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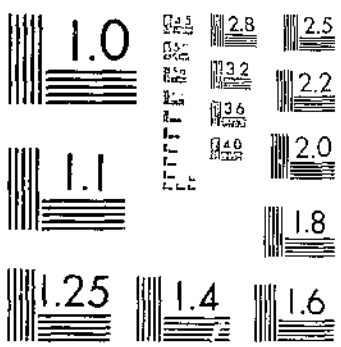

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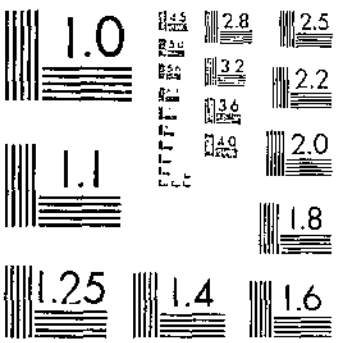

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FEEDING VALUE FOR MILK PRODUCTION OF PASTURE GRASSES WHEN GRAZED, WHEN FED GREEN AND WHEN FED AS HAY OR SILAGE

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INTRODUCTION

Pasture grass at its best has long been considered the best ration for the dairy cow. In some sections of the world where the climate is such that pasture grasses thrive especially well, the dairy cow obtains almost all of her ration in the form of grass. In the Netherlands and New Zealand especially, the winter roughage for the dairy cow may consist entirely of hay made from pasture grasses, silage made from pasture grasses, or both hay and silage.

Recent experiments have reestablished the fact that the nutritive composition of grasses may vary widely according to their stage of maturity. Immature pasture grass is a highly digestible and nutritious animal food.

There would be many advantages to the livestock man in keeping a larger area of his farming land in permanent grasses and legumes. Saving the labor of cultivation in the production of annual crops, preserving soil fertility, and lessening soil erosion, are some of the important advantages.

In most regions of the United States pasture grasses do not grow at a uniform rate through the growing season. Usually the most rapid rate of growth is during the spring. During this period most farms have more grass than can be consumed by the livestock, and a considerable amount of the grass matures. It is essential: (1) To

[1] The writers are indebted to Dan Hansen, associate agronomist, Bureau of Plant Industry, and superintendent of the Huntley (Mont.) field station, for his assistance in carrying on the experimental work, and to Charles B. Parker, junior chemist, Bureau of Dairy Industry, who did the analytical work.

know whether the changes in chemical composition of grass at the various stages of growth are reflected in the rate of consumption and yield of milk by the dairy cow; (2) to know how best to preserve the surplus growth of grass when at its best stage of growth, to be fed at other seasons; and (3) to obtain some indication as to what extent the high-producing cow can be expected to obtain the nutrients she needs for maintenance and production, from grass and from grass hay or grass silage.

To obtain such information an experiment was started at the United States Experiment Station at Huntley, Mont., in 1928. The experiment was planned to secure the yields and feeding value for dairy cows of pasture grasses when pastured and when cut at different stages of maturity and fed as fresh green grass, as cured hay, and

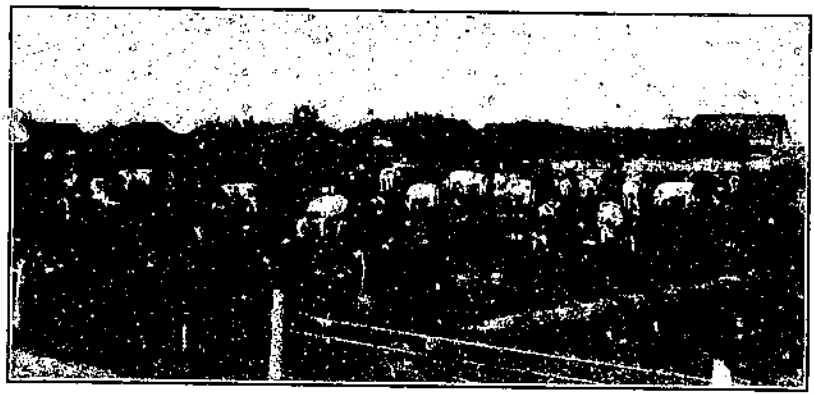

FIGURE 1.—Cows on irrigated pasture at Huntley field station, with buildings in background.

as silage. This bulletin gives the results of 2 years' work on this problem.

The 4½-acre plot used in this test was a part of a field that had been seeded to alfalfa in 1919, and used as an alfalfa hog pasture from 1921 to 1924. It had been plowed and seeded to corn in 1925. In the spring of 1926, it was seeded at the rate of 20 pounds per acre to the following pasture-grass and legume mixture, now known as the Huntley mixture: Awnless bromegrass, 2 pounds; orchard grass, 5 pounds; meadow fescue, 3 pounds; perennial ryegrass, 3 pounds; Kentucky bluegrass, 4 pounds; white clover, 2 pounds; and alsike clover, 2 pounds.

No manure or fertilizer other than the droppings of the grazing animals has been applied to this pasture or had ever been applied to the soil before it was sown to pasture.

THE 1928 EXPERIMENTAL WORK

In 1928 two plots containing 0.92 acre each were reserved for grazing (fig. 1) and clipping. The remainder of the pasture, 2.66 acres, was used for the production of hay and silage.

The results of the experiment in 1928 are given in table 1.

TABLE 1.—*Comparative yields and feeding value of pasture grasses when grazed, when clipped and fed green, and when fed as hay and as silage, 1928*

Items of comparison	Yield and feeding value of grass—			
	When grazed	When clipped and fed green	When fed as hay	When fed as silage [1]
Average daily number of cows per acre—number	1.84	2.60		
Duration of grazing or feeding trial—days	99	99	37	11
Total cow-days per acre—number	182	261	228	263
Average body weight of cows per season—pounds	1,399	1,258	1,332	1,320
Loss in body weight per acre—do	314	238	101	
Production per acre:				
Milk—do	4,575	4,041	5,195	7,994
Butterfat—do	177.4	171.1	180.9	309.2
Yield of roughage per acre—do		[2] 21,639	[3] 7,481	[4] 22,130
Yield of dry matter per acre—do		5,669	6,501	5,576
Average consumption of feed per cow per day—do		75.6	32.8	83.9
Average consumption of dry matter per cow per day—do		19.8	27.3	21.2

[1] See text, page 6.
[2] 73.8 percent moisture, green weight.
[3] 13.1 percent moisture, air-dry weight.
[4] Green weight.

GRAZING EXPERIMENT

The plot used for grazing was divided into two parts, to permit alternate grazing and irrigation. Milking Holstein-Friesian cows were kept on the pasture day and night, the pasture grass being their only feed. Three cows were placed on the pasture May 19 and during the season others were added or removed, according to the rate of growth of the grasses. The pasture season ended August 25, having extended over a period of 99 days.

GRASS CLIPPED AND FED GREEN

The clipped plot was also divided into two parts, to permit alternate irrigating and clipping. It was planned, in order to make the clipping as nearly like grazing as possible, to clip each day a sufficient area so that all of each part would be clipped about every 10 days. Actually, however, the intervals differed greatly.

The clipping was done once each day, as soon as the dew was off, with a 1-horse mower having a homemade metal grass catcher attached to the sickle bar.

Cows similar in breeding and age to those used in the grazing experiment were kept in a barn and dry lot and were fed the clipped grass in mangers, with no other feed. The grass was fed in the morning and evening. The portion of the morning's clipping that was not fed was placed in a dark place in the barn and covered with canvas to prevent undue wilting or loss of moisture.

While the areas clipped differed somewhat each day, the total amounts of grass clipped by 7-day periods indicate the seasonal growth of the pasture grasses. These totals are:

7-day period:	Pounds	7-day period:	Pounds
May 19–25	978	July 7–13	1,931
May 26–June 1	1,403	July 14–20	1,527
June 2–8	1,770	July 21–27	1,218
June 9–15	1,976	July 28–Aug. 3	1,387
June 16–22	1,622	Aug. 4–10	1,181
June 23–29	1,691	Aug. 11–17	696
June 30–July 6	1,826	Aug. 18–24	653

It is apparent that in 1928 pasture grasses were not making a very rapid growth at Huntley till the end of May. Growth was rapid in the first part of June and in the first part of July. Except during the week of June 9 to 15, the 2-week period, June 30 to July 13, seems to have been the period of most rapid growth. The growth decreased very rapidly during August. It is presumed that at all times sufficient moisture was present to provide maximum growth, since the plots were irrigated.

The average mean, maximum, and minimum temperatures at the Huntley station during the 1928 pasture season are given by 5-day periods in table 2.

TABLE 2.—*Average mean, maximum, and minimum temperatures by 5-day periods during the grazing season at Huntley, Mont., 1928*

5-day period	Average temperature			5-day period	Average temperature		
	Mean	Maximum	Minimum		Mean	Maximum	Minimum
	°F.	°F.	°F.		°F.	°F.	°F.
June 1–5	60	73	47	Aug. 1–5	65	79	51
June 6–10	56	73	39	Aug. 6–10	75	95	54
June 11–15	61	73	48	Aug. 11–15	70	89	51
June 16–20	55	64	46	Aug. 16–20	68	87	49
June 21–25	61	74	48	Aug. 21–25	61	78	44
June 26–30	66	81	52	Aug. 26–31 [1]	58	71	46
July 1–5	66	80	53	Sept. 1–5	63	82	43
July 6–10	66	79	52	Sept. 6–10	55	71	30
July 11–15	75	91	60	Sept. 11–15	60	78	43
July 16–20	64	77	52	Sept. 16–20	58	76	40
July 21–25	74	93	56	Sept. 21–25	52	69	35
July 26–31 [1]	73	90	55	Sept. 26–30	54	71	36

[1] 6-day period.

The temperature ranges from August 16 to September 20 are not greatly different from those during most of June when the grass made its most rapid growth. But by August 25 the rate of growth had dropped to a point at which not enough grass was obtained to warrant further clipping.

Table 3 shows the average daily consumption of clipped grass, by 7-day periods, by individual cows. These periods started May 19 and ended August 25.

Cow 13 was fed this clipped grass continuously for 82 days. Her average daily consumption increased from 49.3 pounds during the first week to 105.6 pounds during the eighth week. Cow 52 started on clipped grass on June 15. Her consumption the first week was at the rate of 64.5 pounds per day, but gradually increased until her maximum daily consumption averaged 99 pounds during her eighth week. She was fed the green grass for 72 consecutive days. Cow 59 was fed for 49 consecutive days and cow 46 and cow 48 were fed for 30 and 31 days, respectively.

These amounts do not represent all that the cows would have eaten, however, as will be shown later in discussing the 1929 results. It was thought that the amount of grass obtained by clipping every 10 to 15 days would approach fairly closely the amount of grass

TABLE 3.—*Amount of grass clipped each day from a portion of the 0.92-acre clipped plot, and daily consumption per cow, 1928*

Week and date of clipping	Weight of clipped grass	Grass consumed by cow no.—				
		13	46	48	59	52
First week:	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
May 19	88	34	13	28	.....	.....
May 20	86	32	24	30	.....	.....
May 21	121	45	29	47	.....	.....
May 22	139	55	49	55	.....	.....
May 23	165	60	44	48	.....	.....
May 24	173	59	49	61	.....	.....
May 25	156	60	40	51	.....	.....
Second week:						
May 26	164	57	38	55	.....	.....
May 27	181	63	50	60	.....	.....
May 28	213	73	60	65	.....	.....
May 29	225	62	54	62	34	.....
May 30	207	48	49	61	39	.....
May 31	231	55	62	69	45	.....
June 1	182	40	48	51	43	.....
Third week:						
June 2	224	48	60	60	45	.....
June 3	267	61	62	70	66	.....
June 4	259	74	69	67	59	.....
June 5	258	72	63	67	56	.....
June 6	231	58	67	60	55	.....
June 7	275	82	69	68	56	.....
June 8	256	71	61	66	58	.....
Fourth week:						
June 9	233	68	55	56	54	.....
June 10	273	80	68	64	63	.....
June 11	294	100	64	71	58	.....
June 12	306	88	72	75	69	.....
June 13	282	85	72	66	58	.....
June 14	288	70	74	78	62	.....
June 15	300	73	61	60	65	60
Fifth week:						
June 16	347	81	66	73	66	61
June 17	307	76	59	66	56	50
June 18	295	85	.....	75	64	71
June 19 [1]	.....	.....	.....	.....	.....	.....
June 20	211	84	.....	.....	64	63
June 21	240	103	.....	.....	65	72
June 22	222	83	.....	.....	69	70
Sixth week:						
June 23	201	83	.....	.....	58	60
June 24	223	84	.....	.....	70	69
June 25	246	95	.....	.....	75	76
June 26	256	100	.....	.....	80	72
June 27	276	110	.....	.....	82	78
June 28	253	108	.....	.....	77	73
June 29	232	99	.....	.....	67	65
Seventh week:						
June 30	252	102	.....	.....	70	75
July 1	287	114	.....	.....	82	88
July 2	280	120	.....	.....	81	76
July 3	244	98	.....	.....	70	74
July 4	237	96	.....	.....	67	73
July 5	230	93	.....	.....	60	72
July 6	276	105	.....	.....	79	82
Eighth week:						
July 7	366	122	.....	.....	107	117
July 8	233	90	.....	.....	73	69
July 9	276	116	.....	.....	77	79
July 10	310	111	.....	.....	90	97
July 11	282	113	.....	.....	82	82
July 12	262	102	.....	.....	78	77
July 13	208	85	.....	.....	63	63
Ninth week:						
July 14	256	103	.....	.....	73	75
July 15	253	106	.....	.....	71	74
July 16	287	109	.....	.....	83	85
July 17	190	104	.....	.....	.....	88
July 18	180	104	.....	.....	.....	74
July 19	161	97	.....	.....	.....	64
July 20	200	112	.....	.....	.....	84
Tenth week:						
July 21	148	90	.....	.....	.....	58
July 22	140	87	.....	.....	.....	53
July 23	158	94	.....	.....	.....	61
July 24	183	104	.....	.....	.....	79
July 25	198	105	.....	.....	.....	93
July 26	180	98	.....	.....	.....	82
July 27	211	116	.....	.....	.....	95
Eleventh week:						
July 28	217	111	.....	.....	.....	106
July 29	193	91	.....	.....	.....	102
July 30	189	90	.....	.....	.....	93
July 31	214	102	.....	.....	.....	112
Aug. 1	189	99	.....	.....	.....	90
Aug. 2	213	104	.....	.....	.....	106
Aug. 3	172	91	.....	.....	.....	81
Twelfth week:						
Aug. 4	191	102	.....	.....	.....	87
Aug. 5	230	111	.....	.....	.....	116
Aug. 6	204	102	.....	.....	.....	100
Aug. 7	162	83	.....	.....	.....	79
Aug. 8	158	85	.....	.....	.....	73
Aug. 9	123	.....	.....	.....	.....	120
Aug. 10	113	.....	.....	.....	.....	118
Thirteenth week:						
Aug. 11	99	.....	.....	.....	.....	99
Aug. 12	101	.....	.....	.....	.....	97
Aug. 13	98	.....	.....	.....	.....	98
Aug. 14	92	.....	.....	.....	.....	88
Aug. 15	89	.....	.....	.....	.....	89
Aug. 16	116	.....	.....	.....	.....	112
Aug. 17	101	.....	.....	.....	.....	101
Fourteenth week:						
Aug. 18	100	.....	.....	.....	.....	97
Aug. 19	90	.....	.....	.....	.....	90
Aug. 20	115	.....	.....	.....	.....	115
Aug. 21	117	.....	.....	.....	.....	117
Aug. 22	85	.....	.....	.....	.....	85
Aug. 23	81	.....	.....	.....	.....	81
Aug. 24	65	.....	.....	.....	.....	65
Fifteenth week:						
Aug. 25	69	.....	.....	.....	.....	69

[1] Rain prevented clipping grass on this date. Cows were fed alfalfa hay.

available on the plot where cows were allowed to graze. An attempt was made to feed this amount of grass to the same number of cows as were being grazed on an area of the same size. Probably no one

of the cows consumed as much as her maximum capacity after becoming thoroughly adjusted to the clipped-grass ration. This is shown by the 1929 results when the method of feeding was changed to give the cows all the grass they would consume.

The moisture content of the clipped grass averaged 73.8 percent and underwent but little fluctuation. The crude-protein content of composite samples made up of portions of daily clippings was very uniform and ranged between 11.5 and 12.2 percent (dry-matter basis).

On an acre basis this plot produced feed for 261 cow-days or at the rate of 2.6 cows for 99 days. In that time the computed production was 4,041 pounds of milk containing 171.1 pounds of butterfat per acre. These cows lost weight during the season at the rate of 238 pounds per acre. (See table 1.)

GRASS-HAY AND SILAGE EXPERIMENTS

FEEDING VALUE OF GRASS HAY

The plot reserved for hay production was mowed on July 11, and again on September 15. The first cutting represented 53 days' growth, measured from May 19, the date the cows were turned on the grazed plot, but it probably represented at least 72 days' actual growth, while the second cutting represented 66 days' actual growth. The two cuttings yielded at the rate of 7,481 pounds of air-dry grass hay per acre. (See table 1.)

Five cows that were fed this hay as their sole ration consumed an average of 32.8 pounds per day per cow over a feeding period of 37 days. These cows had been accustomed to a ration of alfalfa hay, corn silage, and grain. At first the cows did not take readily to the hay and declined rapidly both in body weight and in milk production, but as they became accustomed to the dry feed, they gradually regained most of the lost weight and maintained their production.

At the rate the cows consumed this hay, 1 acre produced sufficient hay to feed one cow for a period of 228 days. The computed production for this length of time would be 5,195 pounds of milk containing 180.9 pounds of butterfat. The decline in production of these five cows is 18.6 percent when measured by comparing the average production for the first 3 days of the 37-day period with that of the last 3 days. If, however, the first 2 days are not considered and the average production for the third, fourth, and fifth days is compared with that of the last 3 days, there is an average increase in production of 1 percent.

FEEDING VALUE OF GRASS SILAGE

The plot used for production of silage was cut at the same time as that used for producing hay. This plot produced at the rate of 22,130 pounds of green uncured grass per acre. The moisture content and chemical analyses of the green grass ensiled were not obtained.

The green grass was placed in a small wooden-stave silo. The first cutting was placed in the silo on July 11 and the second was put on top of the first on September 25. The grass from the first cutting was allowed to wilt before it was run through a silage cutter and placed in the silo; the second cutting was put in the silo immediately following mowing. Water was added to the first cutting.

In October the silo was opened and six milking cows were fed the second-cutting silage as their sole ration. The second-cutting silage lasted 11 days. When the first-cutting silage was reached the cows would not eat it. The silage had not spoiled but it did not appear to have developed the proper fermentation. The only reasons that can be ascribed for its poor quality are that it was allowed to become too mature and dry, and that too much water was added.

During the 11 days on the second-cutting silage the six cows consumed an average of 83.9 pounds of silage per cow per day. (See table 1.) The cows apparently relished this silage and for each cow the consumption increased materially up to the time the silage gave out. The average consumption of grass silage per cow a day was only 61 pounds at the start and increased to 95 pounds at the end of the 11 days. During the last 5 days the average consumption was over 90 pounds per day. The average production of milk was 32.5 pounds on the first day, dropped to 28.9 pounds on the ninth day, when it was the lowest during the experiment, but rose again to 30.2 pounds on the eleventh day. Comparing the average production on the first 3 days with that on the last 3 days, the decline was 4.9 percent for the 11-day period. This decline does not seem great, especially when the production (an average of 30 pounds of milk and 1.17 pounds of butterfat per cow per day), the relatively low consumption of dry matter (averaging a little over 21 pounds per day), and an excessive loss in body weight, are considered.

Loss in body weight was calculated from only two weights, one at the beginning and one at the close of the 11-day feeding period, and was subject to error due to difference in fill and other factors. The six cows lost 8, 97, 103, 120, 57, and 90 pounds, respectively, an average of 79 pounds per cow, or more than 7 pounds per cow per day. It would appear that the limited number of weights has resulted in an error that overemphasizes the loss in body weight.

THE 1929 EXPERIMENTAL WORK

In 1929 the investigation followed the same general plan as in 1928, and was conducted on the same plots. The principal change was in feeding the cows on the clipped grass to capacity and in the stages of maturity at which the cuttings were made.

Plot no. 1 was grazed by milking Holstein cows.

Plot no. 2 was clipped and the grass was fed green to milking Holstein cows. The number of days' growth varied, but averaged 30 for the season.

Plot no. 3 was cut at intervals of 45, 48, and 43 days and the grass was made into hay and silage, which was later fed.

Plot no. 4 was allowed to mature and was made into hay and silage, which was later fed.

Comparisons are therefore available on the grazed grass; on green grass cut at an average of 30 days' growth; on hay and silage, representing 45, 48, and 43 days' growth of grass; and on mature hay and mature silage made from two cuttings of grass, representing approximately 80 and 56 days' growth, respectively.

Samples of all cuttings were analyzed for dry matter, crude protein, fat, crude fiber, nitrogen-free extract, and ash.

The 1929 season as a whole was unfavorable for pasture growth, the first of the season being cold and the growth of the grass very slow. July and August were extremely warm.

GRAZING EXPERIMENT

The pasture season started May 30 and ended September 15, a grazing period of 109 days. No other feeds were fed to the cows while they were on grass. Two cows were started on the grazed plot, but on July 12 it was necessary to remove one because the grass was insufficient. The other cow grazed through July 28. It was not necessary to add other cows, as the season was slow and backward. During the latter part of the season the grass became bunchy. However, when the pasture became short, the bunches were eaten. Although the season was longer than that of 1928, the pasture carried only 1.46 cows per acre as compared to 1.84 in 1928.

The total production of the cows, on an acre basis, was 5,509 pounds of milk containing 205.2 pounds of butterfat. This is a little greater than the production of the previous year. Body weight was lost at the rate of 196 pounds per acre.

A summary of the data from the grazing experiment in 1929 is given in table 4. Daily milk yields for the three cows during the periods they were on pasture, together with the percentages of butterfat and the body weights, are given in table 5.

Cow H-53 was in the two hundred and seventy-eighth day of her lactation period and in the sixth month of her pregnancy at the time her grazing period started, so it is not surprising that she showed a very rapid decline in milk production. The decline in milk yield of 55 percent in 25 days, which was hastened to some extent by an injury to her foot on the eighteenth day, can hardly be charged against the pasture, which was at its best during this period. Ordinarily, a decline in weight during the sixth month of pregnancy would not be expected.

TABLE 4.—*Production by cows on grazed plot and the amount of grass needed to meet their daily nutrient requirements, 1929*

Items of comparison		Cow H-53	Cow H-19	Cow H-37 [2]
Stage of lactation	days	278	150	82
Duration of grazing period	do	25	18	62
Average daily body weight	pounds	1,381	1,403	1,220
Loss in body weight	do	54	96	47
Average daily milk production	do	23.9	38.4	42.5
Decline in production over grazing period:				
Milk	do	[1] 17.5	3.3	15.6
Do	percent	55.4	8.2	30.6
Average percentage of butterfat in milk	do	4.9	3.4	3.6
Total digestible nutrients required per day	pounds	20.50	23.10	23.48
Grass needed daily to furnish digestible nutrient requirements [3]	do	121	136	138

[1] The data are for the 92-day period, May 30 to Aug. 29.
[2] Cow H-53 injured a foot on June 16 and this handicapped her grazing.
[3] It is assumed that grazed grass contained the same percentage of digestible nutrients as clipped grass.

TABLE 5.—*The daily yield of milk, the percentage of butterfat in the milk and the body weights of cows on grazed plot, 1929*

Date	Cow H-53 [1]			Cow H-19			Cow H-37			Date	Cow H-37		
	Milk production	Body weight	Butterfat test	Milk production	Body weight	Butterfat test	Milk production	Body weight	Butterfat test		Milk production	Body weight	Butterfat test
	Lbs.	*Lbs.*	*Pct.*	*Lbs.*	*Lbs.*	*Pct.*	*Lbs.*	*Lbs.*	*Pct.*		*Lbs.*	*Lbs.*	*Pct.*
May 30	31.1	[2] 1,408					48.2	[2] 1,235		July 18	41.7		
31	33.3						52.7			19	41.8		
June 1	30.5						52.0			20	43.8		
2	30.5						53.2			21	38.0		
3	32.0						53.6			22	42.7		
4	30.0						52.5			23	40.0		
5	30.5	1,372	4.2				51.6	1,210	3.8	24	43.0	1,232	3.2
6	28.7						53.6			25	41.2		
7	28.7						53.3			26	39.9		
8	28.6						53.1			27	39.6	[2] 1,217	
9	27.4						52.0			28	37.5		3.2
10	26.7						51.8			July 29 to Aug. 3 [3]			
11	23.8						51.6						
12	23.1	1,380	4.4				48.6	1,232	3.5	4	39.2	[2] 1,225	
13	22.5						49.6			5	37.2		
14	22.5						50.0			6	38.9		
15	21.5						41.4			7	38.3	1,220	3.7
16	17.6						45.0			8	38.7		
17	15.1						46.6			9	37.4		
18	16.9		5.5				47.3			10	37.8		
19	16.8	1,333					48.2	1,214		11	36.6		
20	16.6						46.8		3.7	12	37.0		
21	15.6						46.0			13	39.5		
22	14.4						46.3			14	41.1	1,200	3.5
23	12.3		5.5				45.7			15	39.2		
24		[2] 1,354		42.7	[2] 1,456		47.8			16	38.2		
25				40.5			45.4			17	39.9		
26				37.5	1,406	3.3	44.1	1,224	3.9	18	37.8		
27				36.2			44.0			19	37.8		
28				37.8			45.4			20	32.8		
29				39.7			45.4		3.9	21	35.1	1,212	3.3
30										22	31.6		
July 1				41.1			46.7			23	32.0		
2				41.5			47.3			24	31.5		
3				39.9	1,392	3.2	46.7	1,226	3.7	25	31.2		
4				37.8			42.7			26	37.8		
5				38.5			43.2			27	34.2		
6				41.1			43.4			28	34.5	[2] 1,188	
7				38.0			39.7			29	37.4		3.7
8				29.3			40.3			Aug. 30 to Sept. 8 [3]			
9				39.6			40.4						
10				30.1			39.4	1,210	3.6				
11				35.1		3.7	37.2						
12					[2] 1,360		37.7			9	26.6	[2] 1,253	
13							36.8			10	28.3		
14							35.4			11	30.2		
15							38.7			12	30.4		
16							38.5			13	30.9		
17							42.1	1,180	3.4	14	29.7		
										15	33.4	[2] 1,205	3.5

[1] Injured a foot on June 16, handicapping her grazing and reducing her milk production.
[2] Average of three weights.
[3] Grazing on other pasture.

Cow H-19 took the place of cow H-53 in the experiment. She was on the pasture only 18 days before the grass became too short to support two cows, and she was removed. She was in the fifth month of her lactation period when she was started in the experiment. Comparison of the yields of the first 3 days with those of the last 3

days of this 18-day period shows a decline in yield of 8.2 percent. This is a more rapid decline, perhaps, than would be expected under the best feeding conditions. During this period the first hot weather of the season occurred. (See table 7.) During this same 18-day period cow H-37, who was only in the fourth month of her lactation period, declined almost 15 percent in milk yield. To meet her nutritive requirements for milk yield and maintenance, cow H-19 would have needed to consume 136 pounds of grass per day. Her rapid loss in weight would appear to indicate that she did not consume sufficient grass to provide for her nutritive requirements.

Cow H-37, in the eighty second day of her lactation, when grazing started, grazed for 109 days. There were two short periods, however, July 29 to August 3, inclusive, and August 30 to September 8, inclusive, when she was not on the experimental plot. (See table 5.) During these short periods she was grazing on other pasture and was fed nothing but pasture grass. As a basis for comparison the 92-day period from May 30 to August 29, inclusive, is selected as being most indicative. During 85 days of this 92-day period she produced an average of 42.5 pounds of milk per day, and lost 47 pounds in body weight during the 92 days.

At the start of the grazing season she was probably producing somewhat more than she could be expected to maintain on pasture alone unless the grazing were unusually good. However, at the end of the first 30 days on pasture her production had declined only about 12.7 percent (measured by comparing her average production for the first 3 days with that for the last 3 days). During that time she lost 11 pounds in weight. Considering that this was her fourth month in lactation and that she was getting no other feed than pasture, this decline was not excessive. The pasture during this time was at its best. During the period July 1 to 28, she declined 16.8 percent in milk flow and 7 pounds in body weight. The other pasture on which she then grazed for 6 days was evidently better than the experimental pasture, for she maintained production and gained 18 pounds in weight. This brought her back to the weight at which she started the grazing season on May 30. During the next 26 days on the experimental pasture (August 4 to 29) a season when the growth of pasture grasses is usually slowing up at Huntley, she lost weight rapidly, a total of 47 pounds. Until the latter part of this period she maintained production, her decline for the period being 7.9 percent.

GRASS CLIPPED AND FED GREEN

YIELD OF GREEN GRASS FROM CLIPPED PLOT

In 1929 the area used for clipping was divided into two plots (A and B) to permit alternate clipping and irrigating. Plot A contained 0.478 acre and plot B contained 0.493 acre. Each plot was 336 feet in length. Each day a swath of different width, extending the entire length of the plot, was clipped. Each plot was clipped fou times during the season. Table 6 shows the yield of each plot at each cutting, the average number of days' growth for each cutting, and the average amount clipped daily.

TABLE 6.—*Seasonal yields of clipped plot, and yields of each cutting, 1929*

Plot [1]	Cutting	Yield	Duration of clipping period	Days clipped	Average daily clipping	Average days' growth
		Pounds		*Number*	*Pounds*	*Number*
A	First	3,152	May 30–June 7	9	350	[2] 34
B	do	5,882	June 8–24	17	348	[2] 47
A	Second	2,581	June 25–July 9	15	172	30
B	do	2,315	July 10–24	15	154	32
A	Third	1,023	July 25–31	7	146	25
B	do	1,084	Aug. 12–18	7	155	30
A	Fourth	827	Aug. 19–23	5	165	25
B	do	999	Sept. 9–14	6	167	28

[1] The combined area of plots A and B was 0.971 acre. Total yield of green grass on the two plots was 17,863 pounds, or 18,340 pounds per acre.
[2] It is assumed that growth started May 1. There may have been a few days' variation from this.

The decided drop in yield for the second cutting as compared to the first for both plots is partly explained by the fact that the growing period between the first and the second cutting was shorter than the growing period before the first cutting. Assuming that growth previous to the first cutting started May 1, the first day's clipping on plot A represented 30 days' growth; the second day's clipping, 31; the third, 32; the fourth, 33; etc., while the ninth or last day's clipping represented 38 days' growth. Therefore the average number of days of growth for the 9 clippings was 34 days. In the same manner, the number of days of growth for the first cutting on plot B (assuming that growth started May 1) ranged from 39 to 55 days or an average of 47. In fact, this grass was approaching maturity. Another probable reason for the decreased rate of growth is the higher temperatures that prevailed, beginning in the 5-day period of June 26–30. Another reason is the slowing down in growth of perennial grasses after flowering. Table 7 shows the range of temperatures at the Huntley station, by 5-day periods, during the 1929 season.

TABLE 7.—*Average mean, maximum, and minimum temperatures by 5-day periods during grazing season at Huntley, Mont., 1929*

5-day period	Average temperature			5-day period	Average temperature		
	Mean	Maximum	Minimum		Mean	Maximum	Minimum
	°F.	°F.	°F.		°F.	°F.	°F.
June 1–5	55	70	41	Aug. 1–5	73	89	57
June 6–10	65	83	47	Aug. 6–10	70	88	52
June 11–15	64	81	47	Aug. 11–15	73	93	53
June 16–20	50	71	46	Aug. 16–20	71	91	51
June 21–25	66	75	56	Aug. 21–25	72	90	53
June 26–30	70	90	51	Aug. 26–31 [1]	77	95	60
July 1–5	71	88	53	Sept. 1–5	56	69	42
July 6–10	66	79	53	Sept. 6–10	48	63	34
July 11–15	73	89	58	Sept. 11–15	61	77	45
July 16–20	77	96	58	Sept. 16–20	60	79	41
July 21–25	77	96	58	Sept. 21–25	52	61	42
July 26–31 [1]	72	91	51	Sept. 26–30	45	53	37

[1] 6-day period.

The total yields of clipped grass by cuttings show that seasonal growth was much greater in June and early July, than in August and September. After the high maximum temperatures occurring from

July 16 to 31, growth was insufficient to permit clipping from August 1 to 12. Between the fourth cutting on plot A and the fourth cutting on plot B there was another intermission in the cutting. This intermission from August 23 to September 9 also followed a period of high maximum temperatures that prevailed from August 11 to 31.

The 1929 growing season was slower in starting than that of 1928. Clipping was started on May 19 in 1928 and on May 30 in 1929, a difference of 11 days. Clipping ended on August 25 in 1928 and on September 14 in 1929. The growth was not so uniform in 1929 as in 1928, and the total yield, 18,340 pounds per acre, was less.

COMPOSITION OF CLIPPED GRASS

Table 8 shows a marked difference in the nutrient content of the grass samples taken from the various cuttings as the growing season advanced.

TABLE 8.—*Average composition (dry-matter basis) of the grass cut at different periods of the 1929 growing season*

Plot	Cutting	Duration of clipping period	Samples analyzed	Average days of growth	Crude protein	Fat	Crude fiber	Nitrogen-free extract	Ash
			Number	*Number*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
A	First	May 30–June 7	9	[1] 34	15.8	3.5	23	47	9.7
B	do	June 8–24	17	[1] 47	13.1	3.1	30	44	10.1
A	Second	June 25–July 9	15	30	16.7	3.4	25	43	11.7
B	do	July 10–24	15	32	16.4	3.8	27	41	12.0
A	Third	July 25–31	7	25	18.7	4.1	24	41	12.2
B	do	Aug. 12–18	7	30	19.7	4.2	23	40	13.4
A	Fourth	Aug. 19–23	5	25	20.5	4.5	22	40	12.3
B	do	Sept. 9–14	8	28	19.9	4.6	21	42	13.1

[1] It is assumed that growth started May 1.

There was a distinct increase in crude-protein content by cuttings as the season advanced. This is shown by the second and fourth cuttings on plot A, which represent 30- and 25-day growing periods respectively. The second cutting averaged 16.7 percent crude protein while the fourth cutting averaged 20.5 percent. There was a similar increase in protein content from the second to the fourth cutting on plot B. This is evidence that the number of days' growth is not always an accurate measure of the stage of maturity or the nutritive value of grasses.

Possibly the change in flora of the clipped plot as the season advanced also had an effect. Volunteer alfalfa was more noticeable the latter part of the season. It was rather surprising, however, that a higher protein content was not obtained in the early clippings.

The percentage of fat and the percentage of ash also showed a distinct tendency to increase as the season advanced. The crude fiber and nitrogen-free extract showed just the opposite tendency. However, there does not appear to be any definite correlation between the percentages for crude fiber and nitrogen-free extract and the number of days' growth.

FEEDING VALUE OF THE CLIPPED GRASS

The 1929 experimental work in feeding clipped grass differed somewhat from that in 1928, in that the cows were fed to their capacity whereas in 1928 an attempt was made to feed the same number of cows on the clipped grass as were kept on the grazed plot. The consumption per cow was much greater than in 1928. In 1928, the cows consumed an average of 75.6 pounds of clipped grass per day. Since the same number of cows were grazed as were fed the clipped grass in 1928 and since the area was the same, it may be assumed that the cows on pasture and the cows fed the clipped grass obtained approximately the same quantity of grass. In 1929, when the cows were fed the clipped grass to capacity, however, they consumed an average of 136.6 pounds per day. If the cows on pasture in 1928 obtained as much grass as they wanted it may be assumed that cows on pasture do not consume as much as when the grass is cut and delivered to them. Or it may be that it is not possible to judge very closely just how much grass is available for consumption on a pasture, and therefore, it is difficult to allocate properly the number of animals for a pasture of given size, for different periods of the growing season.

Three cows were required to consume the grass from the clipped plot during the period of its most rapid growth up to the latter part of June. After that one cow, H-32, was able to consume the entire growth. Furthermore, during two periods, August 1 to 11, and August 24 to September 8, it was necessary to transfer this cow to pasture, because the growth of grass was insufficient to permit clipping.

Table 9 gives the daily consumption of grass and the daily production of milk for the three cows that were started on the experiment, and table 10 gives the consumption and production of the cow that replaced them.

A summary of the production, consumption, and nutrient requirements for the four cows in the experiment is given in table 11.

Cow H-32 (table 10) received clipped grass from June 25 to September 14, with the exception of the two short periods when it was necessary to put her on pasture because of a lack of sufficient grass to clip. For the 55 days she received clipped grass she was offered 8,829 pounds and consumed 8,343 pounds, or an average of 151.6 pounds daily. The smallest amount consumed in any one day was 101 pounds and the largest was 218 pounds (fig. 2). There was considerable variation in the amount she consumed from day to day. She would consume a large amount for one or two days and then a small amount the next day or two. Apparently she would gorge herself and lose her appetite for large amounts for a few days. This was also the case with the other cows.

At the beginning of the clipped-grass experiment cow H-32 received the grass daily for 37 consecutive days. Her average daily milk production at the beginning of this period (average of June 25, 26, and 27) was 40.7 pounds. Her average at the end of the first 37 days of consecutive feeding (average of July 29, 30, and 31) was 37 pounds, a decline of only 3.7 pounds, or 9.1 percent for the 37-day period.

From August 1 to 11 she grazed on pasture grass similar to that clipped. Her average daily production declined from 37 pounds

TABLE 9.—*Grass consumption and milk production per day, and changes in body weight, of the three cows that started on the clipped-grass feeding experiment, 1929*

Date	Cow H-61 [1]					Cow H-51 [2]					Cow H-48 [3]				
	Clipped grass—		Milk production	Butterfat test	Body weight	Clipped grass—		Milk production	Butterfat test	Body weight	Clipped grass—		Milk production	Butterfat test	Body weight
	Offered	Consumed				Offered	Consumed				Offered	Consumed			
	Pounds	*Pounds*	*Pounds*	*Percent*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Percent*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Percent*	*Pounds*
May 30	56	56	23.5		[4] 1,190	65	65	39.9		[4] 1,254	65	65	24.3		[4] 1,417
May 31	82	82	24.2			87	87	39.5			92	92	24.3		
June 1	92	92	23.5			119	119	33.2			121	121	21.9		
June 2	114	114	21.1			116	116	37.7			119	119	24.2		
June 3	109	109	23.1			146	146	38.7			182	182	23.2		
June 4	139	139	23.3			142	142	39.6			148	148	24.4		
June 5	134	130	23.9		1,155	158	158	40.9		1,225	143	138	24.8		1,417
June 6	126	126	24.6	3.9		121	121	42.2	3.5		121	118	24.6	4.4	
June 7	97	97	23.8			128	128	38.5			130	130	23.0		
June 8	123	123	23.5			148	148	37.6			151	151	23.8		
June 9	128	128	22.9			156	156	38.3			153	153	23.8		
June 10	124	124	23.1			158	158	40.1			169	169	25.2		
June 11	180	180	24.1			175	175	39.6			181	181	24.7		
June 12	154	152	22.7		1,149	158	156	39.2		1,226	160	144	24.1	4.4	
June 13	127	127	22.6	3.7		143	143	39.4	3.5		147	136	23.9		[4] 1,419
June 14	160	160	22.8			160	159	38.6							
June 15	161	153	21.9			152	143	37.5							
June 16	139	125	21.2			190	181	36.3							
June 17	148	146	21.2			153	131	36.9							
June 18	125	118	21.6			137	127	36.1							
June 19	134	128	21.2		1,185	140	133	35.4		1,237					
June 20	132	115	21.8	3.7		136	131	35.9							
June 21	119	113	21.7			123	115	34.9							
June 22	123	114	20.7			142	138	33.9							
June 23	169	156	20.6			163	153	33.5	3.8						
June 24	113	79	21.4	3.7	[4] 1,175	128	100	32.8		[4] 1,245					
Total	3,308	3,186	586.0			3,644	3,529	975.3			2,082	2,047	360.2		
Average	127.2	122.5	22.5		1,188	140.2	135.7	37.5		1,250	138.3	136.5	24.0		1,418

[1] Age 3 years 2 months; stage of lactation, 132 days.
[2] Age 4 years 8 months; stage of lactation, 93 days.
[3] Age 4 years 10 months; stage of lactation, 318 days.
[4] Average of three weights.

TABLE 10.—*Clipped grass consumed and milk produced per day by cow H-32 [1] in the clipped-grass feeding experiment, 1929*

Date	Clipped grass		Milk production	Body weight	Butterfat test	Date	Clipped grass		Milk production	Body weight	Butterfat test
	Offered	Consumed					Offered	Consumed			
	Lbs.	*Lbs.*	*Lbs.*	*Lbs.*	*Pct.*		*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Pct.*
June 25	155	155	40.2	[2] 1,633	3.9	Aug. 8 [3]			32.0		
June 26	192	192	39.8			Aug. 9 [3]			29.5		
June 27	171	166	42.6			Aug. 10 [3]			31.3		
June 28	155	149	44.8			Aug. 11 [3]			32.6		
June 29	190	190	41.1			Aug. 12	160	160	31.1	[2] 1,624	4.1
June 30	174	174	41.1			Aug. 13	170	160	31.2		
July 1	177	173	40.0			Aug. 14	149	149	34.7		
July 2	168	163	38.3			Aug. 15	141	134	33.4		
July 3	181	171	38.1	1,663	3.6	Aug. 16	153	143	32.6		
July 4	149	113	37.3			Aug. 17	162	158	33.6		
July 5	162	158	39.7			Aug. 18	149	141	32.8		
July 6	150	138	38.4			Aug. 19	162	155	32.9		
July 7	233	218	37.9			Aug. 20	162	153	33.0		
July 8	181	181	36.9			Aug. 21	174	174	35.0		4.6
July 9	152	128	38.2			Aug. 22	169	169	34.1		
July 10	161	151	38.5	1,695	3.8	Aug. 23	160	142	35.4	[2] 1,622	
July 11	159	144	37.0			Aug. 24 [3]			31.9		
July 12	146	143	37.3			Aug. 25 [3]			32.1		
July 13	167	165	36.2			Aug. 26 [3]			32.8		
July 14	177	166	37.7			Aug. 27 [3]			32.8		
July 15	155	143	35.8			Aug. 28 [3]			32.7		
July 16	153	144	34.9			Aug. 29 [3]			32.4		
July 17	152	139	36.6	1,650	3.9	Aug. 30 [3]			32.5		
July 18	135	127	36.7			Aug. 31 [3]			31.6		
July 19	159	155	36.4			Sept. 1 [3]			30.1		
July 20	146	143	38.4			Sept. 2 [3]			31.5		
July 21	136	128	33.7			Sept. 3 [3]			28.8		
July 22	140	137	36.4			Sept. 4 [3]			28.0		
July 23	152	147	34.9			Sept. 5 [3]			26.7		
July 24	171	169	35.6	1,664	3.9	Sept. 6 [3]			27.9		
July 25	150	145	34.9			Sept. 7 [3]			27.8		
July 26	147	122	34.0			Sept. 8 [3]			26.7		
July 27	153	140	34.1			Sept. 9	169	168	24.7	[2] 1,601	
July 28	146	[4] 1	36.2			Sept. 10	204	101	30.1		
July 29	156	148	37.5			Sept. 11	192	165	33.1		
July 30	141	128	36.7			Sept. 12	183	175	31.6		
July 31	121	103	36.7	[2] 1,628	3.8	Sept. 13	146	128	32.6		4.4
Aug. 1 [3]			27.5			Sept. 14	100	101	32.8	1,607	
Aug. 2 [3]			34.3			Total [4]	8,820	8,343	1,975		
Aug. 3 [3]			33.4			Daily average [4]	160.4	151.6	35.9	1,620	
Aug. 4 [3]			35.7								
Aug. 5 [3]			35.5								
Aug. 6 [3]			33.1								
Aug. 7 [3]			34.6								

[1] Age 6 years 4 months; stage of lactation, 80 days.
[2] Average of 3 weights.
[3] Cow on pasture.
[4] Totals and averages are for the 55 days the cow was fed clipped grass.

TABLE 11.—*Summary of production, consumption, and nutrient requirements of four cows fed clipped grass, 1929*

Items of comparison	Cow H-32	Cow H-61	Cow H-51	Cow H-48
Stage of lactation at start of feeding period—days	80	132	93	318
Duration of grass feeding—do	[1] 55	26	26	15
Average daily body weight—pounds	1,620	1,183	1,250	1,418
Gain or loss in body weight—do	−26	−15	−9	+2
Average daily milk production—do	35.9	22.5	37.5	24.0
Increase or decline in production over period:				
Milk—do	−8.4	−2.8	−4.1	+.7
Do—percent	−20.4	−11.9	−11.0	+3.1
Average percentage of butterfat in milk—do	3.9	3.7	3.6	4.4
Average consumption of grass per day—pounds	151.6	122.5	135.7	136.5
Average consumption of dry matter per day—do	36.1	29.2	32.3	32.5
Digestible crude protein consumed per day—do	4.86	3.94	4.35	4.38
Digestible crude protein required per day—do [2]	3.42	2.25	3.20	2.62
Total digestible nutrients consumed per day—do	25.79	20.86	23.08	23.22
Total digestible nutrients required per day—do	25.18	16.56	22.09	20.18

[1] Not consecutive. [2] See p. 17. [3] Savage feeding standard.

(average of July 29, 30, and 31) to 31.1 pounds (average of Aug. 9, 10, and 11), a decline of 15.7 percent in the 11 days. From August 12 to 23, when she was again on clipped grass, her average daily production increased from 31.1 pounds to 34.8 pounds (average of Aug. 21, 22, and 23), an increase of 11.9 percent. This increase was made at the time of some of the highest maximum temperatures of the season. (See table 7.)

From August 24 to September 8, inclusive, 16 days, she was grazing again. Her average daily production declined from 34.8 pounds to 27.5 pounds (average of Sept. 6, 7, and 8), or approximately 21 percent. It is probable that the grazed pasture was getting short at this time. When on September 9 she was placed on clipped grass again, her average daily production increased from 27.5 pounds to 32.3 pounds in 6 days, an increase of 17.7 percent.

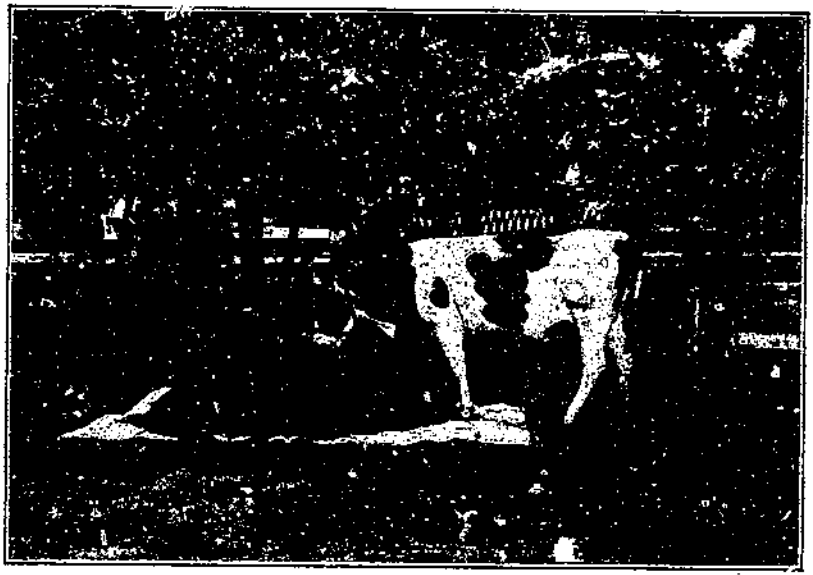

FIGURE 2.—Cow H-32, and 218 pounds of clipped grass, the largest amount she consumed in one day

In every case when she was shifted from the clipped grass to grazing there was a substantial decline in milk production. The same is largely true for her body weight. She practically maintained her body weight while being fed the clipped grass but lost weight while on the grazed pasture, especially from August 24 to September 8, when she declined 21 pounds in body weight for the 16 days.

These figures appear to indicate that this cow did not consume as much grass while grazing as she did when the grass was clipped and fed to her in quantities as great as she would eat. It is believed that there was plenty of grass on the grazed plot, except possibly from August 24 to September 8, when the grass had become short and coarse. Possibly the physical effort of grazing was so great that this cow did not work hard enough to secure as much grass as she could consume.

The cow in the grazing part of this experiment that provides the best comparison with H-32 is H-37. (See table 5.) Both were in about the same stage of lactation when started on the experiment. The grazed cow was producing 10 to 12 pounds of milk a day more than the cow fed clipped grass, but on the other hand she was some 400 pounds lighter and thus required less nutrients for maintenance.

During the first 30 days cow H-32 declined about the same in milk flow as the grazed cow, 12.4 percent as compared to 12.7 percent, but she gained 31 pounds in weight whereas the grazed cow lost 11 pounds. The comparison could not be continued for the remainder of the season because the slow growth of grass made it necessary to switch the fed cow to pasture at frequent intervals.

The grazed cows lost slightly more body weight than did the cows fed clipped grass and their decrease in milk was considerably greater. Their greater loss in weight and their heavier decrease in milk flow indicate that the grazed cows did not secure enough grass to meet their calculated requirements.

Each of the four cows fed clipped grass consumed more total digestible nutrients and digestible crude protein than they required. (See table 11.) In the case of H-32 and H-51 the excess of digestible crude protein was 42 and 36 percent, respectively. Both cows were milking heavily and were in early stages of lactation. The average crude-protein content of the clipped grass (dry-matter basis) was 17.6 percent.

The results of this experiment (table 11), although not so complete as desired, appear to indicate that these cows had the capacity to consume sufficient grass to meet their needs for body maintenance and for producing 35 to 40 pounds of milk per day, without any unusual decline. The decline of 20.4 percent in milk flow for cow H-32, which is for the period from June 25 to September 14, inclusive, is misleading because much of the decline occurred during the two periods when she was on pasture. The percentage decline for this cow that is most comparable to that for the other three cows is for the first 37 days, when she was fed the clipped grass continuously. Her percentage decline for this period was 9.1, which compares favorably with that of cows H-61 and H-51, and is somewhat less than the decline expected under any system of feeding for a 37-day period in the fourth month of lactation.

GRASS HAY AND SILAGE EXPERIMENTS IN 1929

COMPOSITION AND FEEDING VALUE OF GRASSES AT MATURE AND IMMATURE STAGES

Several investigations in England during the last few years have drawn attention to the superior feeding value and nutritive composition of grasses cut at immature stages of growth. When the Huntley experiments were planned in 1929, a search of the literature revealed that investigators in the United States had long ago discovered the superior feeding value of immature grasses, but that apparently no attempt has ever been made to take advantage of this most important discovery in feeding livestock. It was planned, therefore, in the feeding experiments with grass hay and silage, to cut the grasses at mature and immature stages of growth and to study the relationship

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between the nutritive composition and the feeding value for milk production, of the grass hay and silage at the different stages.

As long ago as 1883 the United States Department of Agriculture (*9, p. 231*) [2] reported the chemical composition of *Phleum pratense* (timothy) taken from its own gardens and from samples obtained in Indiana. The percentages of crude fiber and albuminoids are shown in table 12, which was compiled from that report.

TABLE 12.—*Chemical composition of timothy cut at different stages of maturity, compiled from a report by the United States Department of Agriculture, 1883*

Stage of maturity	United States gardens		Indiana	
	Crude fiber	Albuminoids	Crude fiber	Albuminoids
	Percent	*Percent*	*Percent*	*Percent*
Heads not out			29.19	10.97
Heads out	23.95	14.15	[1] 29.65	[1] 7.80
In bloom	27.35	10.99	32.26	5.52
After bloom	28.26	8.74	31.32	5.57
Early seed	27.08	8.18	24.70	4.84

[1] Reported as "before bloom."

Morse (*8*) at the New Hampshire Agricultural Experiment Station cut timothy grass at various stages of maturity in the summer of 1888. His analyses and conclusions on the nutritive constituents of the grass at various stages of maturity agree closely in many respects with those of investigators who have studied the subject more recently. His report appears to have been the first comparatively complete work on this subject.

Morse (*8, p. 65–66, 69*) concludes:

> The percentage of dry matter increased as that of water decreased. The ash was more abundant during the rapid growth of the plant than after the growth had ceased. The ether extract decreased till blossoming, then increased until the seed began to form, when it again decreased, reaching its lowest point as the seed began to harden. The crude fiber increased steadily, with two exceptions, until the formation of seed, after which there was a slight decrease. * * *
>
> The nitrogen-free extract after the grass had nearly reached its full height remained nearly constant, * * *. Crude protein steadily decreased with the development of the plants, although nearly constant after the bloom began to fade. The increase at the time of taking the last sample I attribute to the presence of second growth caused by the wet season of that year (1888).
>
> The amount of grass per acre increases until the time of blossoming. It then decreases. The decrease is due to loss of water.
>
> Dry substance steadily increases until the plant forms seed.
>
> The young grass is richest in fat and protein. The mature grass is richest in carbohydrates or fiber and nitrogen-free extract.
>
> Timothy yields the largest amount of digestible protein when cut at the beginning of bloom.
>
> The total amount of digestible matter is largest when the grass has passed out of bloom or gone to seed.

Crozier (*1*) reported the results of experiments at the Michigan Agricultural Experiment Station in 1894 with orchard grass and timothy. A plot of timothy cut eight times between April 30 and June 24 yielded 15.76 pounds of dry grass with a crude-protein content of 22.62 percent. A similar plot cut once, on June 24, yielded 172 pounds of dry grass with a crude-protein content of 7.81 percent.

[2] Italic numbers in parentheses refer to Literature Cited, p. 47.

Ellett and Carrier (*4*) report the results of experiments started in 1908 by the Virginia Agricultural Experiment Station and the Office of Forage Crop Investigations, Bureau of Plant Industry, United States Department of Agriculture, in which plots in a permanent bluegrass pasture were cut with a lawn mower at periods of 7, 10, 20, 30 days, and once a year. Their data show a gradual falling off in the percentage of protein in the grass cut every 7 days to that cut every 30 days. The greatest difference in protein content, however, is between the grass cut every 7 days and the grass cut once a year. The grass cut every 7 days had almost twice as much protein as the grass cut once a year.

Woodman, Norman, and French (*12, p. 310*) in their investigations on the influence of the intensity of grazing on the yield, composition, and nutritive value of pasture herbage found that under conditions prevailing at the University of Cambridge, a drought severe enough to give the grass a scorched or brown appearance would have the following effects on the chemical composition of the grass:

(1) A very decided falling-off in the percentage of protein; (2) a slight increase in the percentage of N-free extractives and crude fiber; (3) an abrupt rise in the percentage of lime, accompanied by a decline in the percentage of phosphoric acid; (4) a pronounced reduction of the moisture content of the herbage at the time of cutting.

Such effects, in a more modified form, result from such hot, droughty conditions as are encountered over short periods in midseason according to their results. They found also that such scorched herbage had a lower digestion coefficient, especially for the protein. The explanation offered for this depressed coefficient of digestion follows:

It is not likely that the pronounced decrease in the digestibility of the protein in the grass is to be attributed to any alteration in the chemical character of this constituent, but is rather to be put down to the inevitable reduction of the digestibility of the food nutrients, contained in the plant cells, which accompanies lignification of the fibrous cell walls. It has been shown, in the section dealing with the nutritive value of the 1929 and 1930 herbage, that under a system of monthly cuts no evidence of lignification is manifested if the weather conditions are such as to encourage active and continuous growth, but that if lack of rainfall leads to a slowing-up in the rate of growth, then a stage may be reached, within the monthly interval between successive cuts, when the lignification processes will begin to modify the character of the herbage. This probably occurs, on an intensive scale, during a drought which is of such duration as to cause the herbage to become parched and brown. Transportation of fresh food material from the soil into the herbage plants becomes impossible owing to lack of the necessary moisture, and, as a consequence, the vegetative phase of plant development comes to an untimely end. The processes of re-transportation and re-elaboration of material already within the plant, characteristic of the reproductive phase of development, set in prematurely, one result of these operations being the gradual lignification of the cellulose in the cell walls. If this explanation be correct, it would follow that not only the protein, but also the fibre, N-free extractives and ether extract in the brown herbage would be of low digestibility, and the material would have a correspondingly low feeding value (*12, p. 311*).

Woodman and coworkers (*12, p. 316–318*) also consistently obtained higher percentages of protein than were obtained in the Huntley experiments either in the grass clipped at various intervals of growth or in that cut at intervals for hay and silage. Following are some of their findings on the composition of grasses cut at various intervals of growth:

Pasture grass during April and early May contains, on the basis of dry matter, well over 20 percent of crude protein whether the system of cutting is weekly, fortnightly, 3-weekly or monthly; that is to say, its richness in protein, and

indeed its general composition, both organic and inorganic, are, within the limits of the investigations so far carried out, independent of the frequency of the cuts.

The distinction in composition between pasture herbage cut at weekly and at monthly intervals only becomes marked with the advent of the "flush" period of growth. At this stage of the 1929 season, for instance, the monthly cut grass contained 18.71 percent crude protein and 18.84 percent of crude fiber (dry matter basis) while the weekly mown herbage contained 23.66 and 15.97 percent respectively of these constituents. Over the 1929 season (omitting the results for the droughty period of late August and September) the weekly cut herbage was some 3 percent richer than the monthly cut grass in respect of crude protein, slightly poorer in N-free extractives and significantly poorer in crude fiber. This constituted the main difference between the two types of herbage, the distinction in respect to ether extract, lime and phosphoric acid being only slight. The mean crude protein content of the monthly cut grass, on the basis of dry matter, for the seasons of experiment was 20.23 percent (1929) and 19.35 percent (1930).

* * * Pasture grass grown under a system of 3-weekly cuts is equal to weekly and fortnightly mown herbage in respect of digestibility. If the interval between successive cuts be lengthened to a month, the grass obtained in the early part of the season is as digestible as that obtained under systems of weekly, fortnightly and 3-weekly cutting. The cutting of the longer interval on the digestibility of the herbage as the season advances will be determined largely by the weather conditions. If conditions are eminently favourable to quick growth, as in 1930, the digestibility of the herbage, including that of the fiber, will remain high, as under more severe systems of cutting, the only noticeable effect being a slight running-off in the digestibility of the protein constituent during the mid-season, followed by recovery at a later stage. If, on the other hand, the season is substantially one of drought, with consequent slow growth, the herbage will tend, as the season advances, to suffer some degree of lignification, and its digestibility will be lowered. * * *

Lignification in herbage plants is apparently delayed until the final stages of fiber production. The process does not occur during the vegetative phase of development, but begins only in the late-flowering stage, or even during the period of seed formation, when the stems and leaves are being depleted of nutrients. If, however, persistent drought leads to an untimely check or cessation in the growth of herbage, then the lignification processes may set in at an earlier stage of distinctly lower fiber content than is indicated by the results of the quick-growing 1930 season.

Shutt and coworkers (*10*) in Canada conducted experiments to determine the effect of frequency of cutting and the stage of maturity when cut, on the composition of grass. The grass was mostly meadow foxtail. They used four plots, one of which was cut 16 times during the season May 11 to October 16, the second 9 times, the third 8 times, and the fourth 3 times. The range in percentage of crude protein for the plot cut 16 times was from 25.24 for the cutting on June 1 to 32.6 for the cutting on July 27; for the plot cut 9 times the range was from 17.8 for the cutting on June 1 to 26.04 for the cutting on May 18; for the plot cut 8 times the range was 14.52 for the cutting on June 15 to 25.72 for the cutting on September 28; for the plot cut 3 times the percentage of protein was 11.96 for the cutting on July 3, 11.61 for the cutting on August 27, and 16.34 for the cutting on October 26.

Ellenberger, Newlander, and Jones (*3*) conducted pasture investigations in Vermont in 1924, 1925, and 1926. They fenced off 1-rod squares in a number of different pastures. The grass in these squares was cut with a lawn mower often enough to simulate the condition of the cropped pasture grass surrounding the lots. For the years 1925 and 1926 these clippings had an average chemical composition (dry-matter basis) of 11.68 percent of ash, 20.3 percent of crude protein, 18.69 percent of crude fiber, 46.03 percent of nitrogen-free extract, 3.3 percent of ether extract, 0.816 percent of calcium, and 0.320 percent of phosphorus. The composition of the grasses from the various

pastures differed greatly with the productivity of the pastures. No definite interval of time is given for these clippings but the average composition is not greatly different from that given by these authors for grass plucked in the open pastures at intervals of a month.

COMPOSITION OF HAY AND SILAGE MADE FROM VARIOUS CUTTINGS OF GRASS AT HUNTLEY

The grass for both the hay and the silage at Huntley was taken from the same plot, but the plot was divided and the grass from one part was cut at immature stages of growth on June 14, August 1, and September 13, representing a growth period of 45, 48, and 43 days respectively for the three cuttings. The growth period for the first cutting was calculated from May 1, the approximate date on which growth started. Part of the grass cut on these three dates was cured as hay and the rest was ensiled. The hay and silage made from the grass cut on these three dates is referred to in the text as the first, second, and third cutting "interval" hay and silage.

The grass on the remaining part of the plot was allowed to mature before it was cut. The first cutting was made on July 19, 80 days after the approximate start of growth on May 1, and the second cutting was made 56 days later, on September 13. Part of the grass from these two cuttings was cured for hay and part was ensiled. The hay and silage from these two cuttings of grass is referred to in the text as the first and second cutting "mature" hay or silage.

The grass made into hay was cured in the swath and then put in the barn. The grass that was ensiled was raked and handled as soon as possible after it was cut. More or less wilting took place, however. The grass was run through a silage cutter and no water was added. The silage kept well, with very little spoilage. The silage made from the mature grass was somewhat darker in color than that made from the interval-cut grass, but otherwise appeared to be of the same quality.

At the time of cutting the first-cutting interval grass, June 14, the orchard grass and the bromegrass averaged 12 inches in height and had some heads showing at about 18 inches. The alsike clover averaged about 8 inches, and the white clover about 5 inches in height. At the time of cutting the second-cutting interval grass, August 1, the growth averaged about 6 inches and there was considerable volunteer alfalfa in evidence. The alfalfa was in full bloom and was from 18 to 24 inches high. It was estimated that about 5 percent of the first- and second-cutting interval grass, and of the first-cutting mature grass was alfalfa. It was estimated that 20 percent of the third-cutting interval and 10 percent of the second-cutting mature was alfalfa. At the time of cutting the third-cutting interval grass, September 13, the grass was very short, averaging about 4 inches.

At the time of cutting the first-cutting mature grass, July 19, the orchard grass and the bromegrass averaged 18 inches in height and were fully headed. The clovers were in full bloom and the heads were turning brown. At the time of cutting the second-cutting mature grass, September 13, the grass was short, averaging only 6 inches in height. It was not nearly so mature as the grass cut on July 19, but all growth had stopped and the tips of the grass blades had been nipped by frost.

The first-cutting interval hay was exposed to a few light showers while it was being cured.

The second-cutting interval hay was exposed to two light showers and the third-cutting interval hay and the second-cutting mature hay were also exposed to a light shower. The other cuttings were not rained on. Probably only the first-cutting interval hay suffered any rain damage, and that was not great.

Since the hay and the silage were made from grass from the same plots and cut at the same stages of maturity, the only differences between the composition of the hay and that of silage would be those caused through loss of leaves and finer stems in the hay while it was being cured and handled or through leaching by rain or dew, and those caused by seepage, fermentation, or spoilage in the silage. Then, too, there is the possibility that the samples analyzed were not representative.

Table 13 shows the analyses of the silage and hay made from the various cuttings of grass.

TABLE 13.—*Composition (dry-matter basis) of silage and hay made from grass cut at different stages of maturity, 1929*

Stage of maturity	Date cut	Days' growth	Crude protein		Ether extract		Crude fiber	
			Silage	Hay	Silage	Hay	Silage	Hay
		Number	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
First-cutting interval	June 14	45	11.7	9.0	4.1	1.9	32.0	34.0
Second-cutting interval	Aug. 1	48	15.3	13.4	4.9	2.8	31.3	29.0
Third-cutting interval	Sept. 13	43	17.1	14.9	4.8	2.8	24.0	24.7
First-cutting mature	July 19	80	9.6	6.5	2.8	1.6	36.0	39.0
Second-cutting mature	Sept. 13	56	13.6	12.5	5.0	3.3	25.4	27.0

Stage of maturity	Date cut	Days' growth	Nitrogen-free extract		Ash	
			Silage	Hay	Silage	Hay
		Number	*Percent*	*Percent*	*Percent*	*Percent*
First-cutting interval	June 14	45	39.8	46.0	10.2	7.8
Second-cutting interval	Aug. 1	48	36.1	44.0	12.1	10.0
Third-cutting interval	Sept. 13	43	40.5	47.0	13.3	10.0
First-cutting mature	July 19	80	40.0	45.0	10.6	7.7
Second-cutting mature	Sept. 13	56	42.8	46.0	13.0	10.0

The protein content (dry-matter basis) is somewhat higher in the silage than in the hay, in all the cuttings, the greatest differences being in the third-cutting interval and the first-cutting mature.

There is considerably more variation in fat content in the silage from different cuttings than in the hay, but the ranking according to cuttings is practically the same for both silage and hay.

The nitrogen-free extract content in the hay is remarkably uniform for all cuttings. It is lower in the silage but appears to follow no definite trend in relation to stage of maturity.

The ash content is higher in the silage than in the hay, but it follows the same general trend in relation to the various cuttings. The ash was not analyzed for calcium and phosphorus in the hay and silage, but some idea of the calcium and phosphorus content of the grass is obtained from the analysis made of the clippings for the first 10 days (May 30 to June 8) on plots A and B. The grass clipped on these dates had an average growth period of 34.5 days. The average

percentage of calcium was 0.676, and the average percentage of phosphorus was 0.288 (dry-matter basis).

While there are these differences in composition between the hay and the silage made from the same cutting of grass, the trend of the differences for the various cuttings is fairly consistent. The crude-protein content for the interval cuttings is lowest in the first cutting and highest in the third cutting. The crude-protein content of the first-cutting mature hay is the lowest of the whole series of cuttings, while the second-cutting mature hay has approximately the same percentage of protein as the second-cutting interval hay, but is not so high as the second-cutting interval silage. As was to be expected the crude-fiber content varies inversely to the protein. In both the hay and the silage the highest crude-fiber content for the interval cuttings is in the first-cutting interval where the percentage of protein is lowest, and the lowest crude-fiber content is in the third-cutting interval where the percentage of protein is highest. The percentage of crude fiber is higher than was to be expected, in view of the fact that some of the grass was not in a very mature stage when cut and because of results obtained elsewhere with immature grass. The percentage of crude fiber in the first-cutting mature hay seems very high. The percentage of crude fiber (dry-matter basis) given by Woodman and coworkers (*12*) for first-cutting mature grass hay was 24.63 in 1929, and 29.16, 30.84, and 32.49 for hay from three different plots in 1930. However, the hay in Woodman's experiments also ran much higher in percentage of crude protein than the mature hay at Huntley.

It appears from these analyses that there was less loss of nutrients in the dry matter of the silage than in the dry matter of the hay. It also appears that protein and crude fiber were the constituents most markedly affected by the stages of maturity entering into this experiment, with the fat content and the ash content also affected to some extent. The nitrogen-free extract apparently was affected less by the various stages of maturity of the grass than by the method of preserving. It is rather surprising that the silage should be as greatly superior to the hay in nutritive value as the averages for all cuttings indicate. With the exception of the crude fiber and the nitrogen-free extract, which was reduced somewhat in the silage by fermentation of the starches and their conversion into acid, the nutritive constituents in the silage are greater by a considerable margin than those in the hay. The average percentage of crude protein for all cuttings is 11.4 in the hay and 13.5 in the silage, or an increase of 18 percent in the silage. The average percentage of ether extract for all cuttings in the hay is 2.5 and in the silage 4.3, or an increase of 72 percent in the silage. The average percentage of ash for all cuttings is 9.1 for the hay and 11.8 for the silage, or an increase of 30 percent in the silage. The average percentage of crude fiber for all cuttings is 30.7 for the hay and 29.7 for the silage. The average percentage of nitrogen-free extract in all cuttings is 45.6 for the hay and 39.8 for the silage, or an increase of 15 percent in the hay.

If the stage of maturity of the grass when cut for either hay or silage is judged by the higher protein content, the various cuttings would rank from least mature to most mature in the following order: (1) Third-cutting interval; (2) second-cutting interval; (3) second-cutting mature; (4) first-cutting interval; and (5) first-cutting mature. If judged by the lower crude-fiber content, the cuttings would rank

in the same order except that the rank of the second-cutting mature and of the second-cutting interval would be reversed.

While the first-cutting interval grass had about the same number of days for growth (assuming growth started May 1) as the second- and third-cutting interval, and 11 days less than the second-cutting mature, growth was so rapid from May 1 to June 14 that the first-cutting interval grass reached a more mature stage of growth in the same period of time, hence the lower percentage of protein. There is, of course, a possibility of error in stating that growth did not start till May 1. There were periods in August and early September when the growth was very slow. Thus, though the period of growth for the second-cutting mature grass was considerably longer than that for the first-cutting interval, the former did not reach so mature a stage of growth as did the latter. It is possible that the greater amounts of volunteer alfalfa appearing in the later cuttings may have been partly responsible for the higher percentage of protein. However, to offset the influence of the alfalfa in the later cuttings, there was a greater amount of clovers in the first cutting.

Data comparable to those on the composition of the grass silage and grass hay made at Huntley are available in the work of Watson (*11*) in England. The grass Watson used for making the silage and for making hay by artificial drying was—

> from a field of permanent grass which had reached a stage when it might have been cut for early hay and when some of the earlier grasses were showing a "head." There was not much clover in the herbage.

Table 14 gives the composition of the original grass, the grass silage, and the artificially dried hay, reported by Watson.

TABLE 14.—*Composition of original grass, grass silage, and artificially dried grass (stated as percentage of dry-matter basis)—Watson*

	Original grass	Silage	Artificially dried hay
Crude protein	13.93	14.78	14.55
Ether extract	3.46	4.33	2.35
Crude fiber	23.99	28.28	25.38
Nitrogen-free extract	50.76	42.71	49.43
Ash	7.86	9.90	8.29

The composition of grass silage as given by Watson is not greatly different from that of the silage made from the immature grasses at Huntley, being very similar to that of the second-cutting mature silage. The composition of the artificially dried hay as given by Watson is very similar to that of the hay made from the third-cutting interval grass at Huntley.

YIELD OF GRASS CUT AT DIFFERENT STAGES OF MATURITY

The yields in green weight, dry matter, and protein of plots that were cut twice, three times, and four times during the 1929 season, are given in table 15.

TABLE 15.—*Green weight and yield of dry matter and protein, of grass from plots cut 2, 3, and 4 times during the growing season, 1929*

Size of plot and use made of grass	Date cut	Days' [1] growth	Green weight	Dry matter		Protein	
		Days	*Pounds*	*Percent*	*Pounds*	*Percent* [2]	*Pounds*
0.347-acre, cut at maturity for silage	July 19	80	4,280	23.1	988.7	9.6	94.9
	Sept. 13	56	690	35.0	241.5	13.6	32.8
Total			4,970		1,230.2		127.8
Total per acre			14,323		3,545.2		368.2
0.998-acre, cut at intervals for silage	June 14	45	9,600	25.2	2,419.0	11.7	283.0
	Aug. 1	48	5,640	25.7	1,449.0	15.3	221.7
	Sept. 13	43	2,188	25.6	560.0	17.1	95.8
Total			17,428		4,428.0		600.5
Total per acre			17,463		4,436.9		601.7
0.478-acre, used for clipping (plot A)	May 30 to June 7	[3] 34	3,152	22.8	723.8	15.8	112.7
	June 25 to July 9	[3] 30	2,581	23.1	587.1	16.7	97.7
	July 25 to July 31	[3] 25	1,023	25.5	261.9	18.7	49.6
	Aug. 19 to Aug. 23	[3] 25	827	23.4	193.5	20.5	39.5
Total			7,553		1,766.3		299.5
Total per acre			15,804		3,695.2		626.6
0.493-acre, used for clipping (plot B)	June 8 to June 24	[3] 47	5,882	22.4	1,308.3	13.1	171.4
	July 10 to July 24	[3] 32	2,315	25.9	596.8	16.4	97.4
	Aug. 12 to Aug. 18	[3] 30	1,084	24.4	264.6	19.7	52.1
	Sept. 9 to Sept. 14	[3] 28	999	23.0	223.6	19.9	44.0
Total			10,280		2,393.3		364.9
Total per acre			20,852		4,854.6		740.2

[1] Assumed that growth started May 1.
[2] On dry-matter basis.
[3] Average number of days between clippings.

The plots on which the various cuttings were made were not of uniform size, and the yields are calculated on an acre basis to make them comparable. Not all the variation in yield of dry matter per acre can be attributed to the number of times the grass was cut, nor to the maturity of the grass, since the yields of dry matter do not follow any definite order of frequency of cutting. Plot B cut four times, with an average of 34 days between cuttings, had the greatest yield of dry matter on an acre basis. The plot cut three times, with an average of 45 days between cuttings, had the second highest yield of dry matter; plot A cut four times, with an average of 29 days between cuttings, had the third highest yield and the plot cut twice, with an average growth period of 68 days, had the lowest yield.

The yield of protein per acre followed definitely the number of cuttings. Plot B cut four times, with an average of 34 days between cuttings, had the greatest yield of protein, followed by plot A cut four times, with an average of 29 days between cuttings. The plot cut twice, with an average growth period of 68 days per cutting, had the lowest yield of protein per acre. The yield of protein per acre on plot B (cut four times) was a little more than double the yield on the plot that was cut twice.

The ranking of the average percentage of protein for the different plots follows definitely the average days' growth between cuttings. The grass from plot A, with 29 days' growth between cuttings, had an average of 17.9 percent protein (dry-matter basis); the grass from plot B, with an average of 34 days' growth between cuttings, had an

average of 17.3 percent protein; the grass from the plot cut three times, with an average of 45 days' growth between cuttings, had an average of 14.7 percent protein and the grass from the plot cut twice, with an average growth period of 68 days between cuttings, had an average of 11.6 percent protein.

These high percentages of protein are not due to fertilizer treatment. It will be recalled that the soil on which these plots were located had received no fertilizer treatment, other than the droppings from animals pastured on alfalfa.

It is significant that increasing the number of cuttings to four, during the growing season, thereby cutting the grasses at more immature stages of growth, resulted in greater yields of dry matter and in marked increases in both the percentage and the total yield of protein.

RESULTS OF FEEDING HAY AND SILAGE MADE FROM GRASS CUT AT INTERVALS AND AT MATURITY

Because of limited storage space it was necessary to store the hay from each succeeding cutting on top of that from the preceding cutting. The various cuttings had to be fed in the reverse order to that in which they were put in the barn. Because of the small quantities of hay available from some of the cuttings, the abrupt changes from one cutting to another have brought out the differences in palatability more clearly, perhaps, than would a feeding experiment in which the hays were fed simultaneously.

The ensiled grass was placed in two small experimental silos. In one silo the first-cutting interval grass, the first-cutting mature grass, and the second-cutting interval grass was ensiled in the order named. In the other the second-cutting mature grass and the third-cutting interval grass was ensiled in the order named. The silage was not fed in the same order as the hay. The second-cutting interval silage was fed first, and then for some undetermined reason, the third-cutting interval and the second-cutting mature were fed from the second silo before feeding was continued with the first-cutting mature and the first-cutting interval silage that remained in the first silo.

Three cuttings of grass for hay were from a plot of 0.964 acre, and two cuttings were from a plot of 0.275 acre. The total yield of hay from the total area (1.239 acres) was 5,965 pounds, with a dry-matter content of 4,968.8 pounds.

Three cuttings of grass for silage were from a plot of 0.998 acre and two cuttings were from a plot of 0.347 acre. The total yield of silage from the total area (1.345 acres) was 22,398 pounds, with a dry-matter content of 5,658 pounds. Thus there was somewhat more silage than hay available for feeding.

Three cows, H-53, H-48, and H-37, were started on the second-cutting mature hay on October 30 and were continued on hay of the various stages of maturity for 20 days. They received no other feed while they were being fed the grass hay. As soon as one lot of hay was consumed the cows were started on another. Because of the varying amounts of hay available the results of both the hay and silage feeding are measured only in terms of increase or decline in hay and silage consumption, milk yield, and body weight. The three hay-fed cows averaged 1,379 pounds in weight and 117 days in lactation.

Three cows, H-49, H-51, and H-52, were fed the grass silage. They averaged 1,312 pounds in weight and 117 days in lactation. They were started on the second-cutting interval silage October 10 and were fed continuously on silage of various stages of maturity for 40 days. They received no other feed during the silage-feeding experiment.

A sufficient amount of the first-cutting mature hay, of the first-cutting interval hay, and of the first-cutting interval silage, was held for use in a 24-day feeding test with two cows, H-49 and H-53, in which both grass hay and grass silage constituted the entire ration. Cow H-49 had been in the grass-silage feeding test, and cow H-53 in the grass-hay feeding test.

FEEDING GRASS HAY ALONE

Table 16 gives the daily consumption of hay, the milk production, and the body weights of the three cows used in the feeding experiment with grass hay cut at intervals and at mature stages. A summary of the average consumption of hay and the average yield of milk for the three cows during the various periods is given in table 17.

There was a marked difference in the rate of consumption of the hay cut at different periods of growth by the individual cows and with this difference in consumption there was a decided variation in production, as shown by table 17.

The three cows were started on hay made from the second-cutting mature grass, representing 56 days' growth and having a crude-protein content of 12.5 percent. The feeding period was 2 days.

They were then changed abruptly to the third-cutting interval hay. This feeding period was also 2 days. The hay represented 43 days' growth and had a crude-protein content of 14.9 percent. During this 2-day period the average daily consumption increased by about 11 pounds for cows H-53 and H-37, and 19 pounds for cow H-48.

The cows were then put on second-cutting interval hay for a period of 8 days. This hay represented 48 days' growth and had a crude-protein content of 13.4 percent. They declined in both consumption and milk production during this feeding period (table 17).

They were next fed first-cutting mature hay for 4 days. This hay represented 80 days' growth and had a crude-protein content of 6.5 percent, and the change was accompanied by a sharp decline in daily consumption (table 17). It is unfortunate that there was not a greater supply of this hay so that the extent of the decline in consumption and production might have been determined.

With the next change (from the first-cutting mature to the first-cutting interval hay) there was a decided increase in consumption and a slight increase in production (table 17). This hay represented a growth of 45 days (computed from May 1) and had a crude-protein content of 9.9 percent.

As was brought out in the discussion of the chemical composition of the hay and silage of the various cuttings, the second-cutting mature hay was more like the second- and third-cutting interval hays in composition than was the first-cutting interval. The first-cutting interval hay was also more like the first-cutting mature hay in composition than was the second-cutting mature. That being the case these three cows were fed on the three most immature hays during the

TABLE 16.—*Grass-hay consumption and milk production per day, and changes in body weight, of 3 cows fed hay cut at different stages of maturity*

Stage of maturity of the hay	Date fed	Cow H-53 [1]					Cow H-48 [2]					Cow H-37 [3]				
		Grass hay		Milk production	Butterfat test	Body weight	Grass hay		Milk production	Butterfat test	Body weight	Grass hay		Milk production	Butterfat test	Body weight
		Offered	Consumed				Offered	Consumed				Offered	Consumed			
		Pounds	*Pounds*	*Pounds*	*Percent*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Percent*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Percent*	*Pounds*
Second-cutting mature	Oct. 30	41.0	34.0	54.6	-------	[4] 1,393	38.5	31.0	54.4	-------	[4] 1,411	40.5	32.0	34.3	-------	[4] 1,332
	Oct. 31	42.0	39.0	48.0	-------	-------	44.5	39.5	53.7	-------	-------	41.5	40.5	30.9	-------	-------
Third-cutting interval	Nov. 1	61.5	55.0	46.0	-------	-------	61.5	58.5	50.8	-------	-------	66.5	54.0	30.7	-------	-------
	Nov. 2	40.5	40.5	48.7	-------	-------	51.5	50.5	53.6	-------	-------	44.5	42.0	31.4	-------	-------
	Nov. 3	52.0	50.5	49.4	-------	-------	47.0	41.5	55.1	-------	-------	50.5	47.5	31.9	-------	-------
	Nov. 4	52.0	46.0	46.9	-------	-------	67.0	65.0	48.8	-------	-------	53.0	51.0	31.6	-------	-------
	Nov. 5	44.5	44.5	45.3	-------	-------	43.5	41.5	47.3	-------	-------	56.0	47.5	29.2	-------	-------
Second-cutting interval	Nov. 6	53.0	48.0	44.0	4.2	-------	50.0	48.0	49.0	4.2	-------	56.5	47.5	28.3	3.9	-------
	Nov. 7	50.5	49.5	46.6	-------	-------	56.0	50.5	46.7	-------	-------	50.0	42.0	28.4	-------	-------
	Nov. 8	56.0	41.0	46.7	-------	-------	57.5	50.5	48.8	-------	-------	54.5	46.0	28.8	-------	-------
	Nov. 9	55.0	46.0	45.1	-------	-------	65.5	55.5	48.7	-------	-------	57.0	48.5	30.4	-------	-------
	Nov. 10	45.0	42.5	46.2	-------	-------	50.5	47.0	48.4	-------	-------	49.5	41.5	32.5	-------	-------
	Nov. 11	51.0	42.0	45.5	-------	-------	54.0	42.5	48.0	-------	-------	56.0	39.0	31.8	-------	-------
First-cutting mature	Nov. 12	58.0	42.5	44.7	-------	-------	58.0	38.5	47.5	-------	-------	53.0	40.5	28.0	-------	-------
	Nov. 13	56.5	34.5	42.3	4.4	-------	57.0	35.5	41.3	4.7	-------	56.0	36.0	25.9	3.9	-------
	Nov. 14	53.5	35.0	40.0	-------	-------	54.5	38.0	40.3	-------	-------	52.5	37.5	24.3	-------	-------
	Nov. 15	60.0	42.5	37.9	-------	-------	67.0	51.0	38.5	-------	-------	68.5	44.0	23.3	-------	-------
First-cutting interval	Nov. 16	53.5	43.5	42.2	-------	-------	61.5	48.5	41.8	-------	-------	55.0	42.0	24.9	-------	-------
	Nov. 17	54.0	46.0	43.1	-------	-------	63.0	47.0	43.0	-------	-------	51.0	42.0	27.6	-------	-------
	Nov. 18	58.5	41.0	43.0	4.1	[4] 1,345	59.0	42.5	41.4	4.7	[4] 1,386	57.0	39.5	28.4	3.9	[4] 1,352
Total		1,038.0	863.5	906.2	-------	-------	1,107.0	922.5	947.1	-------	-------	1,069.0	860.5	582.6	-------	-------
Average		51.9	43.1	45.3	-------	1,369	55.3	46.1	47.3	-------	1,398	53.4	43.0	29.1	-------	1,342

[1] Age 4 years 11 months; stage of lactation, 57 days.
[2] Age 5 years 3 months; stage of lactation, 62 days.
[3] Age 6 years 5 months; stage of lactation, 231 days.
[4] Average of 3 weights.

TABLE 17.—*Average daily consumption of grass hay, the average daily production of milk, and the increase or decline in consumption and production, by 3 cows fed grass hay of different stages of maturity*

Kind of hay fed and length of feeding period	Cow H-53				Cow H-48				Cow H-37			
	Consumption	Production	Increase (+) or decline (−) in—		Consumption	Production	Increase (+) or decline (−) in—		Consumption	Production	Increase (+) or decline (−) in—	
			Consumption	Production			Consumption	Production			Consumption	Production
	Pounds	*Pounds*	*Percent*	*Percent*	*Pounds*	*Pounds*	*Percent*	*Percent*	*Pounds*	*Pounds*	*Percent*	*Percent*
Second-cutting mature (2 days)	36.5	51.3			35.2	54.0			36.2	32.6		
Third-cutting interval (2 days)	47.7	47.3			54.5	52.2			48.0	31.0		
Second-cutting interval (8 days)	46.0	46.3	[1] −9.6	[1] −2.7	49.9	49.1	[1] −6.4	[1] −6.8	46.4	30.1	[1] −5.6	[1] −1.6
First-cutting mature (4 days)	38.5	43.1	[2] −13.7	[2] −8.0	38.6	44.3	[2] −27.0	[2] −11.5	38.2	27.5	[2] −16.2	[2] −14.7
First-cutting interval (4 days)	43.3	41.5	[3] +16.5	[3] +1.1	47.2	41.2	[3] +23.2	[3] −2.0	41.9	26.0	[3] +8.4	[3] +3.5

[1] From last 2 days on third-cutting interval to last 3 days on second-cutting interval.
[2] From last 3 days on second-cutting interval to last 3 days on first-cutting mature.
[3] From last 3 days on first-cutting mature to last 3 days on first-cutting interval.

first 12 days of the test and on the two most mature hays during the last 8 days. During the first 12 days the cows consumed an average of 45.9 pounds of hay per day, and produced an average yield of 42.8 pounds of milk. During the last 8 days they consumed an average of 41.3 pounds of hay per day, and produced an average yield of 37.3 pounds of milk.

The cows reacted very quickly in both consumption and production to the changes in quality in the different hays. It is probable that with longer feeding periods the cows would have become adjusted to these differences in quality, and the resulting differences in consumption and production would have been measured more accurately.

The experiment does bring out the marked differences, in palatability and in value for milk production, of hay cut from the same fields and cured under the same conditions but differing in the stage of maturity when cut. It also shows clearly that the number of days of growth is not an accurate gage of maturity for grass cut at different periods of the growing season. The 45-day growth of grass, cut June 14, had a very different composition and palatability from the 48-day growth of grass, cut August 1, and the 43-day growth of grass, cut September 13. Apparently the more rapid growth early in the season resulted in a more mature plant than the slower growth for the same length of time later in the season and the hay made from this more mature grass was less palatable and had less value for milk production.

It is probable that the cows would have done better on the second-cutting mature hay, on which the experiment was started, had they been accustomed to grass hay. These cows had always been fed alfalfa hay.

FEEDING GRASS SILAGE ALONE

The individual consumption and production data for the cows H-49, H-51, and H-52 that were on the silage feeding test are given in table 18. Cow H-51 had previously been in the clipped-grass feeding group. A summary giving the average consumption of silage and the average milk yield for the various periods of the test is given in table 19.

Cow H-49 (table 18) consumed an average of 102.7 pounds of silage per day. Her lowest day's consumption was 46 pounds (the first day) and her highest was 144 pounds of the third-cutting interval silage. Her milk production for the 40-day feeding period dropped from 41.8 pounds (average of second, third, and fourth days) to 33.4 pounds (average of the last 3 days). This is a decline of 8.4 pounds. She had been in milk only 39 days when the test started. This cow was badly physicked throughout the entire period, with only occasionally a day that the droppings appeared normal. The other two cows were normal after the first few days. During the 40-day period H-49 declined 82 pounds in body weight, or about 2 pounds per day.

Cow H-51 (table 18) consumed an average of 104.9 pounds of silage per day, with 136 pounds the highest day's consumption. She produced an average of 20.5 pounds of milk per day, declining 3.7 pounds. Her decline in body weight was 61 pounds.

Cow H-52 (table 18) consumed an average of 104.2 pounds of silage per day. Her highest day's consumption was 159 pounds of the third-cutting interval silage. The highest day's consumption for each of the three cows was during the time they were fed the third-cutting interval silage.

The three cows were started on silage made from the second-cutting interval grass (table 19), representing 48 days' growth and having a crude-protein content (dry-matter basis) of 15.3 percent. The feeding period was 11 days. The three cows consumed an average of 106.6, 98.4, and 98.8 pounds, respectively, of this silage per day.

The cows were next fed for 4 days on third-cutting interval silage, representing 43 days' growth and having a crude-protein content of 17.1 percent. Their average daily consumption during these 4 days was 136.4 pounds, by far the highest rate of consumption obtained in the silage-feeding test, and the rate of consumption was still increasing when the supply of this silage was exhausted. The average daily milk production also increased by 4.7 percent, 3.7 percent, and 12.3 percent, respectively. This silage was more palatable than that made from any other cutting. With a longer feeding period on this silage a much greater increase in production might have been obtained.

The cows were then changed to the second-cutting mature silage for 2 days. This silage represented 56 days of growth and analyzed 13.6 percent crude protein. This change was accompanied by a 10.9 percent, 13 percent, and 13.4 percent decrease respectively in consumption of silage by the 3 cows, but by a slight increase in production. Since this feeding period lasted for only 2 days, the increase in production is probably due to a carry-over effect from the feeding of the third-cutting interval silage.

The cows were next fed the first-cutting mature silage for a period of 12 days. This silage represented 80 days of growth and the protein content was 9.6 percent. The average daily consumption, which was 129.5, 125.2, and 143.3 pounds, respectively, while the cows were on the third-cutting interval silage and the second-cutting mature silage, dropped to 78, 94.5, and 75.1 pounds, respectively, during this feeding period.

During the last 11 days of the feeding experiment the cows were fed first-cutting interval silage, representing 45 days' growth and having 11.7 percent crude protein. This first-cutting interval silage, like the first-cutting interval hay, had a comparatively low crude-protein content and in composition was more like the first-cutting mature silage than like the second- and third-cutting interval silage. Likewise the second-cutting mature silage resembled the second- and third-cutting interval silage more closely than it did the first-cutting mature silage. The first-cutting interval silage was better in quality, however, than the first-cutting mature silage, as is shown by the marked increase in consumption and production. The increase in consumption during this 11-day period was 38.1, 26.2, and 41.2 percent, respectively, for the three cows, while the increase in daily milk production was 18.5, 18.4, and 20 percent, respectively.

In this study the first day on silage feeding was excluded because the cows were not yet accustomed to the silage ration and the consumption on that day was abnormally low. The average consumption for 16 days on the silage for the three cuttings that were most immature, namely, the third-cutting interval, the second-cutting interval, and the second-cutting mature, was 117 pounds per day while that on the silage from the most mature grass, namely, the first-cutting mature and the first-cutting interval, was 97.8 pounds for 23 days. The consumption was 20 percent greater on the silage made from the less mature grass.

TABLE 18.—*Grass-silage consumption and milk production per day, and changes in body weight, by three cows fed silage made from grass cut at different stages of maturity*

Kind of silage fed, and date	Cow H-49 [1]					Cow H-51 [2]					Cow H-52 [3]				
	Silage		Milk production	Butterfat test	Body weight	Silage		Milk production	Butterfat test	Body weight	Silage		Milk production	Butterfat test	Body weight
	Offered	Consumed				Offered	Consumed				Offered	Consumed			
	Pounds	*Pounds*	*Pounds*	*Percent*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Percent*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Percent*	*Pounds*
Second-cutting interval:															
Oct. 10	56.0	46.0	51.8	.....	[4] 1,369	53.0	26.0	25.3	.....	[4] 1,302	57.0	40.0	51.4	.....	[4] 1,266
Oct. 11	115.0	108.0	43.3	.....	.....	93.0	88.0	23.3	.....	.....	79.0	77.0	39.9	.....	.....
Oct. 12	120.0	110.0	41.2	.....	.....	123.0	109.0	21.0	.....	.....	115.0	106.0	37.4	.....	.....
Oct. 13	130.0	118.0	41.0	.....	.....	102.0	85.0	24.1	.....	.....	120.0	106.0	39.7	.....	.....
Oct. 14	137.0	109.0	44.8	.....	.....	126.0	111.0	24.7	.....	.....	135.0	118.0	39.9	.....	.....
Oct. 15	115.0	107.0	41.8	.....	.....	112.0	101.0	21.7	.....	.....	110.0	99.0	40.2	.....	.....
Oct. 16	120.0	112.0	40.4	3.7	.....	109.0	104.0	22.8	4.2	1,277	101.0	97.0	39.1	3.7	1,270
Oct. 17	115.0	112.0	42.5	.....	.....	115.0	111.0	22.4	.....	.....	110.0	105.0	40.3	.....	.....
Oct. 18	135.0	125.0	39.3	.....	.....	118.0	111.0	22.7	.....	.....	122.0	114.0	37.6	.....	.....
Oct. 19	126.0	118.0	38.8	.....	.....	125.0	121.0	22.3	.....	.....	131.0	125.0	36.5	.....	.....
Oct. 20	122.0	108.0	42.0	.....	1,396	127.0	116.0	22.7	.....	1,275	123.0	100.0	37.8	.....	1,302
Third-cutting interval:															
Oct. 21	124.0	111.0	36.5	.....	.....	141.0	123.0	20.9	.....	.....	156.0	141.0	36.9	.....	.....
Oct. 22	154.0	144.0	40.2	.....	.....	133.0	123.0	22.6	.....	.....	144.0	137.0	38.6	.....	.....
Oct. 23	157.0	130.0	42.3	3.7	.....	155.0	134.0	23.0	.....	.....	157.0	153.0	43.1	3.4	.....
Oct. 24	153.0	137.0	43.3	.....	.....	152.0	136.0	24.6	3.8	.....	180.0	159.0	44.0	.....	.....
Second-cutting mature:															
Oct. 25	138.0	126.0	43.5	.....	1,365	139.0	126.0	25.0	.....	.....	142.0	135.0	43.7	.....	.....
Oct. 26	148.0	120.0	44.7	.....	.....	128.0	109.0	25.2	.....	.....	169.0	135.0	44.5	.....	.....
First-cutting mature:															
Oct. 27	110.0	62.0	42.2	.....	.....	75.0	65.0	24.1	.....	.....	112.0	55.0	43.4	.....	.....
Oct. 28	94.0	75.0	39.0	.....	.....	143.0	123.0	20.1	.....	.....	40.0	35.0	34.0	.....	.....
Oct. 29	90.0	71.0	34.3	.....	.....	98.0	95.0	20.2	.....	.....	112.0	94.0	29.0	.....	.....
Oct. 30	122.0	95.0	34.0	4.7	1,323	148.0	107.0	18.4	4.4	1,307	104.0	53.0	34.8	4.4	1,240
Oct. 31	107.0	79.0	33.5	.....	.....	108.0	92.0	18.5	.....	.....	119.0	102.0	32.1	.....	.....
Nov. 1	112.0	87.0	31.6	.....	.....	111.0	100.0	17.8	.....	.....	101.0	80.0	31.7	.....	.....
Nov. 2	101.0	84.0	32.3	.....	.....	103.0	92.0	17.6	.....	.....	99.0	75.0	31.5	.....	.....
Nov. 3	98.0	69.0	30.5	.....	.....	104.0	92.0	17.0	.....	.....	102.0	71.0	30.8	.....	.....
Nov. 4	98.0	73.0	29.5	.....	.....	101.0	90.0	16.8	.....	.....	100.0	79.0	30.6	.....	.....
Nov. 5	125.0	80.0	29.8	.....	.....	132.0	89.0	17.1	.....	.....	119.0	90.0	29.9	.....	.....
Nov. 6	113.0	79.0	26.5	4.1	.....	140.0	97.0	17.1	3.9	.....	111.0	80.0	28.7	3.9	.....
Nov. 7	111.0	82.0	28.3	.....	.....	117.0	92.0	15.8	.....	.....	121.0	87.0	29.6	.....	.....

First-cutting interval:															
Nov. 8	136.0	71.0	29.6	-------	1,310	148.0	109.0	16.8	-------	1,271	141.0	105.0	28.6	-------	1,227
Nov. 9	164.0	124.0	30.5	-------	-------	143.0	112.0	16.9	-------	-------	164.0	128.0	30.7	-------	-------
Nov. 10	125.0	110.0	34.6	-------	-------	129.0	103.0	18.0	-------	-------	122.0	107.0	32.7	-------	-------
Nov. 11	155.0	131.0	34.8	-------	-------	162.0	112.0	18.0	-------	-------	155.0	122.0	32.7	-------	-------
Nov. 12	163.0	138.0	32.1	-------	-------	161.0	130.0	17.4	-------	-------	156.0	127.0	33.3	-------	-------
Nov. 13	143.0	109.0	33.3	3.8	1,313	134.0	96.0	18.9	3.9	1,270	140.0	117.0	34.2	3.9	1,227
Nov. 14	142.0	111.0	34.5	-------	-------	151.0	112.0	19.3	-------	-------	150.0	135.0	33.8	-------	-------
Nov. 15	118.0	98.0	34.0	-------	-------	121.0	103.0	19.7	-------	-------	127.0	118.0	34.0	-------	-------
Nov. 16	127.0	96.0	34.6	-------	-------	126.0	114.0	20.5	-------	-------	151.0	136.0	35.0	-------	-------
Nov. 17	131.0	113.0	31.9	-------	-------	151.0	121.0	18.6	-------	-------	141.0	106.0	34.7	-------	-------
Nov. 18	140.0	122.0	33.8	3.6	[4] 1,287	124.0	116.0	20.1	3.9	[4] 1,241	140.0	121.0	36.1	3.9	[4] 1,222
Total	4,990.0	4,111.0	1,472.6	-------	-------	4,961.0	4,196.0	819.5	-------	-------	4,978.0	4,170.0	1,442.0	-------	-------
Average	124.7	102.7	36.8	3.9	1,328	124.0	104.9	20.5	4.0	1,271	124.4	104.2	36.0	3.8	1,244

[1] Age 5 years 1 month; stage of lactation, 39 days.
[2] Age 5 years 1 month; stage of lactation, 223 days.
[3] Age 5 years; stage of lactation, 89 days.
[4] Average of 3 weights.

TABLE 19.—*Average daily consumption of grass silage, the average daily production of milk, and the increase or decline in production and consumption by three cows when fed grass silage of different stages of maturity*

Kind of silage fed, and length of feeding period	Cow H-49						Cow H-51						Cow H-52					
	Consumption	Production	Increase (+) or decline (−) in—				Consumption	Production	Increase (+) or decline (−) in—				Consumption	Production	Increase (+) or decline (−) in—			
			Consumption		Production				Consumption		Production				Consumption		Production	
	Lbs.	*Lbs.*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Lbs.*	*Lbs.*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Lbs.*	*Lbs.*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
Second-cutting interval (11 days)	106.6	42.4	[1] +32.9	-------	[1] −11.8	[2] −4.3	98.4	23.0	[1] +56.0	-------	[1] −3.4	[2] −1.0	98.8	40.0	[1] +52.0	-------	[1] −13.1	[2] −4.3
Third-cutting interval (4 days)	132.7	40.6	[3] +19.7	-------	[3] +4.7	-------	129.0	22.8	[3] +12.9	-------	[3] +3.7	-------	147.5	40.6	[3] +32.4	-------	[3] +12.2	-------
Second-cutting mature (2 days)	123.0	44.1	[4] −10.9	-------	[4] +3.0	-------	117.5	25.1	[4] −13.0	-------	[4] +5.5	-------	135.0	44.1	[4] −13.4	-------	[4] +1.3	-------
First-cutting mature (12 days)	78.0	32.6	[5] −42.6	[6] −34.4	[5] −32.7	[6] −37.9	94.5	18.4	[5] −29.2	[6] −19.0	[5] −28.7	[6] −34.5	75.1	32.2	[5] −42.7	[6] −38.1	[5] −29.8	[6] −33.9
First-cutting interval (11 days)	111.4	33.1	[7] +38.1	-------	[7] +18.5	-------	111.6	18.6	[7] +26.2	-------	[7] +18.4	-------	120.2	33.3	[7] +41.2	-------	[7] +20.0	-------

[1] From first 3 days to last 3 days on second-cutting interval.
[2] From second, third, and fourth days to last 3 days on second-cutting interval.
[3] From last 3 days on second-cutting interval to last 3 days on third-cutting interval.
[4] From last 2 days on third-cutting interval to last 2 days on second-cutting mature.
[5] From last 3 days on third-cutting interval to last 3 days on first-cutting mature.
[6] From last 2 days on second-cutting mature to last 2 days on first-cutting mature.
[7] From last 3 days on first-cutting mature to last 3 days on first-cutting interval.

FEEDING VALUE OF HAY AND OF SILAGE COMPARED

The hay from all cuttings of grass had an average dry-matter content of 83.3 percent, and the silage had an average dry-matter content of 25.2 percent. Computing the dry-matter content of the hay consumed daily by the three cows in the hay-feeding experiment and the dry-matter content of the silage consumed daily by the three cows in the silage-feeding experiment gives a basis for comparing the relative amounts of dry matter consumed in the form of hay and in the form of silage.

Table 20 shows the relative amounts of dry matter consumed in hay and in silage made from the different cuttings of grass.

TABLE 20.—*Dry matter consumed in hay and silage made from the different cuttings of grass*

Stage of maturity	Average hay consumed per day per cow	Dry matter consumed in hay per day per cow	Average silage consumed per day per cow	Dry matter consumed in silage per day per cow
	Pounds	*Pounds*	*Pounds*	*Pounds*
Second-cutting mature	36.0	29.9	125.2	31.5
Third-cutting interval	50.1	41.7	136.4	34.4
Second-cutting interval	47.4	39.5	101.3	25.5
First-cutting mature	38.4	32.0	82.5	20.8
First-cutting interval	44.1	36.7	114.4	28.8

It is apparent that the cows consumed a larger amount of dry matter in the form of hay than in silage. The relative amounts of dry matter consumed in hay and silage do not follow the same rankings for the various cuttings, however. This may be due in part to differences in palatability of the hay and silage that resulted from the curing and handling of the grass, but it is also due in part to the fact that the cows in the hay-feeding experiment were not accustomed to grass hay, when they were started on second-cutting mature hay, and did not have an opportunity to become accustomed to it before the supply was exhausted. Nor were the cows in the silage-feeding experiment accustomed to grass silage when they started on the second-cutting interval silage, though in this case the cows had a longer feeding trial and a better chance to become accustomed to the silage. It is doubtful if there was much difference between the silage and the hay made from the second-cutting interval grass or between the silage and hay from the second-cutting mature grass. There is no question but that the third-cutting interval grass was cut at the stage of maturity that made both the hay and silage far more palatable than the hay or silage of any other cutting. But even in this case the silage-fed cows consumed 7 pounds less dry matter per day. It is unfortunate that the supply of both hay and silage from this cutting was so limited. The difference in consumption of dry matter in silage and hay is reflected in the loss in body weight in the two groups of cows. One of the three cows in the hay-fed group gained in weight but the average loss for the three was 17 pounds during their 20-day test. All three cows in the silage-fed group lost weight, the average loss for the three being 62 pounds during their 40-day test.

Even though the silage-fed cows consumed less dry matter than the hay-fed cows, and even though they lost more than three times as much in body weight, their rate of decline in milk yield was just a little less during the 40 days they were on the silage ration than was that of the cows that were on hay for 20 days. Comparing the average milk yield of each group for the second, third, and fourth days with that of the last 3 days of their respective feeding periods shows that the silage-fed group declined an average of 14.66 percent and the hay-fed group declined an average of 14.83 percent. This appears to indicate that the silage (pound for pound of dry matter) had a greater feeding value for milk production than the hay. It was not possible to conduct digestion trials on the hay and silage. Watson (*11*) conducted digestion trials with sheep on grass silage and on grass hay that was artificially dried, and secured the digestibility coefficients given in table 21.

TABLE 21.—*Coefficients of digestibility on grass silage and artificially dried grass as reported by Watson, in trials with sheep*

	Grass silage	Grass hay (artificially dried)
	Percent	*Percent*
Dry matter	71.74	71.63
Organic matter	73.02	73.64
Ether extract	77.68	51.05
Crude fiber	77.29	77.59
Nitrogen-free extractives	71.73	74.29
Crude protein	67.70	67.08
True protein	49.55	67.86

Watson points out that the two points of difference in digestibility between grass silage and grass hay are in the digestibility of the ether extract and the true protein. He believes that the higher digestibility of the ether extract is due to the fact that it includes the organic acids formed as a result of the fermentation processes, all of which are soluble and thus completely digestible. He has found in other experiments that the digestibility of the true protein is depressed during the making of silage. Watson points out, too, that artificially dried grass, the digestibility of which is given in table 21, is superior to good field-cured hay.

The digestibility coefficients given by Watson for grass silage and grass hay are not entirely applicable to the grass silage and grass hay in the Huntley experiment, particularly because his figures apply to artificially dried hay, whereas the hay used in the Huntley experiment was field cured. They do offer some support, however, for the belief that the silage in this experiment (pound for pound of dry matter) was better for milk production than the hay.

The hay-fed cows were on about a 27 percent higher level of production at the start of the experiment than the silage-fed cows. This may account in part for the more rapid rate of decline in milk yield by the hay-fed cows. Comparing the milk yield of the silage-fed cows on the second, third, and fourth days of the test with their yield on the fifteenth, sixteenth, and seventeenth days, the period during which they were fed the silage made from the most immature grass, shows an increase in milk yield of 8.8 percent. On the other hand, the hay-

fed cows declined 4.6 percent from the second, third, and fourth days to the tenth, eleventh, and twelfth days of their test, the period during which they were fed the hay made from the most immature grass.

A comparison of the milk yield of the silage-fed group for the last 3 days they received silage made from the most immature grass with the yield for the last 3 days they received silage made from the most mature grass, shows a decline of 21.6 percent. During this period the silage-fed cows consumed a much smaller amount of dry matter than the hay-fed cows. The decline in milk yield for the hay-fed cows during the same period was 10.7 percent.

FEEDING GRASS HAY AND GRASS SILAGE TOGETHER

At the conclusion of the feeding trials with hay alone and with silage alone, 2 cows, 1 from the hay-fed group and 1 from the silage-fed group, were continued in a feeding experiment in which they received both grass hay and grass silage. It was planned to feed them at the rate of 2 pounds of silage to each pound of hay consumed. Sufficient silage was offered to meet this ratio, but neither cow consumed enough silage to maintain the balance. Because of the shortage of both hay and silage, the trial was continued only 24 days, from November 19 to December 12, inclusive. During the last 3 days, when both the hay and the silage were offered in unrestricted quantities, the cows ate more hay and less silage.

Table 22 gives the essential data on the hay and silage consumption and daily milk production for these two cows, H-49 and H-53.

Cow H-49 had been on first-cutting interval silage alone just previous to this hay-and-silage feeding test. This cow had scoured almost continuously on silage alone and she continued to scour on hay and silage. Her average consumption during the last 3 days she was on silage alone was 111 pounds per day and her average milk production for the 3 days was 33.4 pounds. She was continued on first-cutting interval silage in the hay-and-silage feeding test, and was fed first-cutting mature hay, in addition, for the first 9-day period, November 19–27. She consumed an average of 21.3 pounds of grass hay and 40.9 pounds of grass silage per day for the 9-day period. The ratio of consumption was 1 pound of hay to 1.9 pounds of silage. Her consumption of hay increased slightly from the first 3 days of this period to the last 3 days, but her consumption of silage remained about the same. Her milk production declined from 33.4 pounds per day (average of the last 3 days on silage alone) to 31.1 pounds per day (average of last 3 days of first 9-day period on hay and silage). This was a decline of about 7 percent in 9 days. It will be recalled that the first-cutting mature hay fed during this period was the poorest in quality of any cutting.

On November 28 the hay for cow H-49 was changed from first-cutting mature to first-cutting interval, but the silage remained the same. This feeding period was for 12 days. Her average daily consumption of first-cutting interval hay was 28.9 pounds, an increase of 7.6 pounds per day over her consumption of first-cutting mature hay. Her daily consumption of silage was 37.2 pounds, a decrease of 3.7 pounds per day. Apparently she preferred the first-cutting interval hay to the first-cutting interval silage. The ratio of consumption during this period was at the rate of 1 pound of hay to 1.3

TABLE 22.—*Consumption of hay and silage, milk production, and changes in body weight by two cows in the hay-and-silage feeding experiment*

Kind of hay and silage fed	Date fed	Cow H-49						Cow H-53					
		Hay		Silage		Milk production	Body weight	Hay		Silage		Milk production	Body weight
		Offered	Consumed	Offered	Consumed			Offered	Consumed	Offered	Consumed		
		Lbs.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
First-cutting interval hay and silage	Nov. 14	(1)	(1)	142.0	111.0	34.5		53.5	35.0	(2)	(2)	40.0	
	Nov. 15	(1)	(1)	118.0	98.0	34.0		60.0	42.5	(2)	(2)	37.9	
	Nov. 16	(1)	(1)	127.0	98.0	34.0		53.5	43.5	(2)	(2)	42.2	
	Nov. 17	(1)	(1)	131.0	113.0	31.9		54.0	46.0	(2)	(2)	43.1	[3] 1,345
	Nov. 18	(1)	(1)	140.0	122.0	33.8	[3] 1,287	58.5	41.0	(2)	(2)	43.0	
First-cutting mature hay and first-cutting interval silage	Nov. 19	20.0	16.0	40.0	40.0	35.1		20.0	13.5	40.0	40.0	43.7	
	Nov. 20	23.0	18.5	40.0	40.0	33.3		23.0	19.0	40.0	40.0	38.8	
	Nov. 21	28.0	21.0	42.0	40.5	31.4		25.5	20.0	40.0	40.0	38.5	
	Nov. 22	32.5	23.0	46.0	43.0	28.9		31.5	23.5	48.0	48.0	36.7	
	Nov. 23	32.5	22.5	45.0	43.0	30.0		35.0	26.0	52.0	52.0	38.2	
	Nov. 24	35.0	25.0	50.0	45.0	31.4		34.0	22.0	44.0	44.0	37.6	
	Nov. 25	32.0	21.0	42.0	40.0	33.0		35.5	19.5	39.0	39.0	37.0	
	Nov. 26	28.5	21.5	43.0	40.0	31.5		30.5	22.5	45.0	45.0	36.6	
	Nov. 27	33.0	23.0	46.0	37.0	28.8	1,277	26.5	18.5	37.0	37.0	33.7	1,296
	Nov. 28	34.5	28.5	57.0	39.0	30.5		33.5	31.5	63.0	50.0	34.9	
	Nov. 29	30.5	25.5	72.0	42.0	33.5		30.0	27.0	74.0	57.0	37.7	
	Nov. 30	37.0	30.0	60.0	40.0	37.0		36.0	27.0	54.0	42.0	42.9	
First-cutting interval hay and silage	Dec. 1	34.5	20.5	41.0	30.0	33.5		38.0	27.0	54.0	33.0	41.0	
	Dec. 2	30.5	32.5	65.0	37.0	33.1		34.5	26.0	52.0	49.0	40.7	
	Dec. 3	32.5	29.5	62.0	32.5	32.2		34.0	30.0	60.0	51.0	39.0	
	Dec. 4	34.0	31.0	62.0	28.0	32.1	1,260	32.0	27.0	54.0	33.0	40.2	1,320
	Dec. 5	32.0	28.0	56.0	37.0	32.4		32.0	30.0	60.0	33.0	40.5	
	Dec. 6	34.0	27.0	54.0	43.0	32.2		31.5	28.5	57.0	33.0	40.7	
	Dec. 7	35.0	27.0	54.0	38.0	32.7		33.0	29.0	58.0	47.0	41.7	
	Dec. 8	33.0	31.0	62.0	43.0	34.2		36.0	32.0	64.0	37.0	42.7	
	Dec. 9	43.0	36.0	72.0	37.0	33.4		36.5	31.5	63.0	44.0	40.1	
First-cutting interval hay and silage [4]	Dec. 10	33.5	28.5	50.0	30.0	32.6		41.0	38.0	30.0	14.0	40.5	
	Dec. 11	43.0	37.0	45.0	30.0	30.9		44.0	39.0	35.0	11.0	39.7	
	Dec. 12	31.5	25.0	18.0	12.0	31.3	[3] 1,274	27.0	24.0	27.5	20.5	39.7	[3] 1,297
Total for 24 days		792.0	628.5	1,224.0	887.0	775.0		782.5	632.0	1,190.5	939.5	942.8	
Average for 24 days		33.0	26.2	51.0	36.5	32.3	1,280	32.6	26.3	49.9	39.1	39.3	1,321
Alfalfa hay, corn silage, and grain	Dec. 13					31.3						30.4	
	Dec. 14					32.4						41.8	
	Dec. 15					35.1						44.8	
	Dec. 16					36.3						46.0	
	Dec. 17					37.6						45.5	
	Dec. 18					39.4						46.2	

[1] No hay fed.
[2] No silage fed.
[3] Average of 3 weights.
[4] Hay and silage offered in unrestricted quantities.

pounds of silage. Her daily milk production increased 7 percent from the last 3 days she was on first-cutting mature hay to the last 3 days on first-cutting interval hay. Her average production during the last 3 days of this period returned to the same level as that of the last 3 days on silage alone. It should be noted that this cow that had scoured throughout the test declined only 20 percent in milk yield from the second, third, and fourth days on silage alone to the nineteenth, twentieth, and twenty-first days on hay and silage—a period of 59 days.

Table 22 gives similar data for cow H-53. Just previous to starting on this hay-and-silage feeding test this cow was on first-cutting interval hay alone. During the last 3 days on hay alone, her average daily consumption was 43.5 pounds and her average daily milk production was 42.8 pounds.

During the first 9 days of the test, when fed first-cutting mature hay and first-cutting interval silage, this cow consumed an average of 20.5 pounds of hay per day and 42.8 pounds of silage. She consumed all the silage that was given her and refused a considerable portion of the hay. The ratio of consumption was 1 pound of hay to 2 pounds of silage. Her average daily milk production declined 16 percent, as measured from the last 3 days on hay alone to the last 3 days of this 9-day feeding period.

On November 28 she was started on first-cutting interval hay, and the first-cutting interval silage was continued. This feeding period was for 12 days. Her average daily consumption of hay increased by more than 50 percent from the last 3 days on first-cutting mature hay and first-cutting interval silage to the last 3 days of this 12-day period. The average daily consumption of silage increased slightly during the same period. Her average daily production increased from 35.8 pounds to 41.5 pounds, an increase of 16 percent. Her milk yield at the close of this 12-day period was back to within 3 percent of her yield at the close of her period on hay alone.

Starting December 10, the plan was to allow the cows to eat as much hay or silage as they desired. No attempt was made to control the ratio. The hay and silage were exhausted on the third day, before the cows were accustomed to the method of feeding, or the relative amounts of hay and silage they would have consumed were known. During the first 2 days cow H-53 greatly increased her consumption of hay at the expense of the silage. Cow H-49 showed some indications of doing the same, though not to the same extent. Neither cow consumed as much dry matter on these 2 days when the hay and silage was offered in unrestricted quantities as they had on the last 2 days of the preceding period, when the ratio of hay to silage was controlled.

Table 23 shows the relative amounts of dry matter consumed when the cows received both hay and silage and when they received hay or silage alone.

TABLE 23.—*Dry matter consumed by two cows when the ration was hay or silage alone, compared with the amount consumed when the ration contained both hay and silage*

Ration and feeding period	Average daily consumption of dry matter by cow—	
	H-53	H-49
	Pounds	*Pounds*
Last 3 days on hay	36.20	27.97
Last 3 days on silage		28.20
Last 2 days on first-cutting mature hay and first-cutting interval silage	27.39	37.90
Last 2 days on first-cutting interval hay and silage	36.60	

Cow H-53 consumed considerably less dry matter while she was receiving the first-cutting mature hay and the first-cutting interval silage than while she was receiving the first-cutting interval hay alone. When the first-cutting mature hay was replaced by first-cutting interval hay, however, her consumption of dry matter in hay and silage returned to the same level as when she was receiving the hay alone. So far as this cow is concerned, it cannot be said

that adding silage to the ration increased the amount of dry matter consumed over the amount consumed when hay was the entire ration. This is not true, however, of cow H-49 who had been on a ration of silage alone. Even on the hay-and-silage ration in which the relatively unpalatable first-cutting mature hay was fed, her consumption of dry matter increased slightly over her consumption when she was on silage alone; but when the hay was changed to first-cutting interval there was a marked increase in the consumption of dry matter over that on the ration of silage alone.

These very meager data appear to indicate that good hay added to a ration consisting entirely of silage will increase the consumption of dry matter, but that silage added to a ration consisting entirely of hay will not necessarily increase the consumption of dry matter.

At the close of the hay-and-silage experiment both cows were put on the herd ration to which they were accustomed—alfalfa hay, corn silage, and a grain mixture. Table 22 shows the milk production by these two cows on this ration for the 6 days following the hay-and-silage feeding test. The two cows made a sharp increase in milk flow during these 6 days. This was probably because (1) they were again on the ration to which they were accustomed; and (2) they received a grain mixture in addition to hay and silage. Cow H-49 received 27 pounds of alfalfa hay and 30 pounds of corn silage a day. Cow H-53 received 31 pounds of alfalfa hay and 30 pounds of corn silage a day. These amounts do not differ greatly from the amounts of first-cutting interval hay and silage they were consuming, but the grain was increased from 4 to 8 pounds per day during the 6 days.

The results of this experiment are in line with those obtained in a feeding experiment with Sudan-grass hay and Sudan-grass silage at the United States Dairy Experiment Station at Woodward, Okla. (*2*). They are also supported by the results of an experiment (*13, p. 12*) at the United States Dairy Experiment Station at Beltsville, Md., in which the value for milk production of beet pulp fed dry and beet pulp fed wet was compared.

Experiments conducted over much longer feeding periods will be required to settle definitely the question whether there is any advantage in feeding both hay and silage when the dry matter of the hay and silage are of equal value, but these experiments do indicate that there is no value in adding silage to the ration when hay that has a dry-matter content of equal value to that of the silage is available.

THE 1928 AND 1929 EXPERIMENTAL RESULTS COMPARED

The results of the grazing experiments, and of feeding the grass in the green form, and as hay and as silage for the 1928 and the 1929 seasons are summarized in table 24.

In order to make the results as nearly comparable as possible, most of the items of comparison have been computed on an acre basis. Even so, the results for the 2 years are not strictly comparable because of (1) the more favorable conditions for growth of grass in 1928; (2) the differences in producing capacities for milk and butterfat yields of the animals used in 1928 and in 1929; (3) the animals not being fed to capacity on the green grass, hay, or silage in 1928; and (4) the variation in the milk yields resulting from the variation in consumption of hay and silage made from grass of the various stages of maturity.

TABLE 24.—*Summary of yields of feed, and of milk and butterfat production of the cows fed grass in the different forms, for 1928 and 1929 seasons*

Items	Grazed		Grass clipped and fed green		Grass hay		Grass silage	
	1928	1929	1928	1929	1928	1929	1928	1929
Duration of grazing season or feeding trial.....days	99	109	99	92	37	20	11	40
Average daily number of cows per acre.....number	1.84	1.46	2.6	1.33	2.3	1.18	3.0	1.66
Production per acre:								
Milk.....pounds	4,575.0	5,509.0	4,041.0	3,896.0	5,195.0	4,420.0	7,993.6	4,762.0
Butterfat.....do	177.4	205.2	171.1	149.7	180.9	185.9	309.2	184.9
Decline in milk yield.....percent	[1] 35.2	[2] 30.6	[3] 18.6	[4] 20.4	[5] 18.6	14.8	4.9	14.7
Loss in body weight per acre.....pounds	314.0	195.6	238.0	48.0	101.0	96.0	----------	238.2
Yield of dry matter per acre.....pounds	----------	----------	5,669.0	4,270.0	6,501.0	3,991.0	5,576.0	3,991.0
Average consumption of feed per cow per day.....pounds	----------	----------	75.6	136.6	32.8	44.1	83.9	103.6
Average consumption of dry matter per cow per day.....pounds	----------	----------	19.8	32.5	27.3	36.7	21.2	26.1

[1] By cow H-32 during 84 consecutive days on pasture, from June 3 to Aug. 25, inclusive. She freshened May 29 and reached full flow of milk on June 3.
[2] By cow H-37 for the 92-day period, May 30 to Aug. 29, inclusive (tables 4 and 5).
[3] By cow no. 13 for the 69-day period from June 1 to Aug. 8, inclusive. This cow started on clipped grass May 19, freshened May 28, but did not reach the peak of her milk flow until the last 3 days in June. She gained 15 percent in milk production from the first 3 days to the last 3 days in June, and declined 29.2 percent thereafter.
[4] By cow H-32 for the 55 days she received clipped grass (tables 10 and 11).
[5] See text p. 6.

The effects of the stage of maturity of the grass when cut for hay and silage on the amounts consumed and the resulting milk yields are perhaps the most striking results of the entire experiment, but because of the limited amounts of hay and silage of the various cuttings available, it is not possible to show the results of feeding only the best hay and the best silage. Consequently the figures given in table 24 are for all the hay and all the silage, regardless of stage of maturity of the grass at time of cutting or of the quality of the roughage, except for that part of the 1928 grass silage that spoiled and was not fed.

The carrying capacity for an acre of grass, in all forms in which the grass was consumed, was higher for the 1928 season because of the much higher yield of grass that year. This is also shown in the yields of dry matter per acre, the average yield for 1928 in all forms being approximately 3 tons as compared to 2 tons in 1929. The carrying capacity per acre for the clipped grass, hay, and silage was somewhat greater than that for the pasture in 1928, for the reason that the cows were not fed to capacity on the grass hay and silage.

The carrying capacities for the four forms of feeding for the 1929 season agree fairly closely. The variations are due to the differences in the amounts of dry matter consumed. The consumption of dry matter was greatest for the hay, followed by the clipped grass and the silage in that order. The fact that the carrying capacity for the grazed pasture was second only to that of the grass silage probably indicates that the amount of dry matter consumed by the grazed cows was between the amount consumed by the cows fed silage and the amount consumed by the cows fed clipped grass.

The yields of milk and butterfat, calculated to the amount that would be obtained from an acre of grass when fed in each of the four

form of feeding, are remarkably uniform for the cows that were grazed and for the cows that were fed green grass and hay, but they are high for the silage-fed cows. The higher yield of the silage-fed cows in 1928 is probably due to the fact that they were on a higher level of production and that the feeding trial was short, lasting only 11 days. The yields for the 1929 season are also very uniform, except that from green grass, which is much lower than those from the other three forms. This low yield from green grass is partly due to the fact that the cow on this experiment was put on pasture at several periods during the season when there was not enough grass available for clipping, and that during these periods on pasture she suffered a marked decline in production. Attention is called to the closeness of the yields on the hay and the silage.

The percentage of decline in milk yield is probably more indicative of the value of the grass in each of the four forms of feeding than is the total milk yield calculated on an acre basis, since it is not influenced to the same extent by the level of production of the cows. The decline in milk yield by the silage-fed cows was just a little greater in 1928 than in 1929, if the difference in length of the two feeding trials is considered. This is to be expected in view of the lower consumption in 1928. The percentage of decline in milk yield for the silage-fed cows in 1929 was practically the same for a 40-day feeding trial as for the hay-fed cows during a 20-day trial. In view of the lower consumption of dry matter by the silage-fed cows, this appears to indicate that the silage was superior to the hay in feeding value for milk production. The percentages of decline in milk yield by the cows fed the green grass and by those grazed are greater than for those fed hay or silage, if no consideration is given to the length of the feeding trial. Considering the length of time cow H-37 was grazed, 92 days in 1929, the percentage of decline was no greater than for the cows fed silage for 40 days. The decline of 9.1 percent for the cow fed the green grass for 37 consecutive days is less than that for the grazed cow when length of time is considered. On the other hand, the percentage of decline for the cows fed hay and silage covers the period when they were fed both the good and the poor hay and silage.

To determine the actual feeding value of hay and silage as compared to that of the green grass or pasture, feeding trials should be carried out over a period of a year with hay and silage as good as that made from the third-cutting interval in 1929. If the hay or silage does not lose any of its nutritive content during the process of curing or fermentation and is made from grass cut at the most desirable stage of maturity, the milk yield should be maintained better when cows are on a ration of hay or silage than when they are grazed, or when they are fed grass cut from a permanent stand throughout the growing season, for the reason that the quality and quantity of the hay or silage would be more uniform than pasture or clipped grass over a long period of time.

One of the facts developed from the 2 years' work is that cows can consume enough green grass, grass hay, or grass silage, without the addition of other feeds to the ration, to supply the nutrients needed for body maintenance and a good flow of milk. The nutritive requirements of the cows in the various phases of the experiment have been calculated from their average weight and average production by

the Savage feeding standards. The nutrients consumed were calculated from the average consumption of dry matter and from the analyses for the grass, hay, and silage.

The samples analyzed in 1928 were so few that the 1929 analyses have been used for the 1928 computations. An average analysis of the interval and mature cuttings was used for the 1929 hay, and for the silage both years, while the analysis for the interval-cut hay alone was applied to the 1928 hay, since the hay was cut at an earlier stage that year than in 1929. The digestibility coefficients were taken from several sources.

Woodman (*12*) and associates conducted digestion trials with sheep on grass cut at monthly intervals during the 1929 season. A digestion trial was run on the grass representing each month from April to August, inclusive. An average of these five digestion trials is used as the coefficient of digestibility for the green grass fed in the Huntley experiment. These digestibility coefficients are:

	Percent
Crude protein	76. 6
Ether extract	48. 6
Nitrogen-free extract	81. 7
Crude fiber	78. 4

Unfortunately there are no digestibility coefficients entirely satisfactory for application to the grass hay used in this experiment. Lindsey and associates, as reported by Henry and Morrison (*6, p. 724*), conducted a digestion trial on grass hay that was cut when very mature.

Hodgson and Knott (*7*) conducted a digestion trial on pasture herbage cut at biweekly intervals and artificially dried by a process that required 12 minutes at temperatures of 100° to 200° F. Two-year-old Holstein heifers were used for this digestion trial.

Watson (*11*) conducted a digestion trial on pasture herbage artificially dried by a process that required approximately 20 minutes. The air-inlet temperature was 200° C. The hay was made from grass that had received a dressing of nitrogen 4 weeks before cutting, and was described as being "short leafy grass," which indicates that it was quite immature. The digeston trial was conducted with sheep.

The coefficients of digestibility obtained from these three sources are shown in table 25.

TABLE 25.—*Coefficients of digestibility for grass hay as reported by other investigators*

Reported by—	Crude protein	Ether extract	Nitrogen-free extract	Crude fiber
	Percent	*Percent*	*Percent*	*Percent*
Lindsey and associates	56. 00	48. 00	62. 00	63. 00
Hodgson and Knott	74. 92	21. 90	74. 55	72. 68
Watson	76. 35	59. 61	76. 94	79. 15

Since the hay fed at Huntley was made from grass cut before it reached an advanced stage of maturity, and since it was field cured, its digestibility probably would fall somewhere between that reported by Lindsey and that reported by Watson or Hodgson. The total digestible nutrients and digestible protein consumed are calculated for the hay for each of the above coefficients.

The coefficients for digestibility of silage, taken from Watson, have been cited.

The data showing the average body weight, and the average production, with the calculated requirements and the consumption for the cows fed the clipped grass, the grass hay, and the grass silage, are given in table 26.

TABLE 26.—*Digestible nutrients, digestible protein, calcium and phosphorus consumed and required per day by cows on clipped grass, grass hay, and grass silage, 1928 and 1929*

Items	Clipped grass		Grass hay		Grass silage	
	1928 [1]	1929	1928	1929	1928	1929
Average amount of feed consumed per cow per day.....pounds	86.8	136.6	32.8	44.1	83.9	103.6
Average amount of dry matter consumed per cow per day.....pounds	20.6	32.5	27.8	36.7	21.2	26.1
Average daily body weight.....do	1,195	1,368	1,332	1,369	1,320	1,281
Average daily milk production.....do	33.4	30.0	22.7	40.6	30.3	31.1
Average percentage of butterfat in milk.....percent	3.7	3.9	3.5	4.1	3.9	3.9
Average amount of nutrients consumed per cow per day.....pounds	14.71	23.21	[2] 15.44 [3] 18.06 [4] 19.51	[2] 20.79 [3] 24.27 [4] 26.25	14.45	17.80
Average amount of nutrients required per cow per day.....pounds	20.53	21.00	17.79	25.29	20.88	20.84
Digestible crude protein consumed per cow per day.....pounds	2.78	4.38	[2] 1.91 [3] 2.60 [4] 2.64	[2] 2.30 [3] 3.13 [4] 3.19	1.93	2.38
Digestible crude protein required per cow per day.....pounds	2.94	2.88	2.32	3.63	2.86	2.89
Calcium consumed per cow per day.....ounces	2.228	3.520	2.953	3.969	2.288	2.810
Phosphorus consumed per cow per day.....ounces	.949	1.498	1.258	1.691	.977	1.203

[1] For cow 13, fed clipped grass for 82 days.
[2] Calculated by the Watson coefficient of digestibility.
[3] Calculated by the Hodgson and Knott coefficient of digestibility.
[4] Calculated by the Lindsey and associates coefficient of digestibility.

In 1928 the cows fed the clipped grass did not consume enough grass to provide the protein or total digestible nutrients required for maintenance and production. It will be recalled, however, that these cows were not fed to capacity in 1928. In 1929 the cows were fed to capacity, and with an average daily production of 30 pounds of 3.9 percent milk, they consumed enough grass to give them a slight margin in total digestible nutrients and an excess of some 44 percent over requirements in protein. There was a very slight loss in weight in 1929 as compared to that in 1928.

The hay-fed cows in 1928 consumed enough hay on the average to supply the required amount of total digestible nutrients and protein when the Lindsey and Hodgson and Knott coefficients of digestibility are used. In 1929 the cows on the grass-hay ration had an average production of 40.6 pounds of 4.1 percent milk per day. Their average daily consumption of 44.1 pounds of hay was sufficient to provide them with the required amount of total digestible nutrients only, if the Lindsey coefficient of digestibility is used. These calculations are based on average consumption and average composition for all the various cuttings of hay. When receiving the third- and second-cutting interval hay the consumption was much greater and the hay was of much better quality than the average composition for all cut-

tings. Consequently, on the better hay, even with the higher milk yield, these cows obtained enough nutrients from hay alone to meet their requirements.

In 1928 the silage-fed cows did not eat enough silage to provide nutrients for their requirements. This probably accounts for some of the loss in weight of the silage-fed cows in 1928, though it appears that not all the abnormally large loss in weight can be accounted for in this way. In 1929 the increased consumption of the silage-fed cows was still insufficient to provide enough nutrients for their requirements, though the shortage in protein was slight.

As stated previously, calcium and phosphorus determinations were made on the first 10 samples of the clipped grass secured in 1929 only. The average for those 10 samples was 0.676 percent calcium and 0.288 percent phosphorus, on a dry-matter basis. This average has been applied to the 1928 and 1929 consumption figures for green grass, grass hay, and grass silage in table 26. These calculations for calcium and phosphorus, especially for the hay and silage, are only indicative. Estimates as to the calcium and phosphorus requirements of cows in milk differ considerably. Ellenberger (*3*) states that results of his experiments check fairly closely with the estimate of Kellner that a 1,000-pound cow producing 20 pounds of 4 percent milk would require 2.25 ounces of calcium and 1 ounce of phosphorus. On this basis, the cows fed the green grass in 1928 did not receive enough calcium or phosphorus. In 1929, however, the grass consumed contained approximately the amount of calcium and phosphorus estimated as required by Kellner. The 1928 hay-fed cows consumed enough hay to exceed their requirements for calcium and phosphorus, while the 1929 hay-fed cows consumed a little more calcium and phosphorus than was needed to meet their requirements. The silage-fed cows were considerably below their mineral requirements in both 1928 and 1929.

These experiments indicate that cows can consume enough grass to meet their nutritive requirements for body maintenance and for a milk flow of at least 30 pounds per day. If grass hay is of good quality, and is made from grass at an immature stage of growth, the grass hay alone will supply nutrients for maintenance and a milk yield of somewhat more than 40 pounds of 4 percent milk. (See production of cows when fed hay of the most immature stages of growth.) The cows did not consume enough grass silage to provide the nutritive requirements for maintenance and 30 pounds of 4 percent milk, though the slower rate of decline in milk yield of the cows receiving the grass silage as compared with those receiving the grass hay indicates that the grass silage may be somewhat superior to the grass hay in stimulating milk flow.

SUMMARY AND CONCLUSIONS

The fact that immature grasses are high in protein and low in crude fiber and that the percentage of protein declines and the percentage of crude fiber increases as the plant matures was discovered as far back as 1883 by research workers in the United States Department of Agriculture, was studied in more detail by Morse at New Hampshire in 1888, and has been confirmed by other investigators from time to time since then; but apparently no attempt has ever

been made to take advantage of this most important discovery in feeding livestock. The work of Woodman and associates, on the chemical composition of grasses at different stages of maturity, at the University of Cambridge in more recent years, has emphasized the value of immature grasses for feeding purposes.

So far as the authors know the investigational work reported in this bulletin is the first work with livestock—outside of digestion trials—to compare the feeding value of the immature grass and its products, hay and silage, with that of the mature.

Stage of maturity of grass cannot always be accurately measured in terms of "days' growth." Temperature or moisture conditions may hasten or retard the growth.

The marked preference of the cows for hay or silage made from immature grass as compared to that made from mature grass is shown by the great difference in rate of consumption and production. A change from immature to mature hay or silage resulted in a prompt decrease in consumption and production.

The gain in milk yield and loss in body weight of cow H-37 during the 1929 season when she was pastured on the experimental plot, and the decline in milk yield and gain in body weight when she was on other pasture, suggests that grasses at different stages of maturity may have very different effect on the stimulation of milk flow and the gain in body weight.

The experimental cows consumed more dry matter in the form of hay than in silage. The consumption of both hay and silage was greatest when the hay or silage was made from the third-cutting interval grass. The average daily consumption for this cutting was 50.1 pounds of hay containing 41.7 pounds dry matter, and 136.4 pounds silage containing 34.4 pounds dry matter. The consumption of dry matter in the form of green grass was between that of the hay and silage.

The cows fed the grass hay in 1929 were on a higher level of production than the cows fed green grass or grass silage. Their average milk yield per day was 40.6 pounds. On the basis of the Hodgson-Knott digestibility coefficient their consumption of digestible nutrients and protein did not quite meet their requirements; on the basis of the Watson coefficient of digestibility there was a considerable shortage of digestible nutrients under requirements; and on the basis of the Lindsey coefficient there was a slight excess of nutrients consumed over requirements.

The silage-fed cows lost weight more rapidly than the hay-fed cows but their decline in milk flow was approximately the same in 40 days as that for the hay-fed cows in 20 days. These declines are for the entire feeding period, however, and therefore include the time when the cows were receiving both the good and the poor hay and silage.

There is some indication that the grass silage was more stimulating to milk flow than the grass hay.

Adding grass silage to the ration of a cow receiving grass hay did not increase the consumption of dry matter, but adding grass hay to the ration of a cow receiving grass silage did result in an increased consumption of dry matter.

Green grass, whether grazed or cut and fed green, can be consumed in quantities large enough to supply the nutrients for body maintenance and for a large flow of milk when the grass is available in

sufficient quantities and at an immature stage. The difficulty in maintaining a large flow of milk over a considerable period on grass alone is caused by the great variation in rate of growth at different seasons, even where moisture is available. The variation in the growth of the grass results in an oversupply of nutrients at one period and an undersupply at another. This is apparently the main cause of decline in milk flow of cows grazed or fed green grass.

In 1928 the same number of cows were fed the clipped grass as were being pastured on a plot of the same size as that furnishing the clipped grass. The 1928 cows consumed an average of only 75.6 pounds of green grass per day. Since the same number of cows were grazed, it may be assumed that the grazed cows obtained approximately the same amount of grass. The 1929 cows when fed to capacity, however, consumed an average of 136.6 pounds of green grass per day. This may indicate the impossibility of properly determining the number of cows that should graze a plot of given size, or it may indicate that a cow will eat a great deal more when the grass is cut and brought to her than when she has to harvest it herself.

Comparisons of the yields of dry matter, protein, and the percentage of protein, of the four plots in 1929, show that the two plots that were cut four times had the first and third highest yields of dry matter, the plot cut three times had the second highest yield, and the plot cut twice had the lowest yield. The yield of protein and the percentage of protein are definitely related to the number of cuttings, the plots cut four times having both the greatest yield of protein and the highest percentage of protein, while the plot cut twice had the lowest. The yield of protein (on an acre basis) on one of the plots cut four times was a little more than double that of the plot cut twice.

Although the incompleteness of these experiments is recognized, the results, together with those of other experiments by this Bureau, point the way to possible changes in methods of livestock feeding. Some of these methods or changes are—

The livestock man may have most of his land in permanent grass and legumes. He may graze his animals, but the surplus growth of grasses and legumes may be saved in the form of hay or silage, to be fed as supplements to the pastures and to form either the entire ration or the main part of the ration during that part of the year when grazing is not available.

To make such a system possible the grass would have to be cut at an immature stage of growth such as that of the third-cutting interval. This would be true at least for milk production.

The hay, silage, or grazed grass would be the basal ration. Grain could be added in such amounts as increased production would warrant. These experiments and others carried out by this Bureau and under way, show that dairy cows can consume an amount of hay, silage, or green grass sufficient to support body maintenance and a good flow of milk.

The advantages of such a system of livestock farming would be: Less cultivation of soil; conservation of soil fertility and reduction of soil erosion; farms would keep the number of animals they could support; when prices of products were low, more dependence could be put on the hay or silage ration, with perhaps a lower but more profitable production.

Animals that have been accustomed to a heavy grain ration cannot be changed abruptly to a ration of roughage alone without a marked loss in production. Such animals must develop the ability to consume large amounts of roughage. In any event a roughage ration will not be successful unless the roughage is of fine quality in every respect.

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