described. On the twentieth day of each 30-day period the moisture content of the hay was determined.

In the period when timothy hay was fed there were increases of one percent in the live weight of the animals and in the amount of silage consumed. But these are insignificant. There was a decrease of eight percent in the consumption of hay and decreases of seven percent in the production of milk and butterfat in the same period however. The dry matter content of the alfalfa was 86.6 percent and that of the timothy hay 88.0 percent. They have been calculated to a dry matter basis and then to a uniform moisture content of 10 per cent as shown in table IX.

The feed costs of production per 100 pounds of milk and per pound of fat were calculated from the prices for those standard feeds that have already been given and the amounts of the feeds consumed. From this it can be determined that the feed cost of production during the alfalfa period was 71 cents per 100 pounds of milk and 15 cents per pound of butterfat.

To find the value of the timothy hay the products were taken

TABLE VIII—SUMMARY OF MILK AND BUTTERFAT PRODUCTION AND FEED CONSUMPTION IN TRIAL II

Period	Average live weight	Production		Feed consumption		
		Milk	Fat	Hay	Corn silage	Grain
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
Alfalfa	891	1,865.9	94.70	566	2,325	720
Timothy	896	1,746.7	87.66	523	2,357	720
Increase	5	—119.2	—7.04	—43	32	----
Increase percent	1	—7	—7	—8	1	----

TABLE IX—HAY DRY MATTER CONSUMED

Hay	Total consumed	Dry matter content	Dry matter content	Consumption on 10% moisture basis
	lbs.	%	lbs.	lbs.
Alfalfa	566	86.6	490	544
Timothy	523	88.0	460	511
Increase	—43	1.4	—30	—33
Increase percent	—8	2	—6	—6

at the same cost per pound as in the check periods and from the total feed cost of production is taken the cost of all feeds but timothy. In this way there is left the value of the amount of timothy fed.

This gives a value for the dairy products of $12.40 and the cost of the feeds used, other than timothy, was $12.17. Consequently, the value of 23 cents must be set down for the 523 pounds of timothy fed. As 523 pounds of timothy hay were fed the value of it per ton is 86 cents. This shows what a poor feed timothy hay is for dairy cows. When alfalfa is charged at the relatively low cost of $15 per ton, timothy is worth 86 cents.

As a general rule timothy hay should be sold and alfalfa or clover hay bought to feed dairy cows.

TRIAL III—CORN SILAGE AND ALFALFA HAY VERSUS CORN FODDER AND TIMOTHY HAY

In this trial a basal grain ration of cracked corn, ground oats and linseed oil meal, in the proportions of 4:4:1 by weight, was fed thruout. Alfalfa hay and corn silage were used as the roughages in the first and third periods while corn fodder and timothy hay were used in the second period. The prices given earlier for corn silage, alfalfa hay and the grains were used in determining the feed cost of production and then taking the same cost for the production in the fodder and timothy hay period and subtracting from that the value of the grains fed, the combined value of the experimental roughages was obtained.

When corn fodder and timothy hay were fed there was a decrease of two percent in the live weight of the animals and decreases of 18 percent and 14 percent in milk and fat production, respectively. At the same time the hay consumed increased by one percent, a small change, and the weight of fodder consumed was 65 percent less than the amount of silage consumed on the average in the other periods.

TABLE X—SUMMARY OF MILK AND BUTTERFAT PRODUCTION AND FEED CONSUMPTION IN TRIAL III

Period	Average live weight	Production		Feed consumption		
		Milk	Fat	Corn roughage	Hay	Grain mixture
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
Silage and alfalfa	904	2,063.2	86.15	2,503	544	663
Fodder and timothy	882	1,697.3	73.55	853	549	663
Increase	—22	—365.9	—12.60	—1,650	5	----
Increase percent	—2	—18	—14	—65	1	----

The moisture contents of the roughages used were the same as in Trial II which was under way at the same time, so it is not necessary to discuss the dry matter content of the feeds. In calculating the feed cost of production for the silage and alfalfa periods it is found to be 80 cents per 100 pounds of milk and 19 cents per pound of butterfat. If the same costs be given to the products in the timothy hay and fodder period then the total cost of production is $12.58, and this is reduced to $6.74 when the cost of the grains is eliminated.

In other words, the 853 pounds of corn fodder and 549 pounds of timothy hay used have a total value of $6.74. From the two previous trials it was found that when timothy hay and corn fodder were compared individually with good roughages their values were 86 cents per ton for the timothy hay and $5.61 per ton for the corn fodder as fed, but only $5.05 per ton when the refuse is taken into consideration.

Figuring on this basis, the value of the timothy hay and allowing for the waste in feeding the value of the fodder would be $2.15 and the timothy hay 23 cents, or a total of $2.38 for these roughages.

It appears, therefore, that the two poor roughages, corn fodder and timothy hay, have a somewhat higher value when fed together than when either is fed with a good roughage. This is undoubtedly due to the fact that the animal has to obtain as great an amount of nutrients from them as possible or starve.

BIBLIOGRAPHY

1. Armsby, H. P.
1890. Comparison of Corn Silage and Corn Fodder for Milk Cows.
Ann. Rpt., Penn. Agr. Expt. Sta. 1890:187.

2. Cooke, W. W., and Hills, J. L.
1891. Corn Fodder versus Corn Silage for Milk Cows.
Ann. Rpt., Vt. Agr. Expt. Sta. 5:551.

3. Cooke, W. W., and Hills, J. L.
1892. Four Ways of Preserving Corn Fodder.
Ann. Rpt., Vt. Agr. Expt. Sta. 6:58.

4. Frasher, W. J., and Hayden, C. C.
1910. Alfalfa versus Timothy Hay for Cows.
Bul. Ill. Agr. Expt. Sta. 146.

5. Henry, W. A.
1882. The Relative Value of Dry Fodder Corn and Silage as Food for Milch Cows.
Wis. Agr. Expt. Sta. Rpt. on Experiments in Amber Cane and the Ensilage of Fodder. 2:78.

6. Henry, W. A.
1887. Corn Silage versus Fodder Corn for Milk and Butterfat Production.
Ann. Rpt., Wis. Agr. Expt. Sta. 4:25.

7. Henry, W. A.
1887. Cut versus Uncut Corn Fodder.
Ann. Rpt., Wis. Agr. Expt. Sta. 4:34.

8. Henry, W. A.
1888. Corn Ensilage versus Dry Fodder Corn for Producing Milk and Butter.
Ann. Rpt., Wis. Agr. Expt. Sta. 5:5.

9. Henry, W. A., Morrison, F. B.
1917. Feeds and Feeding.

10. Hills, J. L.
1889. Feeding Tests of Milch Cows.
Ann. Rpt., Vt. Agr. Expt. Sta. 3:50.

11. Shelton, E. M.
1889. Waste of Fodder in Feeding.
Ann. Rpt., Kan. Agr. Expt. Sta. 2:55.

12. Short, F. G.
1889. Ensilage versus Fodder Corn for Milk and Butter Production.
Ann. Rpt., Wis. Agr. Expt. Sta. 6:130.

13. Voorhees, E. B., and Lane, C. B.
1897. The Cost and Feeding Value of the Dry Matter of Dried Corn Fodder and Silage.
Bul. N. J. Agr. Expt. Sta. 122.

14. Woll, F. W.
1888. Silage versus Fodder Corn for Milk Production.
Ann. Rpt., Wis. Agr. Expt. Sta. 5:67.

15. Woll, F. W.
1889. Corn Silage versus Dry Fodder Corn for Milk and Butter Production.
Ann. Rpt., Wis. Agr. Expt. Sta. 6:365.

16. Woll, F. W.
1890. Corn Silage versus Corn Fodder for Milk and Butter Production.
Ann. Rpt., Wis. Agr. Expt. Sta. 7:187.

17. Woll, F. W.
1891. The Relative Value of Corn Silage and Field Cured Fodder Corn for Milk and Butter production.
Ann. Rpt., Wis. Agr. Expt. Sta. 8:49.

EXPERIMENT STATION OFFICERS AND STAFF

Raymond A. Pearson, M.S.A., LL.D., President
C. F. Curtiss, M.S.A., D.S., Director — W. S. Stevenson, A.B., B.S.A., Vice-Director

AGRICULTURAL ECONOMICS AND FARM MANAGEMENT

E. G. Nourse, A.B., Ph.D., Chief
C. L. Homes, A.B., Ph.D., Asst. Chief
C. C. Taylor, B.S., Asst.
C. L. Benner, A.M., Asst.
John Hopkins, Jr., A.M., Asst.
Knute Bjorka, M.S., Asst.
C. W. Crickman, B.S., Asst.
W. H. Youngman, B.S., Asst.
E. J. Working, M.S., Asst.
Frank Robotka, B.S., Asst.

AGRICULTURAL ENGINEERING

J. B. Davidson, B.S., M.E., A.E., Chief
W. A. Foster, B.S. in E., B.Arch., Asst. Chief
E. V. Collins, B.S. in A.E., B.S. in Agron., Asst. Chief
Verne W. Stambaugh, B.S. in A.E., Research Fellow

AGRONOMY

W. H. Stevenson, A.B., B.S.A., H.C.D., Chief
H. D. Hughes, B.S., M.S.A., Chief in Farm Crops
P. E. Brown, B.S., A.M., Ph.D., Chief in Soil Chemistry and Bacteriology
L. C. Burnett, B.S.A., M.S., Chief in Cereal Breeding
L. W. Forman, B.S.A., M.S., Chief in Field Experiments
J. L. Robinson, B.S., M.S., Superintendent of Cooperative Experiments
H. W. Johnson, B.S., M.S., Ph.D., Asst. Chief in Soil Chemistry
Paul Emerson, B.S., M.S., Ph.D., Asst. Chief in Soil Bacteriology
F. S. Wilkins, B.S., M.S., Asst. Chief in Farm Crops
T. H. Benton, B.S., M.S., Soil Surveyor
D. S. Gray, B.S., Soil Surveyor
C. L. Orrben, B.S., Soil Surveyor
A. M. O'Neal, Jr., B.S., Soil Surveyor
J. T. Auten, B.S., Soil Analyst
W. G. Baker, B.S., Field Experiments
P. E. Nordaker, B.S., Field Experiments
J. L. Boatman, B.S., Field Experiments

ANIMAL HUSBANDRY

H. H. Kildee, B.S.A., M.S., Chief
J. M. Evvard, B.S.A., M.S., Chief in Swine and Beef Cattle Production
Wray E. Hammond, B.S.A., M.S., Supt. of Experiments in Animal Husbandry
C. C. Culbertson, B.S. in A. H., Asst. Chief in Animal Husbandry
Q. W. Wallace, B.S., Assistant in Animal Husbandry
A. R. Lamb, M.S., Chief in Nutrition
A. B. Caine, M.S., Chief in Horse Investigations
P. S. Shearer, P.S., Chief in Animal Breeding
M. D. Helser, B.S.A., M.S., Chief in Meat Investigation
G. E. Weaver, M.S., Chief in Dairy Husbandry
James Waddell, B.S., M.S., Asst. Chief
Fordyce Ely, B.S., M.S., Asst. in Dairy Husbandry
H. A. Bittenbender, B.S.A., Chief in Poultry Husbandry
R. L. Cochran, B.S., Asst. Chief

BACTERIOLOGY

R. E. Buchanan, M.S., Ph.D., Chief, Associate in Dairy and Soil Bacteriology
Buford H. Butcher, B. S., Graduate Asst.

BOTANY AND PLANT PATHOLOGY

L. H. Pammel, B.Agr., M.S., Ph.D., Chief
Charlotte M. King, Asst. Chief
I. E. Melhus, B.S., Ph.D., Chief in Plant Pathology
L. W. Durrell, B.S., M.S., Asst. Chief in Plant Pathology
J. N. Martin, B.S., Ph.D., Asst.
A. L. Bakke, B.S., M.S., Ph.D., Asst.
Ray F. Crawford, B.S., Asst.
O. H. Elmer, B.S., Asst.
Karl F. Petsch, B.S., Field Asst.
F. P. Sipe, B.S., Fellow

CHEMISTRY

W. G. Gaessler, B.S., M.S., Acting Chief
A. R. Lamb, B.S., M.S., Asst.
Edith Wilson, Asst.
J. A. Schullz, B.S., Asst.

DAIRYING

M. Mortenson, B.S.A., Chief
B. W. Hammer, Ph.D., Chief in Dairy Bacteriology
F. F. Sherwood, M.S., Asst. Chief
Merle P. Baker, B.S., Asst. in Dairying

ENTOMOLOGY

Carl J. Drake, B.Sc., B.Ped., M.A., Ph.D., Chief in Entomology
F. A. Fenton, B.A., M.S., Ph.D., Asst. Chief in Entomology
Albert Hartzell, B.S., M.S., Asst.
Wallace Park, B.S., Asst. Chief in Apiculture
Wallace Colman, A.B., M.S., Asst.

HORTICULTURE AND FORESTRY

_____, Chief
T. J. Maney, B.S., Chief in Pomology
Harvey L. Lantz, B.S., Asst. Chief
H. H. Plagge, B.S., Asst. in Pomology
A. T. Erwin, M.S., Chief in Truck Crops
W. C. Calvert, B.S., Asst. in Truck Crops
E. A. Piester, B.S., Acting Chief in Landscape Architecture
G. B. MacDonald, B.S.F., M.F., Chief in Forestry

RURAL SOCIOLOGY

G. H. Von Tungeln, Ph.B., M.A., Chief
H. G. Loomer, B.A., Asst.
W. W. Weaver, B.S., Asst.

BULLETIN SECTION

F. W. Beckman, Ph.B., Bulletin Editor
Olive Sandford Alcox, Asst. Bulletin Editor

PHOTOGRAPHIC SECTION

E. H. Richardson, Photographer