YIELD, CHEMICAL COMPOSITION, AND FEEDING VALUE FOR MILK PRODUCTION OF

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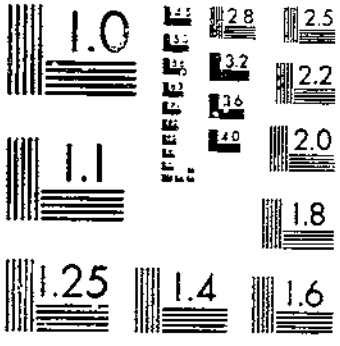

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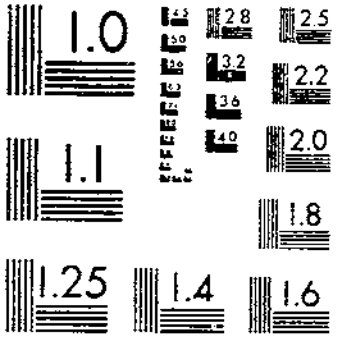

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Yield, Chemical Composition, and Feeding Value for Milk Production of Alfalfa Hay Cut at Three Stages of Maturity[1]

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INTRODUCTION

Alfalfa hay ranks high as a roughage feed for dairy cattle and is grown widely throughout the United States. In 1938, according to Agricultural Statistics (*15*),[3] 28,858,000 tons of alfalfa hay was pro-

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[3] Italic numbers in parentheses refer to Literature Cited, p. 50.

duced on 13,462,000 acres. This was 24 percent of the total acreage and 36 percent of the total production of tame hay.

Several years ago the Bureau of Dairy Industry began a series of roughage-feeding experiments at its various field stations to develop information with which to improve the quality of roughages and increase their use in feeding dairy cows for economical milk production. In one experiment (*6*), Holstein cows of good producing ability were fed throughout the lactation period on good-quality alfalfa hay exclusively, and they produced at remarkably high levels. Feeding experiments with Sudan grass (*1*) and pasture grasses (*4, 5*) showed definitely that these roughages had a much better milk-producing value when they were cut at an early stage of maturity than when they were cut at a more mature stage.

Since alfalfa hay is so widely used for milk production, it is important to know what effects cutting the crop at various stages of maturity might have on the duration of the stand or on the total yield of feed. It is also important to know whether cutting the crop at any particular stage of maturity would improve its milk-producing value enough to compensate for any adverse effects on the stand or yield.

This bulletin gives the results of an investigation, at the United States Department of Agriculture Dairy Field Station, Huntley, Mont., in which alfalfa hay was cut at three different stages of maturity and fed to dairy cows as the sole ration throughout the lactation period.

REVIEW OF THE LITERATURE

A number of research workers have studied the effect of cutting the alfalfa crop at different stages of maturity on the stand and on the yield and composition of the hay obtained. It is well established that within certain limits the stand is not materially affected and that as the plants advance toward maturity there is a decrease in protein content and an increase in fiber content. Comparatively few experiments have been carried out to test the relative feeding value of alfalfa cut at different stages, and the present investigation appears to be the first long-time feeding experiment with dairy cows. This review of the literature on work with alfalfa cut at different stages is confined to the few experiments that include nutritional aspects.

Mills (*9*) in 1896 and Foster and Merrill (*2*) in 1899 carried out probably the earliest work of this nature, at the Utah Agricultural Experiment Station. As a result of harvesting alfalfa (1) when first blossoms appeared, (2) when in full bloom, and (3) when half the blossoms had fallen, they obtained the largest yields of hay per acre, and the greatest amount of beef per acre and per unit of hay, from the earliest stage and the smallest amounts from the most mature stage. The earliest stage hay also contained the highest amount of protein and most leaves. All factors considered, they concluded that for beef-cattle feeding, alfalfa should be cut when the first bloom appears.

Salmon and coworkers (*12*) at the Kansas Agricultural Experiment Station cut alfalfa from small plots for 8 years (1914–21), when at the bud, one-tenth-bloom, full-bloom, and seed stages. Cutting in the bud stage (before any blossoms appeared) markedly decreased the vigor, stand, and yield, the effect being clearly apparent during the

second year. Cutting at one-tenth bloom also had a similar effect, but this result was not apparent until much later. Cutting at full bloom maintained the stand and the vigor of the plants to a satisfactory degree. Delaying cutting until the seed stage (when pods were well formed but not mature) reduced the yield, but not the subsequent stand or apparent vigor of the plants. They were of the opinion that frequent cutting stimulated growth and caused larger yields, until the plants were weakened, after which the yields were reduced. The proportion of the leaves harvested tended to decrease as cutting became less frequent, but the first cuttings made up so much of the total crop that the effect was not great. The ash and protein content decreased as cutting was delayed, while the crude fiber content increased. Sixty- to ninety-day feeding tests (for 3 years) with steers on alfalfa hay without any other feed showed that 1,628 pounds of bud-stage hay produced 100 pounds of gain in liveweight as compared to 2,086 pounds of the one-tenth-bloom hay, 2,163 pounds of full-bloom hay, and 3,910 pounds of seed-stage hay. Digestion trials showed an average digestion coefficient of 78 percent for the protein in hay cut at the bud stage, 73 percent for that in the one-tenth-bloom and full-bloom hay, and 67 percent for that in the hay cut at the seed stage. The crude fiber in the bud-stage hay had an average digestion coefficient of 35 percent, as compared to an average of 48 percent for the one-tenth-bloom, 43 percent for the full-bloom, and 41 percent for the seed-stage hay.

Kiesselbach and Anderson (*8*) at the Nebraska Agricultural Experiment Station cut alfalfa at the prebloom, initial-bloom, one-tenth-bloom, new-growth (between one-tenth-bloom and half-bloom), half-bloom, full-bloom, and seed stages. They showed conclusively that the protein content decreased from 21.98 percent for the prebloom stage to 18.13 for the full-bloom stage, and that the crude-fiber content increased from 25.13 to 30.82 percent. The new-growth (definite appearance of new shoots at the crown) and half-bloom stages gave the greatest yield of hay per acre and the seed stage gave the smallest. Cutting at relatively immature stages tended to thin the stand and retard root development. The investigators concluded that from the combined standpoint of acre-yields of hay and feed constituents, quality of hay, and permanency of stand, cutting at the new-growth stage was the most desirable practice. Under normal blooming conditions this stage falls between the one-tenth-bloom and half-bloom stages and the time to cut may be judged by either the new growth or bloom.

Woodman and associates (*16*, *17*) in England carried out exhaustive field trials and digestion trials with sheep on alfalfa (lucerne) cut at the prebud, bud, and flowering stages. As compared to frequently cut pasture grass, they considered that alfalfa cut in the bud and flowering stages was distinctly inferior to the immature grass, and comparable in nutritive properties to what they term a superior coarse fodder. Alfalfa cut at a prebudding stage was superior to later cuttings, and compared favorably with young pasture grass in nutritive value. These workers point out that the alfalfa plant produces fiber at an early stage of growth, and that the digestibility of the fiber diminished rapidly as a result of lignification. The fact that the digestibility of the protein and nitrogen-free extract did not diminish

correspondingly early, suggested to them that development of fiber and its lignification takes place mainly in the stems. The average crude protein content was 28.1 percent for five cuttings of prebudding hay (moisture-free basis) as compared to 21.5 and 19.3 percent for the bud-stage and bloom-stage cuttings, respectively. The crude-fiber content averaged 19.3 percent for the prebud-stage, and increased to 26.5 for the bud-stage, and 27 for the bloom-stage hay. Digestion coefficients were considerably higher for hay cut in the prebud stage than for hay cut at the later stages. The digestion coefficients for crude protein averaged 80 percent for the prebud-stage, 78 percent for the bud-stage, and 76 percent for the bloom-stage hay. Those for crude fiber averaged 64, 48, and 43 percent, respectively.

Sotola (*13*) of the Washington Agricultural Experiment Station carried on investigations with irrigated alfalfa hay that was produced in the Yakima Valley and cut at one-fourth, one-half, and three-fourth bloom stages. The protein content decreased and the fiber content increased as the plants matured. Digestion trials were conducted with lambs. The hay that was cut at the half-bloom stage was highest in digestible crude protein and in total digestible nutrients. It also gave the highest yields of nutrients per acre. In later experiments comparing the nutritive value of alfalfa leaves and stems, Sotola (*14*) found that 67 to 83 percent of the protein of the alfalfa plant was contained in the leaves, and that a given weight of leaves was 3.57 times as efficient as the same weight of stems in supplying digestible protein.

The results obtained at these stations, and by Newlander and coworkers (*11*) at the Vermont Agricultural Experiment Station, are compared later with data obtained in this experiment (pp. 25 and 26).

EXPERIMENTAL PROCEDURE

The investigation was conducted with two distinct objectives in view: (1) To determine the effect of cutting alfalfa at different stages of maturity on the stand of alfalfa, on the yield of hay, and on the chemical composition, color, and leafiness of the hay. (2) To determine the relative nutritive value of the hays cut at the different stages of maturity, by feeding experiments and digestion trials.

The investigation was continued for several years in order to observe the cumulative effect, on the yield and stand of alfalfa, of cutting the crop at the different stages and also to minimize yearly variations in the data obtained. Data on yields were obtained for the 3 years 1935, 1936, and 1937, and observations were made on the stand during these years and also during the cropping season of 1938.

Three stages of maturity were selected for cutting the alfalfa in this experiment, as follows: (1) Initial-bloom stage, when not more than 10 percent of the plants were in bloom, (2) half-bloom stage, when approximately 50 percent of the plants were in bloom, and (3) full-bloom stage, when 90 to 100 percent of the plants were in bloom. Under the conditions of this experiment, the extent of bloom was considered the most desirable basis on which to determine stage of maturity because the different stages could be easily recognized. These three stages were selected also because it was thought they would have the least undesirable effect on the yield and stand.

The agronomists at the Huntley station assisted in the agronomic phases of the experiment and gave valuable advice in regard to stage

of bloom and stand.[4] Determinations of the composition of the hay were made at Beltsville, Md.[4]

The feeding trials with dairy cows were for full yearly lactation periods; and the ration of each group was limited to hay, thus making any difference in the nutritive value of the different hays more apparent than if other feeds were included in the ration.

Digestion trials with sheep were run on the different hays.

The Huntley station, where the field work and the feeding trials with dairy cattle were carried out, is located on the Huntley Reclamation Project in the Yellowstone Valley of southern Montana. The essential climatic data for this locality are given on pages 8 and 9.

The Field Used

A field was rented for this experiment, which consisted of 15 acres that had been seeded to alfalfa in 1933. The soil was considered heavy and not as desirable for alfalfa as some of the lighter soils. The stand of alfalfa was excellent and uniform, however, and as the field could be irrigated quite uniformly it was considered desirable for this investigation. It was remarkably free of weeds. Although no accurate records are available concerning the history of this field prior to 1935, no fertilizer or manure was applied for several years prior to 1935 or during the 3 years the experiment was in progress.

Cutting, Curing, and Storing the Hay

The field was divided into three plots of approximately 5 acres each. Each year of the experiment the alfalfa on one plot was to be cut at the initial-bloom stage, that on another plot at the half-bloom stage, and that on the remaining plot at the full-bloom stage. Because of weather and seasonal conditions it was impossible to adhere strictly to this schedule at all times, as will be brought out in discussing the results.

After the hay was cut it was allowed to remain in the swath until well wilted, when it was raked into windrows with a dump rake and cocked. When considered properly cured it was hauled to the barnyard, weighed, and either stacked in a yard adjacent to the barns or placed in the mow. As was to be expected in an experiment of this kind, some of the cuttings were put up in ideal condition while others were somewhat damaged by rain. Figure 1 shows the extent of blooming in the three different stages just before the second cutting in 1937. Figure 2 shows a portion of the experimental field on which hay was being cut, and also illustrates the general topography.

Determining Composition and Feeding Value

Samples of each individual cutting were taken at the time it was stacked or placed in the mow, and also later when it was fed. Most of the hay produced on the three plots was fed to groups of Holstein cows for full lactation periods of 365 days. Details of the feeding procedure are given on page 26.

[4] See footnote 2, p. 1

When the hay from a cutting was being fed, weekly samples were taken. At the end of the feeding period (365 days) these samples were thoroughly mixed by cuttings, divided into two parts, and both parts sent to Washington, D. C., for analysis. One part was used for determining the chemical composition and the other for determining the color, grade, and leafiness of the hay.[4]

In order to calculate the amount of dry matter and nutrients consumed by the cows, dry-matter determinations were made on the alfalfa hay at approximately monthly intervals during the feeding

FIGURE 1.—*A*, Initial-bloom, *B*, half-bloom, and *C*, full-bloom stage hay, 1937, ready for second cutting.

experiment. These determinations showed somewhat higher percentages of dry matter than those made at the time of stacking or placing the cutting in the mow. To avoid the use of two sets of dry-matter percentages, those made at the time of feeding are used in all dry-matter calculations.

A sufficient amount of each stage of hay from the 1937 crop was sent to the Western Washington Experiment Station, Puyallup, Wash., for conducting a 15-day digestion trial with sheep.[4] Samples of the hay fed and the feces of the sheep were sent to the Beltsville, Md., laboratory, where the chemical analyses for determination of digestibility were made. This is referred to in more detail in the discussion of the digestibility of the hays.

[4] See footnote 2, p. 1.

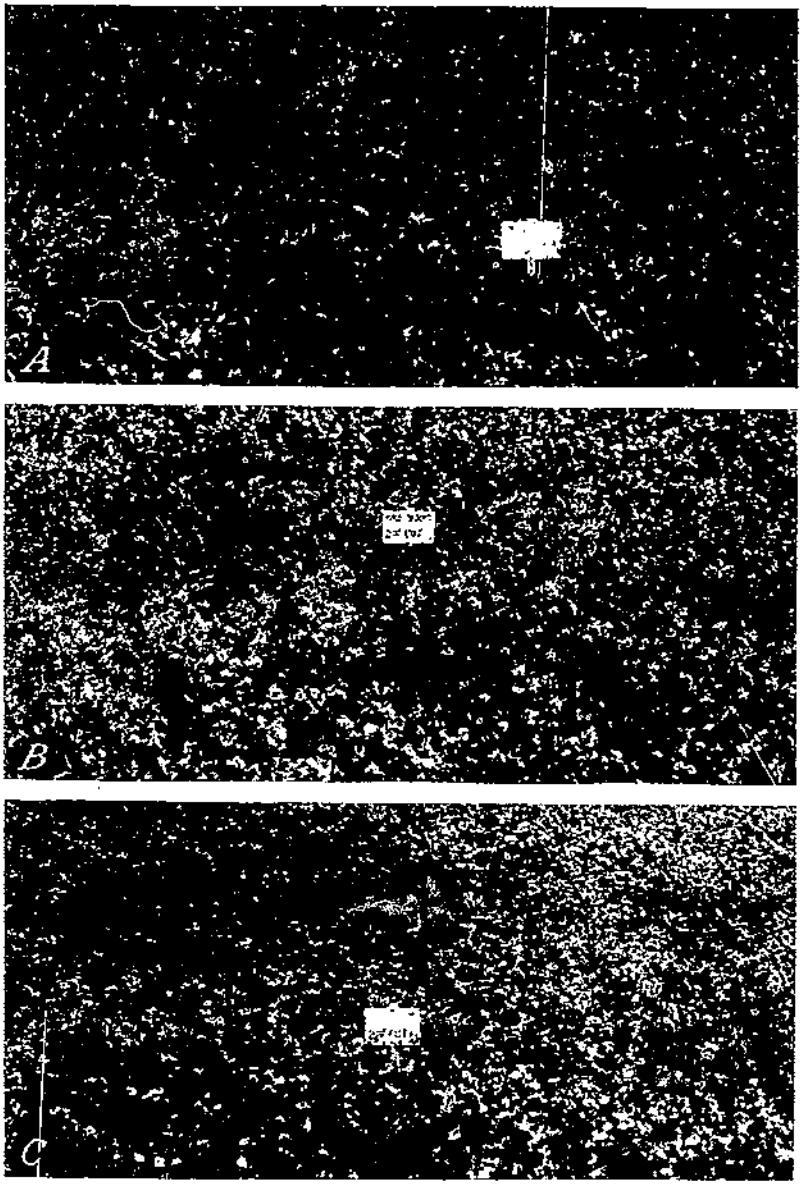

FIGURE 2.—Portion of the experimental field, on which hay is being cut, showing the general topography.

CLIMATIC DATA

Climatic data on the general weather conditions at Huntley, including temperatures, precipitation, and frosts, are summarized by month and years in tables 1, 2, and 3.

TABLE 1.—*Highest, lowest, and mean monthly temperatures at the Huntley, Mont., field station*[1] *for the years 1935, 1936, and 1937, and mean temperatures for the period 1911–37*

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.
1935:												
Highest	62	67	72	81	79	92	101	102	93	83	61	57
Lowest	−26	1	−13	−1	27	33	43	35	22	4	−14	5
Mean	22	34	28	41	51	62	72	67	59	46	30	31
1936:												
Highest	55	48	63	86	96	104	106	101	99	87	68	60
Lowest	−16	−53	−7	−7	34	39	47	41	26	16	−10	−15
Mean	20	−3	35	44	62	69	79	71	59	48	35	23
1937:												
Highest	39	55	67	77	99	103	104	101	93	81	67	49
Lowest	−42	−33	2	19	26	38	44	40	29	23	−3	−20
Mean	1	17	34	46	59	63	74	70	61	50	33	24
1911–37 (mean)	19	28	32	45	55	64	72	69	58	46	34	23

[1] Data furnished by the Division of Western Irrigation Agriculture, Bureau of Plant Industry.

TABLE 2.—*Precipitation at the Huntley station by months and years during 1935, 1936, and 1937, and the average precipitation for the period 1910–37*[1]

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
	In.	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*
1935	0.45	0.38	2.80	1.22	2.91	1.33	1.08	0.28	0.43	0.57	0.80	0.48	12.73
1936	.98	1.23	.38	.73	1.22	1.71	.90	.51	1.14	.60	.15	.27	9.82
1937	.30	.53	.55	.47	.53	2.55	.47	.08	.85	2.36	.45	.38	9.52
1910–37 (average)	.83	.53	.98	1.18	1.60	1.64	.85	1.02	1.11	1.10	.75	.66	12.25

[1] See footnote 1, table 1.

TABLE 3.—*Data on last killing frosts in spring and first in autumn, and length of frost-free period, at the Huntley station*[1]

Year	Last killing frost in spring		First killing frost in autumn		Frost-free period
	Date	Minimum temperature	Date	Minimum temperature	
		°F.		°F.	*Days*
1935	May 14	31	Sept. 24	32	132
1936	Apr. 29	31	Sept. 15	26	138
1937	May 15	26	Sept. 23	32	130
1911–37 (average)	May 19	30	Sept. 17	30	120

[1] See footnote 1, table 1.

Table 1 shows temperature data. It will be noted that extremely low temperatures were recorded in February 1936, when a low of −53° F. was reached and in January 1937 when a low of −42° was reached. While the mean temperatures for 1935, 1936, and 1937 vary somewhat from the 1911–37 mean, it is not believed that this had any significant effect on the results of this experiment.

Table 2 shows the monthly precipitation at Huntley during the years the experiment was in progress. Attention is directed to the fact

that the total yearly rainfall in 1936 and in 1937 was markedly lower than the yearly average for 1910–37. The amount and distribution of rainfall, or especially snowfall, during the winter months may have been a rather important factor in causing the winter-killing of plants that were weakened by too frequent cutting during the summer months.

Table 3 shows the dates of the last killing frost in the spring and the first in the autumn, together with the length of the frost-free period. The frost-free period for each of the 3 years that this experiment was in progress was somewhat longer than the 1911–37 average of 120 days.

GROWTH OF ALFALFA ON THE INITIAL-, HALF-, AND FULL-BLOOM PLOTS

Considerable variation in seasonal conditions and in insect damage occurred during the 3 years that the experiment was in progress. Since these factors are of importance in the interpretation of the results, a description is given of the field observations, by seasons, of the growth of the alfalfa and the cuttings obtained on the three plots harvested at different stages of naturity, in 1935, 1936, and 1937, and the growth and stand in the spring of 1938. The date of each cutting and the period of growth are listed in table 5 on page 19.

Observations of Growth and Cuttings in 1935

INITIAL-BLOOM PLOT, 1935

Growth started April 15, and the first cutting was made on June 20, when the alfalfa averaged 25 inches in height. Some yellow sweetclover was present, which was in bloom. There were practically no weeds. The second cutting was made on August 1, when the alfalfa averaged 18 inches in height. The bloom was fairly uniform throughout the plot. Grasshoppers were too few to check growth of new shoots. The third cutting was made on September 18, when the alfalfa averaged 10 inches in height, and was beginning to flower uniformly over the entire plot. New growth shoots were just beginning to appear. Some damage was done by grasshoppers along an irrigation ditch. This plot went into the winter with an aftermath of 4 inches. The hay from this third cutting was stacked somewhat too green. It came out of the stack in good condition but was of a tobacco-brown color in the center of the stack. No mold was present.

HALF-BLOOM PLOT, 1935

The first cutting was made on June 24. The alfalfa averaged 27 inches in height and was quite uniform, except that a small strip along an irrigation head ditch was somewhat shorter and a little farther along in bloom. A few yellow sweetclover plants were present and in bloom. The second cutting was made on August 12, at an average height of 17 inches and was uniform. Grasshoppers had checked the growth somewhat for this cutting, although poisoned bait had been spread continually. The third cutting was made on October 1. Several frosts had checked the blooming and it was difficult to determine when the plants were in the half-bloom stage. The new growth shoots were from one-fourth to one-half of an inch in height. The aftermath averaged 2 inches in height.

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FULL-BLOOM PLOT, 1935

Heavy rains fell after the first cutting on July 2, and two light rains fell after the hay was raked. Consequently this cutting was of poor color, although most of the leaves were saved. The hay averaged 27 inches in height, and a small amount of yellow sweetclover was present and in bloom. The second cutting was made on September 1 under good haying conditions, when the plants averaged 17 inches in height. Grasshoppers had damaged this plot and cutting more than the initial-bloom and half-bloom plots, as they seemed to concentrate on the full-bloom plot after the cuttings on the other two plots were made. The tops of the plants in many instances had fallen because of grasshopper damage. The full-bloom plot went into the winter with an aftermath averaging 7 inches in height.

OBSERVATIONS OF GROWTH AND CUTTINGS IN 1936

The summer of the 1936 growing season was one of the hottest on record for Huntley, which no doubt materially affected the yields of hay on all plots. In an effort to keep down grasshoppers, poison bait was applied on all plots throughout the season.

INITIAL-BLOOM PLOT, 1936

The first cutting was made on June 13, and averaged 25 inches in height. Light showers and hot winds caused a small loss (estimated at 5 percent) of leaves in curing, hauling, and stacking. A few weeds were present especially in the area along the irrigation ditches. The second cutting was made on July 22 when the temperature was 100° F. The hot weather and grasshoppers that followed the first cutting had considerably checked the growth and the alfalfa averaged 13 inches in height. The new shoots were from one-eighth to one-fourth of an inch in length. The third cutting on August 29 was put up under ideal weather conditions with practically no loss of leaves. While the weather was exceptionally hot during August, the grasshoppers did practically no damage to the third cutting. The initial-bloom plot went into the winter with a growth of 6 inches.

HALF-BLOOM PLOT, 1936

Damage by grasshoppers was so great that it was difficult to determine the extent of the bloom, but the alfalfa was cut on June 22 and the plants averaged 25 inches in height. The grasshoppers attacked the flowering parts of the plants, destroying and shattering the petals. The loss of leaves was estimated to be between 5 and 10 percent, and was attributed to extremely hot weather. Recovery following the first cutting was very slow because of grasshopper injury. The plot was mowed the second time on August 3, but rain prevented raking until August 5. The growth was rather uneven as regards bloom, probably on account of grasshopper damage. The plants averaged about 16 inches in height when cut. It is estimated that the yield on this cutting was reduced by 25 percent as a result of grasshopper injury. The third cutting was made on September 16. Press of other work caused delay in raking and hauling. This together with a light frost the day before cutting caused considerable loss of leaf. The aftermath was 2 to 4 inches in height.

FULL-BLOOM PLOT, 1936

The yield of first cutting, made on June 25, was reduced because of grasshopper damage. Although the plants were at least in the full-bloom stage, no flowers remained because of the damage. The plants averaged 26 inches in height. The second cutting on August 12 was put up under ideal conditions with but little grasshopper damage. A third cutting was made on this plot on September 30. At the time of cutting the first flowers had not appeared and the plants averaged 10 inches in height. The hay from this cutting was not fed as full-bloom hay. The aftermath averaged 3 inches in height.

As a whole, the hot weather, grasshopper damage, and rains at the time of cutting for the 1936 season, were unfavorable from the standpoint of yield and quality of the hay.

Observations of Growth and Cuttings in 1937

The alfalfa on all three plots started growth about April 5. On April 20, a check was made to determine whether there had been any noticeable effect on the stand from cutting at various stages of maturity. Very little winter-killing was noticed, possibly less than 1 percent, and it appeared to about the same extent on all three plots. The growth on the initial-bloom plot was taller on that date than that on the half-bloom or full-bloom plots. This was probably because the initial-bloom plot went into the winter with a greater aftermath than the other two plots. This aftermath had a tendency to hold the snow, which provided more moisture for the plants to start spring growth in 1937. About 1 acre of the initial-bloom plot showed a slower starting growth than the remainder of the plot. It was noted during the winter of 1936–37 that the snow blew off of this portion of the field and left it bare.

The spring of 1937 was extremely dry, making it necessary to irrigate the entire field as soon as water was available, on May 10.

Continued dry weather made it necessary to irrigate the field again the first week in June, but immediately following this irrigation a rain that totaled 0.64 inch fell. By June 10 the first flowers were appearing on the initial-bloom plot, but the field was too wet to cut. Between June 10 and 13 there was an additional 1.84 inches of rainfall. This delayed cutting of the initial-bloom plot until June 21, at which time the field was in the half-bloom stage. Grasshoppers were held in check by the rain. A description of the cuttings obtained from the three plots during this season follows.

INITIAL-BLOOM PLOT, 1937

When the delayed first cutting was made on June 21, 1937, the new shoots were 1½ to 2 inches long and the plants were 32 inches in height. While the alfalfa was mostly in the half-bloom stage, there was a small area in the three-fourths-bloom stage, due probably to difference in soil. The hay was raked on June 23, cocked on June 24, and hauled and stacked on June 25 and 26. The color was good and practically all leaves were saved.

The second cutting on this plot was made on July 20, raked on July 21, and cocked on the same day. The plants averaged 20 to 24 inches in height, and new shoots were 1 to 1½ inches. The hay went into the stack in an excellent condition.

The third cutting was made on August 29, raked on September 2, and hauled and stacked on September 3. The alfalfa averaged 22 inches in height, and averaged about one-tenth in bloom. A small area of the plot was in full bloom, half of it was one-tenth in bloom, and the rest was in the initial-bloom stage. New shoots were about 2 inches in height.

The fourth cutting was made on October 25, raked and hauled on October 27. The alfalfa averaged 6 to 8 inches in height. No bloom was showing, neither were there any new shoots. The fourth cutting was made in order to close the experiment as the lease could not be renewed. There was practically no aftermath.

HALF-BLOOM PLOT, 1937

The first cutting in 1937 on the half-bloom plot was made on June 21. The new shoots were 1 to 1½ inches in height. The alfalfa averaged 26 inches in height. The bloom was rather uneven but the plants would average one-half bloom. The stand did not appear to be quite as heavy as the first cutting on the initial-bloom plot, although there appeared to be no appreciable amount of winter killing. The hay was raked on June 23, cocked on June 23 and 24, and hauled on June 26. It was of good color and there was very little loss of leaves.

The second cutting was made on July 28, raked on July 29, and cocked on July 29. It was hauled and stacked on July 30. There was a slight excess of moisture in the hay when stacked, but not enough to make it turn brown in the stack. Practically all leaves were saved. The hay averaged 18 to 20 inches in height, but was not uniform. The new shoots were from 3 to 5 inches in length.

The third cutting was made on September 9, and averaged 16 to 18 inches in height with considerable variation. New shoots were 2 to 3 inches in height. It was raked on September 12, bunched and cocked on September 14, and hauled and stacked on September 16. Practically all leaves were saved. The aftermath averaged 3 inches in height.

FULL-BLOOM PLOT, 1937

The first cutting this season on the full-bloom plot was made on June 26. The south half of the plot had been in full bloom 2 days before the entire plot was cut, as the north half was a trifle slower in reaching full bloom. New shoots were from ¾ to 1½ inches in length. The alfalfa averaged 26 inches in height when cut. The hay was raked on June 27, hauled and stacked on June 30. It had a good color, and the leaves were fairly well retained with only slight loss.

The second cutting suffered from water injury and sunscald when it was irrigated the first time. As irrigation water was somewhat scarce, irrigation was postponed several days in order to secure a head of water that would run over the field. The water was very slow in covering the field and the weather was extremely hot. A considerable amount of this alfalfa did not start to grow for about 2 weeks, after which it made fairly rapid recovery, although the yield of the second cutting was probably reduced 20 to 25 percent. The second cutting was made on August 6, raked and cocked and stacked on August 7.

The third cutting was made at an immature stage. The plants averaged 14 inches in height; new shoots were about 1 inch in length. One-half of the field was in about ¼-bloom, one-fourth was in about

½-bloom, and one-fourth was in ⅛-bloom stage. The hay was cut on September 25, and raked on October 1 and was in condition to be stacked on October 2, but teams were not available and hauling was deferred. Because of rains in the meantime the hay was not hauled until October 11. Practically all leaves were saved but considerable bleaching took place. This hay would be classed as very poor in color. The aftermath was from 2 to 4 inches in height.

As the lease of the field expired at the end of the 1937 cropping season, the hay-cutting experiment was ended at that time, when the alfalfa had been cut at different stages for 3 years. The following observations of the field were made, however, during the spring of 1938 to determine the cumulative effect of cutting at the different stages on the growth and stand of the alfalfa on the three plots.

Observations of Growth and Stand in Spring of 1938

In 1938 growth on this field started markedly about March 15, although many plants were turning green about 2 weeks earlier. On April 1, the plants on the full-bloom and half-bloom plots were about 1 inch in height, while those on the initial-bloom plot were about one-half of an inch in height. During April about one-half of the field appeared to be quite slow in making early growth. This was especially true of the initial-bloom plot, which had had a fourth cutting late in the fall of 1937 and had gone into the winter with practically no aftermath from the 1937 crop. On April 20, the plants on the full-bloom plot averaged about 4 inches in height, those on the half-bloom plot about 3, and those on the initial-bloom plot about 2 inches. There was marked improvement in the growth and stand on all plots during May.

The last observations of this field were made on May 25. The average height of the plants on the initial-bloom plot at that time was from 8 to 10 inches. There was noticeably shorter growth over the east two-thirds than over the west one-third of the plot. The stand was good to excellent on most of the plot. The number of dead and weak plants was apparently slightly larger on the initial-bloom plot than on the half-bloom or full-bloom plots.

On the half-bloom plot the growth averaged from 10 to 13 inches in height. Growth was uneven and the stand was irregular on small areas distributed over the entire plot. The growing plants appeared to be slightly more vigorous, darker in color, and farther advanced than those in the initial-bloom plot. Dead and weak plants were fairly numerous in very small areas, but appeared to be fewer in this plot as a whole than in the initial-bloom plot.

On the full-bloom plot the average height of the plants was from 9 to 12 inches. The stand, growth, and color were about the same as on the half-bloom plot. The number of dead and weak plants appeared to be slightly greater than that in the half-bloom plot, but less than that in the initial-bloom plot.

The alfalfa as a whole on the entire field was considered very good as to stand, development, and general condition, in late May 1938. With the exception of the retarded growth of plants on the east side of the initial-bloom plot, the field was equal to or above the average for this locality.

The removal of a fourth cutting late in the fall of 1937 from the initial-bloom plot probably had more to do with the late start and retarded growth in 1938 on that plot than any other factor. During the 1935 and 1936 seasons, the plot that was cut latest in the fall made the slowest growth the succeeding year. In 1937 the final or fourth cutting on the initial-bloom plot was made on October 25, or 1 month later than the last cutting on the full-bloom plot, which was cut later than the half-bloom plot.

Another factor that may have retarded growth in 1938 on the initial-bloom plot, is that this part of the field is on a somewhat higher level that the rest of it. Consequently, it does not hold as much snow during the winter, and does not take water quite so easily during irrigation. Then, too, the short aftermath tended to let the snow blow away. While growth was slow, there were not many more dead and sick plants, however, on the initial-bloom plot than on the half- and full-bloom plots. A stand count of plants was taken on 6 areas on each of the 3 plots, or 18 areas in all. On averaging the results for each plot, it was found that the number of plants per acre was about the same over the entire field—that is, the average number of plants for the half-bloom plot and the average for the full-bloom plot were each about the same as the average for the initial-bloom plot. An estimate was also made of the number of dead and sick or weak plants on each plot. This indicated that the proportion of such plants was approximately 4 percent on the half-bloom plot, 5 on the initial-bloom plot, and a trifle less than 5 on the full-bloom plot.

Since this field was originally seeded to alfalfa in 1933, 1938 was the sixth year of growth. It is generally recognized that a stand of alfalfa, continuously cropped and not permitted to be grazed, will maintain itself for 6 to 7 years under the local conditions. In the fifth or sixth year the stand begins to get thin and grass starts to come in.

Considering all factors, cutting the alfalfa at the three stages of maturity, as practiced in this experiment over the 3-year period, appears to have had no significant effect on the stand.

QUALITY AND YIELD OF HAY OBTAINED FROM CUTTINGS AT DIFFERENT STAGES

Composition of the Hay

Table 4 shows the chemical composition (dry-matter basis) of the alfalfa hay made from individual cuttings, according to the stage of maturity and the year. Yearly average and 3-year average results, by stages, are also shown. Three of the cuttings were aftermath which did not reach the desired stage of bloom. These were the third cutting on the full-bloom plot in 1936 and 1937; and the fourth cutting on the initial-bloom plot in 1937. The analyses of these three cuttings are given, but are not included in the averages. One other cutting, included under initial bloom (first cutting 1937), was in a more advanced stage when cut. This advance in growth was no doubt largely responsible for the low protein and high crude-fiber content of this cutting.

TABLE 4.—*Composition (dry-matter basis) of the alfalfa hay made from cuttings at different stages of maturity*

Year and cutting	Crude protein			Ether extract			Nitrogen-free extract			Crude fiber			Calcium			Phosphorus		
	Initial bloom	Half bloom	Full bloom	Initial bloom	Half bloom	Full bloom	Initial bloom	Half bloom	Full bloom	Initial bloom	Half bloom	Full bloom	Initial bloom	Half bloom	Full bloom	Initial bloom	Half bloom	Full bloom
1935:	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
First cutting	18.56	17.43	15.31	1.57	1.52	1.06	40.54	43.27	40.32	31.08	29.93	36.16	1.068	1.026	1.150	0.211	0.163	0.139
Second	17.28	16.94	16.44	1.34	1.57	1.23	42.58	42.58	43.21	30.52	30.53	29.91	1.396	1.045	1.470	.191	.174	.143
Third	19.98	21.80	.....	1.63	1.30	.....	42.35	42.35	.....	25.58	22.04	.....	1.707	1.292	.....	.162	.213	.....
Average, 1935	18.61	18.72	15.58	1.51	1.46	1.15	41.82	42.73	41.77	29.06	27.50	33.04	1.360	1.121	1.310	.188	.183	.141
1936:																		
First	16.26	13.27	13.80	1.20	1.41	1.64	40.26	41.00	39.64	33.37	36.00	36.17	1.373	1.368	1.295	.164	.138	.139
Second	18.85	19.49	15.64	1.78	1.65	1.64	44.02	43.67	42.33	26.70	25.23	32.49	1.397	1.202	1.102	.211	.236	.171
Third	17.26	19.21	[1]20.67	1.95	2.35	[1]2.35	43.06	43.51	[1]42.39	25.29	23.64	[1]23.48	1.553	1.478	[1]1.475	.206	.246	[1].201
Average, 1936	17.46	17.32	14.72	1.64	1.80	1.64	42.45	42.73	40.99	28.45	28.29	34.33	1.441	1.329	1.229	.194	.207	.155
1937:																		
First [2]	16.06	16.95	15.91	1.93	1.78	1.96	41.34	40.67	42.40	33.37	33.33	32.33	1.267	1.250	1.152	.156	.175	.164
Second	20.40	18.60	17.13	2.26	1.94	2.42	41.71	41.29	42.43	26.53	30.00	29.03	1.165	1.143	1.323	.258	.232	.172
Third	19.53	20.93	[3]19.03	1.99	2.16	[3]1.80	42.14	42.41	[3]42.36	27.34	25.38	[3]27.78	1.456	1.514	[3]1.481	.209	.238	[3].211
Fourth	[4]20.73	.....	.....	[4]2.86	.....	.....	[4]43.44	.....	.....	[4]23.65	.....	.....	[4]1.751	.....	.....	[4].236	.....	.....
Average, 1937	18.66	18.83	16.52	2.06	1.96	2.09	41.73	41.46	42.42	29.08	29.57	30.68	1.296	1.302	1.238	.208	.215	.168
Average, 3 years	18.24	18.29	15.71	1.74	1.74	1.66	42.00	42.31	41.72	28.86	28.45	32.68	1.366	1.251	1.259	.197	.202	.155

[1] Represents aftermath cut in the pre-initial-bloom stage, not included in the yearly or 3-year average.
[2] In 1937 the first cutting that was to be made at the initial-bloom stage was delayed by rain and represents approximately half-bloom. Included in the averages.
[3] Represents aftermath cut when in one-fourth bloom. Not included in the averages.
[4] Represents aftermath cut before any blooms appeared. Not included in the averages.

CRUDE PROTEIN

On the average there was little difference in the crude-protein content of the hay cut at the initial-bloom and that cut at the half-bloom stage of maturity (table 4). The hay cut at the full-bloom stage, however, averaged 2.56 percent lower in protein content than the two earlier stages.

There was rather wide and extreme variation in protein content, however, between the different cuttings made at the same stage of bloom. This is clearly illustrated by the difference between the first and second cuttings in 1936 on the half-bloom plot. The former contained 13.27 and the latter 19.49 percent of protein. It is probable that the slower growth early in the season was responsible for the relatively low protein content of the first cuttings. This conclusion is further borne out by the fact that with but two exceptions the first cuttings on all plots were markedly lower in protein than the later cuttings.

The highest crude-protein content (21.8 percent) was the third cutting in 1935 on the half-bloom plot, which represented 50 days of growth, and the lowest (13.27 percent) was the first cutting in 1936 on the half-bloom plot, which had 73 days' growth. The number of days' growth for all first cuttings was computed from the time that first growth was noted in the spring and probably is not comparable with the period of time elapsing between the first and second or the second and third cuttings.

The second cutting on the initial-bloom plot averaged 37 days' growth for the 3-year period 1935–37, and 18.84 percent of protein. The third cutting averaged 42 days' growth and 18.92 percent of protein, or almost the same protein content as the second, yet representing 5 more days of growth.

The second cutting on the half-bloom plot averaged 43 days' growth and 18.34 percent of protein, while the third cutting averaged 46 days and 20.65 percent of protein. This was a considerably higher content of protein, yet it represents a longer growing period. On the other hand, the second cutting on the full-bloom plot averaged 50 days' growth and only 16.40 percent of protein.

While the hay representing the longest growing period on the average contained the least amount of protein, it is apparent that the number of days' growth is not a true criterion of the stage of the plant, at least so far as the protein content is concerned. This bears out previous observations by the authors in experiments with pasture grasses (*4*). The average protein content of the alfalfa hay cut in 1936 in this experiment was considerably lower than that of the hay cut in 1935 and 1937, doubtless because of the poor seasonal conditions in 1936 and the damage caused by grasshoppers.

It is also evident that, as a rule, the protein content is correlated with the proportion of leaves to stems. The percentage of leaves in each of the initial-, half-, and full-bloom cuttings is given later on in table 7. The two samples with the least protein (first cutting, 1936, half-bloom, and first cutting, 1936, full-bloom) contained but 28 and 25 percent of leaves by weight, while the samples with the most protein contained between 50 and 60 percent of leaves. The average for all cuttings at both the initial- and half-bloom stages was 46 percent of leaves and 18.27 percent protein, while all cuttings made at the

full-bloom stage averaged only 41 percent of leaves and 15.71 percent of protein.

Although there was considerable variation between cuttings, it is apparent that so far as protein content is concerned there was little difference between the alfalfa hay cut at the initial-bloom and that cut at the half-bloom stage, but the hay cut at the full-bloom stage was distinctly inferior. It is also quite evident that the first cuttings of all stages were inferior to the later cuttings in protein content.

ETHER EXTRACT

The results obtained for determinations of ether-extract content of the various cuttings are presented in table 4. The samples, as previously stated, had aged for some months when these determinations were made. Since weekly samples were taken as the hay was being fed to dairy cattle, a large composite sample of each cutting had accumulated at the end of the feeding trial, when the samples of each cutting were thoroughly mixed and small samples were sent to Beltsville. Hence the analysis for ether extract could not be made until the year following the one in which the hay was cut.

Additional analyses for ether extract were obtained on some of the hay in connection with the digestion trials with sheep at the Western Washington Experiment Station, Puyallup, Wash. The digestion trials, which are fully discussed in a later section (pp. 23–26), were conducted on hay from 1937 cuttings which was sent there in the spring of 1938. Samples of the hay fed to the sheep and the feces excreted were dried and sent to Beltsville for chemical analyses. These samples were finely ground. In calculating the digestion coefficients from these analyses it was discovered that in practically every case the results showed more ether extract was voided in the feces than was consumed in the hay.

By comparing analyses made at different times on the same cutting of hay, it was found that the ether-extract content of the hay samples was diminishing rather rapidly as the samples aged. For example, the original samples of the unground hay of the 1937 crop were analyzed in May 1938. Similar samples, but finely ground, from the same lot of hay used in the digestion trial, were analyzed in August 1938, and additional analyses on the same ground samples were made in September 1938. The results of the three monthly determinations for percentage of ether extract with hay cut in 1937 and analyzed in May 1938 (when unground), August 1938 (when finely ground), and September 1938 (finely ground) were: Initial bloom, 2.06, 1.19, and 1.03; half bloom, 1.96, 1.17, and 1.07; full bloom, 2.09, 1.44, and 1.23. These figures indicate that the ether extract in the ground samples of hay was unstable, and that some components were either lost or converted into constituents insoluble in ether. It is probable that the ether extract recovered in the feces was more stable, as it had undergone enzymatic action in the stomach and intestines of the sheep. In the case of the protein, crude fiber, and ash, the corresponding percentages of the two sets of samples showed but little variation.

It seems evident that the ether-extract figures were too low, probably even for the original determinations presented in table 4, because such a long interval of time elapsed before the determinations were made,

and very little significance should be attached to them. With the exception of six samples that were mostly from the 1937 crop, the content when analyzed was less than 2 percent, which is considered exceedingly low for alfalfa hay.

CRUDE FIBER

With few exceptions the crude-fiber content of the various cuttings was lower for the initial- and half-bloom stages than for the full-bloom stage (table 4). Furthermore, the crude-fiber content in most cases decreased with each successive cutting during the growing season. As lignification takes place largely in the stems of the plant, it is of interest to consider the fiber content in connection with the proportion of leaves present. By comparing the crude-fiber content (table 4) with the proportion of leaves to stems as shown in table 7 (p. 22) it is seen that as a rule a low crude-fiber content was accompanied by a high proportion of leaves. The third cutting in 1935 at half-bloom stage had the lowest crude-fiber content (22.04 percent) and the highest amount of leaves (66 percent) of all samples. Conversely, the first cutting in 1936 at the full-bloom stage, with a crude-fiber content of 36.17 percent, had the lowest percentage of leaves of any sample. The significance of the amount of leaves present has already been brought out as regards protein content.

CALCIUM AND PHOSPHORUS

The calcium content generally averaged slightly higher for the hay made at the initial-bloom stage than for that made at the later stages (table 4). There was wide variation, however, between individual cuttings. The investigations of Salmon and coworkers (*12*) at the Kansas station and Woodman (*16, 17*) in England show that the calcium content increases slowly as the plant matures. In their experiments samples of green hay were taken for analyses which did not undergo the weathering due to curing, as did the samples in this experiment. It is believed that this could account for any lack of consistency in the calcium percentages as it is well known that the curing process can materially affect the amount of calcium.

In average phosphorous content, there was little difference between the initial- and half-bloom stages, but the full-bloom stage was distinctly lower. This is in accordance with the findings of Salmon (*12*) and Woodman (*16, 17*). The former expressed the opinion that phosphorus is associated with new growth, and that after the plant is in full bloom, but little new growth takes place and there is less plant need for phosphorus.

In general the relative effect, on the composition of alfalfa hay, of cutting it at the initial-, half-, and full-bloom stages was in accord with the results of other investigations, in that the protein and phosphorus decreased and the crude fiber increased as the plants matured and that the protein and crude fiber were closely associated with the amount of leaves present. The calcium content in some cases may have been affected by curing and storing methods. The results for the ether-extract determinations, owing to aging of the samples, are of doubtful significance.

It is clearly apparent that under the climatic conditions the farmer would likely meet in cutting and putting up his alfalfa hay, there would be little choice between cutting at the initial-bloom stage or

the half-bloom stage from the standpoint of nutrient composition. On the other hand, allowing the hay to reach the full-bloom stage would be distinctly detrimental to its nutrient composition.

Effect on Yield of Hay and Nutrients

Table 5 gives the number and dates of the cuttings, the yields of cured hay per acre, and the dry matter, crude protein, and total digestible nutrients produced per acre according to the stage and cutting, by years, together with the 3-year average results.

TABLE 5.—*Yields of hay, dry matter, and nutrients per acre for alfalfa hay cut at three stages of maturity in 1935, 1936, and 1937, and the average yields for the 3-year period*

INITIAL-BLOOM STAGE

Cutting	Date cut	Period of growth	Yield of field-cured hay per acre	Dry matter		Yield of crude protein per acre	Total digestible nutrients [1]	
				By analysis	Yield per acre		By analysis	Yield per acre
1935:		*Days*	*Pounds*	*Percent*	*Pounds*	*Pounds*	*Percent*	*Pounds*
First	June 20	66	4,596	89.23	4,101	761		
Second	Aug. 1	42	2,801	85.66	2,399	415		
Third	Sept. 18	48	2,457	89.72	2,204	440		
Total or average			9,854	88.20	8,704	1,616	59.02	5,137
1936:								
First	June 13	64	3,843	88.80	3,413	555		
Second	July 22	39	1,754	87.77	1,540	290		
Third	Aug. 29	38	1,968	90.62	1,783	335		
Total or average			7,565	89.06	6,736	1,180	59.02	3,976
1937:								
First [2]	June 21	76	4,812	86.68	4,171	670		
Second	July 20	29	2,522	88.51	2,232	455		
Third	Aug. 29	40	2,062	80.45	1,844	360		
Fourth [3]	Oct. 25	57	417	89.35	373	77		
Total or average			9,396	88.21	8,247	1,485	59.02	4,867
3-year average:								
First		69	4,417	88.24	3,895	662		
Second		37	2,359	87.31	2,057	387		
Third		42	2,162	89.93	1,944	378		
Total or average			8,938	88.49	7,896	1,427	59.02	4,660

HALF-BLOOM STAGE

1935:								
First	June 24	70	5,113	88.68	4,534	709		
Second	Aug. 12	49	2,379	86.24	2,052	348		
Third	Oct. 1	50	2,116	87.00	1,841	401		
Total or average			9,608	87.31	8,427	1,539	56.73	4,781
1936:								
First	June 22	73	3,701	88.70	3,283	436		
Second	Aug. 3	42	2,060	85.63	1,764	344		
Third	Sept. 16	44	2,143	90.56	1,941	373		
Total or average			7,904	88.30	6,988	1,153	56.73	3,964
1937:								
First	June 21	76	4,214	87.02	3,667	622		
Second	July 28	37	2,870	89.00	2,554	475		
Third	Sept. 9	43	1,933	87.84	1,698	355		
Total or average			9,017	87.95	7,919	1,452	56.73	4,493
3-year average:								
First		73	4,384	88.13	3,828	616		
Second		43	2,440	86.96	2,123	389		
Third		46	2,064	88.47	1,827	376		
Total or average			8,888	87.85	7,778	1,381	56.73	4,413

See footnotes at end of table.

TABLE 5.—*Yields of hay, dry matter, and nutrients per acre for alfalfa hay cut at three stages of maturity in 1935, 1936, and 1937, and the average yields for the 3-year period*—Continued

FULL-BLOOM STAGE

Cutting	Date cut	Period of growth	Yield of field-cured hay per acre	Dry matter		Yield of crude protein per acre	Total digestible nutrients	
				By analysis	Yield per acre		By analysis	Yield per acre
1935:		*Days*	*Pounds*	*Percent*	*Pounds*	*Pounds*	*Percent*	*Pounds*
First	July 2	78	4,155	88.43	3,674	563		
Second	Sept. 1	61	1,978	85.87	1,699	279		
Total or average			6,133	87.15	5,373	842	53.93	2,898
1936:								
First	June 25	76	3,406	87.77	2,990	413		
Second	Aug. 12	48	2,559	87.05	2,228	349		
Third [4]	Sept. 30	49	1,403	84.10	1,180	244		
Total or average			7,368	86.31	6,398	1,006	53.93	3,450
1937:								
First	June 26	81	3,830	87.20	3,340	531		
Second	Aug. 6	41	1,937	87.21	1,689	289		
Third [5]	Sept. 25	50	1,551	89.15	1,383	263		
Total or average			7,318	87.85	6,412	1,083	53.93	3,458
3-year average:								
First		78	3,797	87.80	3,335	502		
Second		50	2,158	86.71	1,872	306		
Third			985	86.63	854	169		
Total or average			6,940	87.05	6,061	977	53.93	3,260

[1] Digestion coefficients obtained in digestion trials with 1937 hay used for 1935 and 1936 calculations.
[2] The first cutting, 1937, was in the half-bloom stage.
[3] Aftermath, no blooms, not included in total yields or averages.
[4] Cut at pre-bloom stage.
[5] Third cuttings, 1937, was mowed at ½-bloom stage.

The initial- and half-bloom plots each furnished three typical cuttings each season, and the aftermath on the former plot in 1937 was also cut. The full-bloom plot furnished two cuttings of typical full-bloom hay each season, and in 1936 and 1937 third cuttings were made but the hay did not reach the typical full-bloom stage. The average 3-year yields were 8,938, 8,888, and 6,940 pounds of field-cured hay per acre, respectively, for the three stages. Considering the 3-year average yield of the initial-bloom plot as 100, the half-bloom plot yielded 99.4 percent as much, while the full-bloom plot yielded only 77.7 percent as much. The yields on the initial-and half-bloom plots in 1936 were materially lower than in 1935 and 1937, due to extremely hot weather and serious grasshopper damage. On the other hand, the yield on the full-bloom plot in 1936 was greater than in the other 2 years. The first cutting, 1936, of full-bloom alfalfa was materially reduced in yield by grasshopper damage, but the second cutting was very heavy for that year and apparently made its growth when the grasshopper damage was small.

Table 6 shows the relation of the separate cuttings to the total yield of field-cured hay obtained per acre from the first, second, and third cuttings, expressed as a percentage. The 3-year average results indicate that there was little difference between the initial- and half-bloom plots in this respect, as the first cutting made up approximately 49, the second cutting 27, and the third cutting 24 percent of the total yield. On the full-bloom plot the first cutting averaged 55, the second cutting 31, and the third cutting (none of which reached the typical full-bloom stage) 13 percent of the total yield.

TABLE 6.—*Relation of the yield of field-cured hay obtained from the first, second, or third cutting at initial-, half-, or full-bloom stage to the total yield per acre during each year of the experiment, and the relative average yield for the 3-year period*

Stage of maturity	1935			1936			1937			3-year average		
	First cutting	Second cutting	Third cutting	First cutting	Second cutting	Third cutting	First cutting	Second cutting	Third cutting	First cutting	Second cutting	Third cutting
	Pct.	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
Initial-bloom	46.7	28.4	24.9	50.8	23.2	26.0	[1] 51.2	26.8	22.0	49.6	26.1	24.3
Half-bloom	53.2	24.8	22.0	46.8	26.1	27.1	46.7	31.8	21.4	48.9	27.6	23.5
Full-bloom	67.7	32.3		46.2	34.7	[2] 19.0	52.3	26.5	[3] 21.2	55.4	31.2	13.4

[1] Represents approximately half-bloom; included in the 3-year average.
[2] Third cutting made at pre-initial-bloom stage; included in the average.
[3] Third cutting made at ¼-bloom stage; included in the average.

As the dry-matter content of the hay when cut at different stages was approximately the same with little variation, on a yearly basis, the yield of dry matter per acre naturally follows the yield of field-cured hay per acre, as shown in table 5.

The yield of crude protein per acre averaged 1,427 pounds in hay cut from the initial-bloom plot as compared to 1,381 for the plot cut at half bloom, and 977 for the plot cut at the full-bloom stage. These figures indicate that cutting at half bloom produced 96.8 and cutting at full bloom only 68.4 percent as much crude protein as cutting at initial bloom.

Table 5 also shows the production of total digestible nutrients per acre. The digestion coefficients obtained by digestion trials with sheep (using only hay produced in 1937) were used in computing the total digestible nutrients of the hay for the 3 years. The details of the digestion trials are presented on pages 23–26. The initial-bloom plot produced a 3-year average of 4,660 pounds of total digestible nutrients per acre as compared to 4,413 for the half-bloom plot, and 3,269 for the full-bloom plot. The half-bloom plot produced 94.7 percent and the full-bloom plot produced 70.2 percent as much total digestible nutrients per acre as the initial-bloom plot.

On the whole, from the standpoint of yields of hay and nutrients, there apparently was a slight advantage in harvesting the hay at the initial-bloom as compared to the half-bloom stage, the difference being chiefly in the increased yield of total digestible nutrients. Because of the fewer cuttings and the lower content of digestible nutrients, the full-bloom plot produced only about 78 percent as much hay and about 70 percent as much total digestible nutrients. These yields of hay are in line with the investigations at the Kansas station (*12*) when alfalfa was cut at the one-tenth-bloom and full-bloom stages. At the Nebraska station (*8*), however, during a 4-year period, alfalfa hay cut at the half-bloom stage outyielded that cut at the initial-bloom stage by 12.5 percent, while alfalfa cut at the full-bloom stage gave an increased yield of 5 percent.

EFFECTS ON COLOR, LEAFINESS, AND GRADE

The amount of green color, leaves, and the grade assigned to hay from each cutting at initial-, half-, or full-bloom stage during the 3 years, are shown in table 7. These determinations were made by the Grain and Seed Division, Agricultural Marketing Service, from a

composite of samples that were taken weekly throughout the feeding year. At least a year elapsed between the time of cutting and grading the hay. The accumulated lots were kept in burlap bags in a hay mow that was fairly dark. The samples were handled considerably, and the moisture content was low, which no doubt caused some shattering of leaves and loss of color. As all hay produced was remarkably free from grasses, weeds, and foreign material, nothing was removed from the samples. The harvesting and storing methods, together with field notes, have already been discussed.

TABLE 7.—*Amount of green color and leaves in alfalfa hay made from cuttings at different stages of maturity, 1935–37, and the grade classification of the hay*

Year and cutting	Green color			Leaves			Grade classification of hay		
	Initial bloom	Half bloom	Full bloom	Initial bloom	Half bloom	Full bloom	Initial bloom	Half bloom	Full bloom
1935:	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*			
First	55	50	33	34	32	25	U. S. No. 2	U. S. No. 2	U. S. No. 3.
Second	78	75	72	42	46	48	U. S. No. 1 Extra Green.	U. S. No. 1 Extra Green.	U. S. No. 1.
Third	63	56		50	66		U. S. No. 1 Extra Leafy.	U. S. No. 2 Extra Leafy.	
Average	65	60	53	42	48	36			
1936:									
First	75	80	62	42	28	25	U. S. No. 1 Extra Green.	U. S. No. 2 Extra Green.	U. S. No. 2 Green.
Second	80	75	62	56	46	53	U. S. No. 1 Extra Leafy, Extra Green.	U. S. No. 1 Extra Green.	U. S. No. 1 Extra Leafy.
Third	78	80		40	45		U. S. No. 1 Extra Green.	...do	
Average	78	78	62	46	40	39			
1937:									
First	69	72	60	40	42	43	U. S. No. 1	U. S. No. 1	U. S. No. 1.
Second	80	95	85	53	52	52	U. S. No. 1 Extra Leafy, Extra Green.	U. S. No. 1 Extra Leafy, Extra Green.	U. S. No. 1 Extra Leafy, Extra Green.
Third	70	75		61	58		U. S. No. 1 Extra Leafy.	...do	
Average	76	81	77	51	51	48			
Average for 3 years.	73	73	64	46	46	41			

The samples of hay made in 1935 and 1936 at the initial- or half-bloom stage contained more green color as a rule than the hay cut at full bloom. With the hay cut in 1937, the half bloom ranked highest in color, the full-bloom next, and initial-bloom lowest. The 3 years' results for the initial- and half-bloom stages averaged 73 percent in color as compared to 64 for full bloom.

In most cases the hay from first cuttings contained less color than the later cuttings, especially in 1935. The first cutting of full-bloom hay in 1935, which was subjected to heavy rains after mowing, contained only 33 percent of green color. Although the 1936 season was extremely hot and damage by grasshoppers was heavy, that year's cuttings were superior in color to those of 1935. As a rule, the lots

of hay with lower percentages of green color were rained on or were stacked before the hay was well cured.

On an average for the 3-year period, the hay from the initial- and half-bloom plots contained more leaves (46 percent) than the hay cut at full-bloom stage with only 41 percent. Without exception the first cutting, all stages, had a lower proportion of leaves than the second cutting, and except in 1936 the third cutting, all stages, contained more leaves than the second cutting. The first-cutting samples, all stages for 1935, were extremely low in leafiness as well as color, as shown by the low grades assigned to them.

In considering the grades assigned to the various cuttings and the importance of green color and leafiness in determining the grade, it is of interest to note that none of the samples of first-cutting hay of any stage or year were classified as Extra Leafy, and that only a few first-cutting samples (for 1936) were classed as Extra Green or Green. In general, the later or second or third cuttings were progressively superior in these respects.

Summary and Conclusions From the Field Work and Analyses

Summarizing the results of the field work of this experiment, it is evident that on the whole the alfalfa cut at the initial- or half-bloom stage was markedly superior in yield of hay, composition of the hay, and yield of nutrients per acre to the alfalfa cut at the full-bloom stage. The alfalfa cut at the initial-bloom stage was slightly superior, especially in yield of total digestible nutrients per acre, to the alfalfa cut at half-bloom, but the differences were too slight to have any great significance. Apparently the line of demarkation between these two stages is indistinct, and under practical farm conditions cutting at or between either stage would be good practice.

The first cutting at the initial- or half-bloom stage was distinctly inferior with few exceptions, in practically all points of comparison, to the subsequent cuttings on the same plots, but represented approximately 50 percent of the total crop. This suggests the advisability of employing a combination of different stages in putting up alfalfa hay where conditions are the same as in this experiment. If the first cutting were made just before the first blooms appear and the second cutting were made at the half-bloom stage, this practice might tend to improve the quality of the first cutting and increase the proportional yield of the later cuttings, which are of better quality. While this experiment does not afford specific information on this combination of stages, the assumption appears logical. A somewhat similar combination was suggested by Salmon and coworkers (*12*) at the Kansas station, after extensive experiments relating to time of cutting alfalfa.

THE DIGESTION TRIALS

Experimental Procedure in the Digestion Trials

Facilities were not available at Huntley for conducting digestion trials, and this feature of the investigation as previously noted (p. 6) was conducted at the Western Washington Experiment Station. The digestion trials were run in May and June of 1938 with hay cut

in 1937 from the experimental plots. For this purpose the first three cuttings from the initial-bloom plot in 1937 (table 4) were mixed together and fed; also the three cuttings from the half-bloom plot; and the first two cuttings from the full-bloom plot. Thus the digestion coefficients represent an average for three cuttings or two cuttings, as the case may be. Trials were not conducted with hay from the 1935 and 1936 cuttings, and the digestion coefficients obtained for 1937 cuttings were used in all calculations involved for the 3 years. Sheep were used as the experimental animals and the alfalfa hay fed was the sole diet during the trials.

The generally accepted method of conducting digestion trials was used. Three sheep were used in each trial for each stage of alfalfa hay, and the average coefficient for the three results was used. Alfalfa hay of the stage under trial was fed for a period of 20 days, and only the last 15 days' data were used. Feces excreted during the 15 days were collected and weighed.

The chemical analyses of the hay and feces were made at the Beltsville, Md., laboratories of the Bureau of Dairy Industry, from finely ground samples sent to that laboratory. Determinations were made for moisture content on the hay as fed and on the feces collected at the time of the trials, and for the amount of dry matter consumed and amount of dry matter excreted in the feces. Using these figures the results of the chemical analyses were converted to a dry-matter basis, and the digestion coefficients were calculated. As was previously noted (pp. 17–18), complications arose in regard to the determinations for ether extract.

Results of the Digestion Trials

The quantity of nutrients ingested and voided in the feces, together with the quantity and percentage digested for the hay cut at the initial-, half-, or full-bloom stage are given in table 8.

Table 8.—*Digestibility of alfalfa hay cut at three different stages of maturity*

INITIAL BLOOM

Nutrients	Dry matter	Ether extract	Crude protein	Nitrogen-free extract	Crude fiber
By sheep 1:					
Ingested grams	10,545.0	217.23	1,968.75	4,400.43	3,066.49
Voided in feces do	3,917.6	190.79	442.30	1,245.01	1,635.50
Digested do	6,627.4	26.44	1,526.45	3,155.42	1,430.89
Digested percent	62.8	12.2	77.5	71.7	46.7
By sheep 2:					
Ingested grams	10,545.0	217.23	1,968.75	4,400.43	3,066.49
Voided in feces do	3,883.0	192.99	460.14	1,200.24	1,621.15
Digested do	6,662.0	24.24	1,508.61	3,200.19	1,445.34
Digested percent	63.2	11.2	76.6	72.7	47.1
By sheep 3:					
Ingested grams	10,545.0	217.23	1,968.75	4,400.43	3,066.49
Voided in feces do	3,773.0	201.48	412.39	1,204.72	1,555.61
Digested do	6,772.0	15.75	1,556.36	3,195.71	1,510.88
Digested percent	64.2	7.3	79.1	72.6	49.3
Average percentage digested by 3 sheep	63.4	10.2	77.7	72.3	47.7

TABLE 8.—*Digestibility of alfalfa hay cut at three different stages of maturity*—Con.

HALF BLOOM

Nutrients	Dry matter	Ether extract	Crude protein	Nitrogen-free extract	Crude fiber
By sheep 1:					
Ingested.....grams	10,395.0	203.74	1,957.38	4,300.77	3,073.80
Voided in feces.....do	4,031.8	183.85	445.92	1,243.00	1,804.23
Digested.....do	6,363.2	19.89	1,511.16	3,066.77	1,269.57
Digested.....percent	61.2	9.8	77.2	71.2	41.3
By sheep 2:					
Ingested.....grams	10,395.0	203.74	1,957.38	4,300.77	3,073.80
Voided in feces.....do	4,031.6	182.74	442.93	1,240.33	1,791.10
Digested.....do	6,361.6	21.00	1,514.45	3,060.44	1,282.70
Digested.....percent	61.2	10.3	77.4	71.0	41.7
By sheep 3:					
Ingested.....grams	10,395.0	203.74	1,957.38	4,309.77	3,073.80
Voided in feces.....do	4,025.2	182.34	453.64	1,231.31	1,804.50
Digested.....do	6,369.8	21.40	1,503.74	3,078.46	1,269.30
Digested.....percent	61.3	10.5	76.8	71.4	41.3
Average percentage digested by 3 sheep	61.2	10.2	77.1	71.2	41.4

FULL BLOOM

By sheep 1:					
Ingested.....grams	11,211.2	234.31	1,852.09	4,755.79	3,439.60
Voided in feces.....do	4,770.3	173.63	453.66	1,589.46	2,105.72
Digested.....do	6,440.9	60.68	1,398.43	3,166.33	1,273.88
Digested.....percent	57.5	25.9	75.5	66.6	37.0
By sheep 2:					
Ingested.....grams	11,211.2	234.31	1,852.09	4,755.79	3,439.60
Voided in feces.....do	4,828.4	108.16	480.43	1,653.24	2,143.81
Digested.....do	6,382.8	126.15	1,371.66	3,102.55	1,295.79
Digested.....percent	56.9	53.8	74.1	65.2	37.7
By sheep 3:					
Ingested.....grams	11,211.2	234.31	1,852.09	4,755.79	3,439.60
Voided in feces.....do	4,702.0	176.33	432.11	1,576.58	2,061.36
Digested.....do	6,509.2	57.98	1,419.98	3,179.21	1,378.24
Digested.....percent	58.1	24.7	76.7	66.8	40.1
Average percentage digested by 3 sheep	57.5	34.8	75.4	66.2	38.3

DISCUSSION AND SUMMARY OF RESULTS OF DIGESTION TRIALS

With the exception of the ether extract, the digestion coefficients of the nutrients (table 8) were remarkably consistent for the individual sheep, and the averages show a consistent decrease in digestibility from the initial- to the full-bloom stage. The average digestion coefficient for the crude protein was 77.7 for the initial-bloom hay as compared to 77.1 for half-bloom and 75.4 for full-bloom hay. The digestion coefficients for the crude fiber were more significant, and averaged 47.7 for initial-bloom, 41.4 for half-bloom, and 38.3 for full-bloom hay. With this constituent the widest difference was between the initial- and half-bloom stages. This result tends to corroborate observations by Woodman (*17*) as to the effect of stage of growth on digestibility of alfalfa when cut at an early (prebud) and flowering stage, as discussed on pages 3 and 4. In his experimental work an average off our digestion trials with sheep on alfalfa (lucerne) cut at the so-called flowering stage gave the following digestion coefficients: Crude protein, 76.3; nitrogen-free extract, 71.6; and crude fiber, 42.6.

The results of the three digestion trials at the Kansas station (*12*) with steers using one-tenth-bloom and full-bloom alfalfa hay, were discussed on pages 2 and 3, and are very similar to those obtained in this

experiment. In the Kansas trials the digestion coefficient of crude protein was approximately 73 percent for both stages and the coefficients of crude fiber were 47.7 for one-tenth-bloom and 42.6 for full-bloom hay.

The digestion trials at the Vermont Agricultural Experiment Station (*11*) with cows on sun-cured alfalfa that was cut at a stage of little or no bloom and also from alfalfa that was cut at the half-bloom stage gave an average digestion coefficient for crude protein of 71.3 for the no-bloom and 65.8 for the half-bloom hay. The digestion coefficient of the nitrogen-free extract compared closely for both hays but that of the crude fiber was considerably higher (averaging 55.3) for the no-bloom than for the half-bloom hay (53.2). The total digestible nutrient content of the dry matter averaged 63.3 percent for the no-bloom and 58.3 for the half-bloom hay.

Using the digestion coefficients that were obtained for the alfalfa hay produced at Huntley in 1937, the total digestible nutrient content of the dry matter was 59.02 percent for the initial-bloom, 56.73 for the half-bloom, and 53.93 for full-bloom hay (table 5).

In summarizing the results of the digestion trials in this experiment, it is apparent that the superior qualities of the hay cut at an early stage of growth (initial- or half-bloom stage) as judged by the composition, leafiness, and color, are borne out by the superior digestibility of the nutrients important for milk production, as compared with alfalfa hay cut at full-bloom.

The differences in quality between the initial- and half-bloom hays were rather slight, but in relative digestibility, for example, of the crude fiber, the initial-bloom hay was markedly superior to the half-bloom hay. As a matter of fact, the differences would probably have been greater if the hay of the first cutting (initial-bloom plot) in 1937 could have been mowed at the proper time, or if this cutting had been withheld from the digestion trial. It will be recalled that this cutting had reached the half-bloom stage, because mowing was delayed by unfavorable weather conditions.

THE FEEDING TRIALS WITH DAIRY COWS

Procedure in Feeding Trials

Alfalfa hay cut at the three different stages of maturity was fed to three groups of Holstein cows. (See table 11, pp. 31–32.) The feeding trials each ran for a full lactation period of 365 days. Each group was fed exclusively on hay cut at the initial-, half-, or full-bloom stage and no other feed was given during the trial, but the cows had access to salt and bonemeal. The cows were not started on the experiment simultaneously, but were placed in their particular groups a short time before they freshened.

Since the amount of hay of each stage produced each year was not sufficient to carry two cows for a 365-day lactation period, it was necessary to use some of the hay produced in 1936 to complete lactation records begun on 1935 hay; and to use some of the hay cut in 1937 to complete the records begun on hay cut in 1936. Thus, while the field data include 3 full cropping years, the feeding trials cover only a feeding period of 2 years but hay from all 3 cropping years was used. The cows were started on the hay approximately 30 days before they

freshened so they would become thoroughly accustomed to it, although they were accustomed to eating large quantities of roughage and some of them had previously been used in roughage-feeding experiments.

Data on the Individual Cows Used

The breeding experiments at the Huntley station require that all females raised to producing age be tested under full-feed conditions to determine their inherited capacity for milk and butterfat production. Prior to being placed in the alfalfa-feeding experiment, all the cows had made official production records when fed grain at the approximate rate of 1 pound to each 3 pounds of milk produced, in addition to a good quality of alfalfa hay, corn silage, and pasture. Their feed and production records under this system of feeding were available for comparison with their feed and production records when they were fed the respective alfalfa-hay rations.

The herd number and the age of each cow when she entered the hay-feeding experiment, the number of days she carried a calf during the lactation, and the length of her dry period prior to her lactation are shown in table 9. Similar information is also given for each cow when she was on the full-feed ration. With the exception of cow 95, all were first-calf heifers when they made their official records on full feed. The group on initial-bloom hay averaged 5 years 6 months in age, while the other two groups averaged 5 years 2 months and 4 years 8 months, respectively.

Table 9.—*Ages, days carried calf, and other data for cows when fed alfalfa hay cut at three different stages of maturity, and when on full-feed rations*

Cow No.	When fed the alfalfa hay ration				When on full feed			
	Stage of hay, and cuttings [1]	Age	Period of carrying calf	Prior dry period	Age	Period of carrying calf	Prior dry period
		Yrs. Mos.	*Days*	*Days*	*Yrs. Mos.*	*Days*	*Days*
88	Initial bloom (3 cuttings, 1935, and first cutting, 1936).	6 5	180	72	2 11	175	
98	do	4 3	0	169	2 6	70	
96	Initial bloom (3 cuttings, 1936, and first cutting, 1937).	5 9	71	107	2 0	170	
Average (3 cows).		5 6	84	116	2 6	138	
95	Half bloom (3 cuttings, 1935, and first cutting, 1936).	4 7	199	54	3 6	226	64
96	do	4 5	175	48	2 0	170	
88	Half bloom (3 cuttings, 1936, and first cutting, 1937).	7 9	23	99	2 11	175	
311	do	3 10	105	87	2 7	108	
Average (4 cows).		5 2	148	72	2 9	103	
97	Full bloom (2 cuttings, 1935, and first cutting, 1936).	4 7	141	333	2 7	183	
301	do	4 3	207	419	2 2	85	
95	Full bloom (2 cuttings, 1936, and first cutting, 1937).	5 10	229	84	3 6	226	64
310	do	3 10	27	276	2 1	3	
Average (4 cows).		4 8	151	278	2 7	125	

[1] For description of each cutting, and months in lactation period when fed, see table 11.

Eight different cows (registered Holstein-Friesians) were used in the hay experiment and they completed a total of 11 yearly production records. Cows 88, 95, and 96, each completed 2 yearly lactation records during the experiment, and cows 97, 98, 301, 311, and 316 each completed 1. One cow that started on initial-bloom hay developed a bad case of foot rot and was dropped after 169 days, thus the results for this hay are based on the production of 3 cows instead of 4.

The cows were kept in stanchions when on the hay rations. In favorable weather they were turned into an exercising lot where no feed was available. While making their full-feed records they were kept in a pen barn and had access to a dry lot and pasture when available.

The experimental hay was weighed out to the cows twice a day and the amount not eaten was weighed back once a day. Records were kept of the cutting as well as the stage of hay that was fed.

All cows were milked three times a day, by milking machines, both when making their records on the alfalfa hay and under full-feed conditions.

Records Kept During the Feeding Trials

Daily milk weights were kept, and once each month a sample of milk was tested for butterfat. Body weights were taken on 3 consecutive days each month. The average monthly weight was calculated by averaging the weights for 2 consecutive months. The average body weight for a lactation period is the average of the weights for the first and last month in lactation. The cows were also weighed each day for a few days previous to and immediately following calving, which provided precalving and after-calving weights. Routine breeding and calving data were recorded at all times.

Ration Fed When the Cows Made Records Under Full-Feed Conditions

The full-feed system used when the cows were on official test at Huntley has been outlined on page 27. The grain mixture fed under full-feed conditions consisted of 200 pounds of corn meal, 200 of oats, 200 of millfeed, and 100 of linseed meal. This mixture was varied slightly at times to take advantage of price differences, but the calculated total-digestible-nutrient content of 76.9 percent, as based on Morrison's tables (*10*), remained practically the same.

The alfalfa hay fed when the cows were on full feed was grown locally under irrigation and was of good quality. The average content of crude protein, as indicated by 16 samples analyzed over a 5-year period and reported in 1938 (*6*), was 15.72 percent, while the average crude-fiber content was 31.34 percent. The usual custom in the locality where the hay was purchased is to cut alfalfa at approximately the full-bloom stage. Based on the coefficients for digestibility of the full-bloom hay obtained by digestion trials in the present experiment, the purchased hay contained 48.15 percent of total digestible nutrients on a total basis or 52.20 on a dry-matter basis. The average moisture content was 8.28 percent.

The total-digestible-nutrient content of the corn silage, beets, and

dried beet pulp, fed when the cows were on full feed, was 18.7, 14, and 71.6 percent, respectively, based on analyses given by Morrison (*10*), for such feeds. The cows were on good, irrigated, tame-grass pasture a part of the day during the grazing season when on full feed.

Comparative Milk and Butterfat Production

Table 10 shows the milk and butterfat production by the individual cows and by groups, when they were fed initial-, half-, or full-bloom hay; also the production by the same cows under full-feed conditions. Since all but two of the records were made at immature ages, all records have been calculated to a mature-age basis to make them comparable. The correction factors used were based on unpublished data of the Bureau. Both the actual and the calculated records are given in the table.

TABLE 10.—*Milk and butterfat production by yearly lactation periods of cows when fed on alfalfa hay cut at initial-, half-, or full-bloom stage of maturity, and their production under full-feed conditions*

Cow No.	When fed the alfalfa hay ration					When on full feed				Relation of calculated production on alfalfa hay to calculated production on full feed	
	Stage of hay, and cuttings	Actual production		Calculated production		Actual production		Calculated production			
		Milk	Butterfat	Milk	Butterfat	Milk	Butterfat	Milk	Butterfat	Milk	Butterfat
		Lb.	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Pct.*	*Pct.*
88	Initial bloom (3 cuttings, 1935, and first cutting, 1936).	10,828	416	10,828	416	14,075	537	17,994	655	60.4	63.5
98	do	11,006	300	11,887	421	16,008	559	20,766	721	57.2	58.4
96	Initial bloom (3 cuttings, 1936, and first cutting, 1937).	10,478	371	10,582	374	15,514	498	21,083	675	50.2	55.4
Average (3 cows).		10,771	392	11,099	404	15,429	531	19,918	684	55.7	59.1
95	Half bloom (3 cuttings, 1935, and first cutting, 1936).	8,046	290	8,529	307	15,397	550	17,707	633	48.2	48.5
96	do	9,301	314	9,952	336	15,514	498	21,720	697	45.8	48.2
88	Half bloom (3 cuttings, 1936, and first cutting, 1937).	10,391	370	10,391	370	14,675	537	17,904	656	58.0	56.5
311	do	9,172	329	10,181	365	14,737	585	18,779	743	54.2	49.1
Average (4 cows).		9,228	326	9,763	345	15,081	543	19,028	682	51.3	50.6
97	Full bloom (2 cuttings, 1935, and first cutting, 1936).	7,011	287	7,432	304	12,691	502	16,245	643	45.7	47.3
301	do	8,838	341	9,545	368	16,118	558	21,921	773	43.5	47.6
95	Full bloom (2 cuttings, 1936, and first cutting, 1937).	9,498	319	9,593	322	15,397	550	17,707	633	54.2	50.9
316	do	8,425	297	9,352	330	14,439	558	20,486	785	45.8	42.0
Average (4 cows).		8,443	311	8,981	331	14,661	545	19,077	709	47.1	46.7

The group on initial-bloom hay (table 10) averaged 55.7 percent as much milk and 59.1 percent as much butterfat as they had produced under full-feed conditions; whereas, the group on half-bloom hay averaged only 51.3 percent as much milk and 50.6 percent as much butterfat as they had produced on full-feed (mature basis). The

calculated production on half-bloom hay was about 88 percent as much milk and 85 percent as much butterfat as the production on the initial-bloom hay, although both groups of cows had shown about the same producing capacity under full-feed conditions.

The group on full-bloom hay averaged the lowest of the three groups in both milk and butterfat production, despite the fact that these cows had made the highest butterfat record on full feed and were favored with a longer dry period than the other groups before going on the hay ration.

The calculated butterfat production on full-bloom hay was 96 percent of that on half-bloom hay and 82 percent of that on initial-bloom hay.

It is interesting to compare the two consecutive records by two cows (96 and 88) on the hay ration. Both cows made a higher record on the

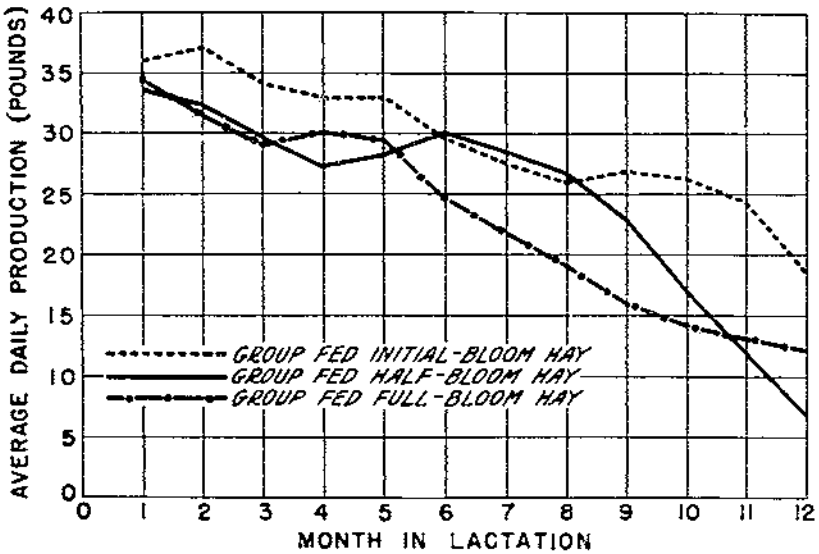

FIGURE 3.—Average daily milk production by months in lactation of cows fed initial-, half-, or full-bloom hay for entire lactation periods.

initial-bloom hay than on the half-bloom hay, although cow 96 made her record on the initial-bloom hay after she had been on half-bloom hay.

For cow 96 the difference in the effect of the dry period prior to freshening and the pregnancy period on the two records was in favor of the record on initial-bloom hay, but for cow 88 the difference was in favor of the record on half-bloom hay. One probable reason for cow 88 making a lower record on half-bloom hay was that it was much lower in protein content that the initial-bloom hay, particularly that fed during the last 3 months of the lactation. In her lactation on initial-bloom hay all cuttings fed had a high protein content with the exception of that fed during the twelfth month.

It is also interesting to note the apparent inconsistency of the two consecutive records by cow 95 in the hay experiment. Her production on half-bloom hay, which followed her lactation on full feed, was lower than her production on full-bloom hay. She was dry for 30 days longer prior to her lactation on full-bloom hay than when she was on the half-bloom hay, but she was also pregnant for 30 days longer. During her last 6 months on half-bloom hay, however, she was fed a cutting of hay that was the lowest in crude protein and one of the highest in crude fiber of any cutting in the experiment (table 4). The low quality of this particular cutting was apparently caused by extreme grasshopper damage. Her yield dropped heavily when this cutting was fed, but held up well during the last 6 months of the following lactation on full-bloom hay.

The three groups of cows were very similar in their inherent milk- and butterfat-producing capacity, as indicated by their official records made under full-feeding conditions (mature-age basis). Their production on the three stages of hay, therefore, apparently indicates a relative feeding value for these hays as follows: Initial-bloom hay first, half-bloom hay second, and full-bloom hay third.

PRODUCTION BY MONTHS IN LACTATION

Table 11 was prepared to show the relative persistency of milk production on initial-, half-, or full-bloom hay. The comparison is for average daily milk production by months in lactation. As the quality of the various cuttings of hay fed apparently bears a close relationship to the increase or decline in milk yield, the relative periods that the various cuttings of initial-, half-, or full-bloom alfalfa were fed are also indicated. Table 11 also shows the relation expressed as a percentage, of the average daily production for any month to that of the maximum or highest month, which was considered as 100 percent. Figure 3 shows the same data graphically.

TABLE 11.—*Average daily milk production by months in lactation of the cows when fed alfalfa hay cut at different stages of maturity*

COWS FED INITIAL-BLOOM HAY

Month of lactation period	Cow 88		Cow 98		Cow 96			
	Cutting fed	Average daily milk production	Cutting fed	Average daily milk production	Cutting fed	Average daily milk production	Average daily milk production (3 cows)	Relation to maximum production
		Pounds		*Pounds*		*Pounds*	*Pounds*	*Percent*
First	First, 1935	44.1	First, 1935	34.5	First, 1936	30.3	36.1	97.8
Second	do	45.4	do	35.2	do	30.5	37.1	100.0
Third	do	36.7	do	36.1	do	28.2	33.7	90.8
Fourth	do	34.6	do	35.3	do	27.7	32.5	87.6
Fifth	do	31.3	do	33.4	Second, 1936	33.2	32.6	87.9
Sixth	Second, 1935	28.0	Second, 1935	30.1	do	31.1	29.7	80.1
Seventh	do	24.5	do	28.9	do	29.5	27.6	74.4
Eighth	do	22.3	do	28.0	Third, 1936	28.7	26.3	70.9
Ninth	Third, 1935	25.1	Third, 1935	29.9	do	27.3	27.4	73.9
Tenth	do	22.4	do	29.0	do	27.7	26.4	71.2
Eleventh	do	19.3	do	26.7	do	27.5	24.5	66.0
Twelfth	First, 1936	13.6	First, 1936	20.8	First, 1937	21.4	18.6	50.1

TABLE 11.—*Average daily milk production by months in lactation of the cows when fed alfalfa hay cut at different stages of maturity*—Continued

COWS FED HALF-BLOOM HAY

Month of lactation period	Cow 95		Cow 96		Cow 88		Cow 311		Average daily milk production (4 cows)	Relation to maximum production
	Cutting fed	Average daily milk production	Cutting fed	Average daily milk production	Cutting fed	Average daily milk production	Cutting fed	Average daily milk production		
		Lb.		*Lb.*		*Lb.*		*Lb.*	*Lb.*	*Pct.*
First	First, 1935	24.2	First, 1935	33.0	First, 1936	40.5	First, 1936	36.6	33.6	100.0
Second	do	32.9	do	36.9	do	29.0	do	30.6	32.4	96.4
Third	do	28.3	do	31.4	do	30.0	do	28.9	29.7	88.4
Fourth	Second, 1935	29.2	do	26.7	do	27.7	do	25.5	27.3	81.3
Fifth	do	26.7	do	27.1	Second, 1936	31.3	Second, 1936	28.2	28.3	84.2
Sixth	Third, 1935	27.1	do	23.5	do	34.7	do	33.5	30.2	89.9
Seventh	do	23.5	Second, 1935	24.4	Third, 1936	35.2	Third, 1936	31.7	28.7	85.4
Eighth	do	21.3	do	24.3	do	34.4	do	27.6	26.9	80.1
Ninth	First, 1936	13.0	Third, 1935	25.9	do	29.8	do	23.5	23.1	68.7
Tenth	do	8.4	do	24.4	First, 1937	21.3	First, 1937	13.9	17.0	50.6
Eleventh	do	4.1	do	22.3	do	15.7	do	6.5	12.2	36.3
Twelfth	do	2.4	First, 1936	11.8	do	11.8	do	2.5	7.1	21.1

COWS FED FULL-BLOOM HAY

Month of lactation period	Cow 97		Cow 301		Cow 95		Cow 316		Average daily milk production (4 cows)	Relation to maximum production
	Cutting fed	Average daily milk production	Cutting fed	Average daily milk production	Cutting fed	Average daily milk production	Cutting fed	Average daily milk production		
		Lb.		*Lb.*		*Lb.*		*Lb.*	*Lb.*	*Pct.*
First	First, 1935	35.8	First, 1935	36.2	First, 1936	37.7	First, 1936	28.4	34.5	100.0
Second	do	33.1	Second, 1935	38.7	do	30.1	do	24.0	31.5	91.3
Third	do	27.7	do	26.4	do	25.4	do	27.3	29.2	84.6
Fourth	do	26.9	do	33.0	Second, 1936	30.8	Second, 1936	29.1	30.0	87.0
Fifth	Second, 1935	23.7	do	31.4	do	31.6	do	31.4	29.5	85.5
Sixth	do	22.3	First, 1936	23.6	do	31.0	do	22.0	24.7	71.6
Seventh	do	19.7	do	18.7	First, 1937	28.4	First, 1937	20.4	21.8	63.2
Eighth	First, 1936	14.3	do	18.2	do	26.0	do	18.6	19.4	56.2
Ninth	do	9.9	do	15.1	do	22.1	do	18.3	16.4	47.5
Tenth	do	6.5	do	13.4	do	20.3	do	17.4	14.4	41.7
Eleventh	do	3.5	do	11.4	do	19.9	do	18.5	13.3	38.6
Twelfth	do	3.3	do	11.8	do	17.0	do	17.0	12.3	35.6

On the initial-bloom hay the maximum production per cow per day was reached during the second month of lactation (37.1 pounds). There was a steady decline until the ninth month, when there was a slight increase. Thereafter the decline was rather gradual. During the twelfth month this group averaged 18.6 pounds of milk per cow per day, or 50.1 percent of its highest yield in any one month. The increase that began with the ninth month corresponds to a change from second- to third-cutting (1935) hay for cows 88 and 98. The slight rise in the average for the fifth month was due to the increased

yield by cow 96, which apparently was the result of shifting her from first- to second-cutting (1936) hay during that month.

On half-bloom hay the maximum production per cow per day was reached during the first month of lactation (33.6 pounds). There was a decline until the fifth month, when a rather surprising increase occurred apparently as a result of shifting cows 88 and 311 from first- to second-cutting (1936) hay. Up to the end of the eighth month the yield of this group was fairly persistent, but in the ninth month it declined rapidly, until in the twelfth month it was much lower than for the other two groups. Starting with the ninth month cow 95 was changed from third-cutting, 1935, hay that contained 21.8 percent of protein to first-cutting, 1936, hay, which had a protein content of 13.27 percent, and she declined rapidly in milk production. Why cows 88 and 311 declined so rapidly in the ninth month when they were still on third-cutting, 1936, hay, which was high in protein content, is not known. When they were changed to first-cutting, 1937, hay in the tenth month there was a further sharp decline, which continued through the twelfth month.

On full-bloom hay the maximum production was also reached during the first month of lactation, then it declined more rapidly than on half-bloom hay until the third month, when a shift to second-cutting hay caused a slight increase in production for the next 2 months. After this there was a steady decline in milk yield, though not quite so rapid as with the half-bloom hay. During the twelfth month of lactation on full-bloom hay the average daily milk yield was 35.6 percent of the maximum, as compared to only 21.1 percent on the half-bloom hay.

RELATIVE EFFECT OF FEEDING HAY MADE FROM THE FIRST, SECOND, OR THIRD CUTTING

In all cases the lactations were started on a first cutting of the stage of hay fed, followed by the second cutting, and in the case of cows fed initial- or half-bloom hay, by the third cutting. When the hay cut during one year had been fed out, the lactation periods were completed with hay from the first cutting of the succeeding year (table 11).

Since the first cutting of each stage was shown in practically all cases to be inferior in composition to the latter cuttings, the first-cutting hay would be expected to produce less milk than the later cuttings. Further evidence that the later cuttings were superior to the first for milk production is afforded by the change in average daily milk production of the individual cows (table 11) when shifted from an early to a later cutting.

With initial-bloom hay the change from a first to a second cutting apparently resulted in increasing the milk flow in the case of one cow and decreasing it in two cases (table 11). That is, when the second-cutting, 1935, hay which was lower in protein than the first-cutting, 1935, hay was fed to cows 88 and 98 their milk yield declined, but when the second-cutting, 1936, hay which excelled the first-cutting, 1936, hay in protein was fed to cow 96 her yield increased.

Shifting from second-cutting, 1935, to third-cutting, 1935, hay which was higher in protein resulted in an increased flow of milk for cows 88 and 98, but shifting from second to third cutting, 1936, decreased the yield of cow 96.

With half-bloom hay when cows 95 and 96 were shifted from first- to second-cutting, 1935, hay that differed but little in protein content, one cow gave slightly more and the other less milk. When cows 88 and 311 were changed from first-cutting, 1936, to second-cutting, 1936, hay which was more than 6 percent higher in protein than the earlier cutting, the milk yield of both cows increased decidedly. The shift from a second to a third cutting resulted in a slight increase by three cows and a decline by one cow. The latter was being fed some of the third cutting obtained in 1936, which was lower in protein than the second cutting for that year. When the four cows were again shifted to the first cutting of hay obtained during the next year, they all decreased in production.

When full-bloom hay was fed three cows showed an increase in production and one a decrease when shifted from a first to a second cutting, while all four showed rather sharp declines when changed from a second-cutting to first-cutting hay of the succeeding year.

For each of the three stages of growth (initial-, half-, or full-bloom) the average percentage of protein for the 3 years in the first-cutting hay was lower than that in second- or third-cutting hay. The feeding and production records indicate that as a rule the cows produced better on second- or third-cutting than on first-cutting hay. The decline in production was more pronounced when cows were changed to first-cutting hay in the late months of the lactation period than when they were started on first-cutting hay at the beginning of the lactation period, as was to be expected. Also in the latter part of the lactation periods (table 11) the decline was much more rapid with cows that were changed to first-cutting hay in the seventh, eighth, or ninth month than with those fed second- or third-cutting hay until near the end of the lactation.

The superior yield of the group on initial-bloom hay was no doubt partly due to the fact that this group received first-cutting hay for a total of only 3 cow-months in the closing months of the lactation period, whereas the group on half-bloom hay received first-cutting hay for a total of 11 cow-months, and the group on full-bloom hay received first-cutting hay for 24 cow-months.

Figure 4 shows the differences in the lactation curves of the three cows that were in two different groups in the hay-feeding trials in two different lactations. These curves show graphically the average daily milk production of each of the three cows, when fed solely on hay made from various cuttings at the three stages. The effect of changing from one to another cutting of the same stage can be seen.

SUMMARY OF DATA ON MILK PRODUCTION

The comparative yearly production of the three groups of cows on the three different stages of hay indicates that the milk-producing value of the initial-bloom hay was the highest, half-bloom hay next, and full-bloom hay the lowest.

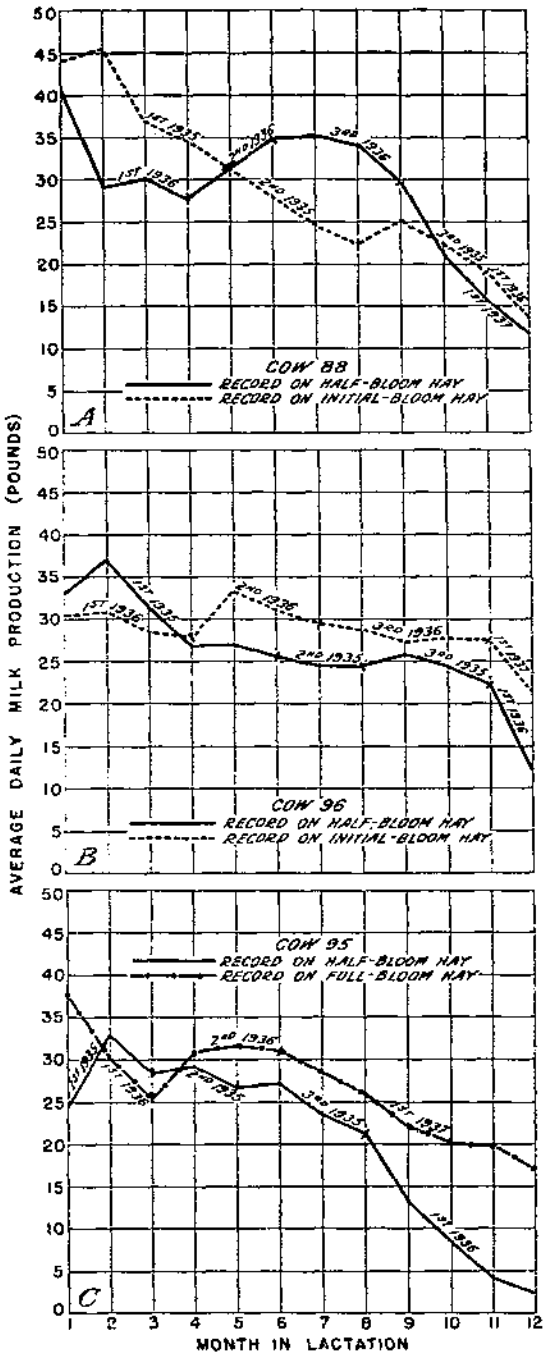

FIGURE 4.—Changes in milk production of three cows when each made a yearly record on alfalfa hay obtained from various cuttings at the initial-, half-, or full-bloom stage, and a second record on a different stage than was fed in the first lactation: *A*, cow 88; *B*, cow 96; *C*, cow 95.

From the standpoint of maintaining persistency of production, however, the initial-bloom hay was best but the full-bloom was slightly better than the half-bloom hay. This rank is indicated both by the rapidity of the decline in daily production and the percentage of change from the maximum. The superiority for milk production of the later cuttings of hay as compared to the first cuttings all stages, is very evident, as shown by the increased production that resulted when the cows were shifted from a first cutting to a later cutting.

Feed and Nutrient Consumption

Hay consumption when initial-, half-, or full-bloom hay was fed

The total consumption of hay by the individual cows during lactation periods on alfalfa hay of initial-, half-, or full-bloom stage with the average of each group is shown in table 12. The amount and percentage of refused hay, and the consumption per pound of milk and butterfat produced, are also shown.

TABLE 12.—*Total amount of hay fed, consumed, and refused by cows when fed alfalfa hay cut at different stages of maturity, for yearly lactation periods*

Cow No.	Stage of hay, and cuttings	Hay fed	Hay consumed	Hay refused		Hay consumed per pound of milk produced	Hay consumed per pound of butterfat produced
		Pounds	*Pounds*	*Pounds*	*Percent*	*Pounds*	*Pounds*
88	Initial bloom (3 cuttings, 1935, and first cutting, 1936).	15,077	14,043	1,034	6.6	1.35	35.2
98	do	14,692	13,792	900	6.1	1.25	35.4
96	Initial bloom (3 cuttings, 1936, and first cutting, 1937).	16,021	14,735	1,286	8.0	1.41	39.7
Average (3 cows).		15,463	14,390	1,073	6.9	1.34	36.8
95	Half bloom (3 cuttings, 1935, and first cutting, 1936).	14,714	13,761	953	6.5	1.71	47.4
96	do	14,178	13,221	957	6.7	1.42	42.1
88	Half bloom (3 cuttings, 1936, and first cutting, 1937).	16,755	15,765	990	5.9	1.52	42.6
311	do	16,179	15,021	1,158	7.2	1.64	45.7
Average (4 cows).		15,457	14,442	1,015	6.6	1.57	44.5
97	Full bloom (2 cuttings, 1935, and first cutting, 1936).	15,143	14,282	861	5.7	2.04	49.8
301	do	14,557	13,715	842	5.8	1.55	40.2
95	Full bloom (2 cuttings, 1936, and first cutting, 1937).	16,137	14,985	1,152	7.1	1.58	47.0
316	do	14,763	13,256	1,507	10.2	1.57	44.6
Average (4 cows).		15,150	14,060	1,090	7.2	1.69	45.4

There were, apparently, some inconsistencies in hay consumption by the individual cows on the different stages of hay. For example, both the highest and the lowest consumption per cow was on the half-bloom hay (cows 88 and 96). Also while both of these cows each

made a record on the initial-bloom hay and on the half-bloom hay, one consumed more of the initial-bloom hay and the other consumed more of the half-bloom hay. Another cow (95) with records on both the half-bloom and the full-bloom hay consumed more of the full-bloom hay. On the average, however, the three groups of cows received about the same amount of hay, consumed about the same amount, and refused about the same amount. This appears to indicate that there was little or no difference in the palatability of the three stages of hay.

The cows on the initial-bloom hay consumed the least hay per pound of milk and butterfat produced, followed by those on the half-bloom hay and the full-bloom hay in the order named.

In an earlier investigation by the Bureau (*6*) 15 registered Holstein-Friesian cows at several stations were fed for 26 lactations on alfalfa hay alone. The hay was of good quality and included first, second, and third cuttings of alfalfa which probably averaged between half bloom and full bloom when cut. Some of the hay was produced in the vicinity of Huntley, Mont. The average hay consumption by these 15 cows was 14,134 pounds for an average lactation period of 356 days, or at the rate of 39.7 pounds per cow per day. Five of these cows made a total of eight lactation periods at the Huntley station on hay which had about the same average protein content as the full-bloom hay fed in this experiment. Their average daily consumption was 42.7 pounds, or 4.2 pounds more than was consumed by the group fed full-bloom hay in this experiment. They were fed larger quantities of hay, however, and the amount weighed back was approximately 15 percent of the amount fed. The 15 cows on an average ate 1.3 pounds of hay for each pound of milk produced, and 36 pounds for each pound of butterfat. These ratios of hay consumption to milk and butterfat production are approximately the same as for initial-bloom hay in this experiment (table 12).

In another experiment by this Bureau (*5*) immature grass hay was fed to four Holstein cows for a total of six lactation periods. The consumption of grass hay averaged 15,648 pounds per cow, or 43.5 pounds per cow per day, which was 6.7 pounds higher than the consumption of initial-bloom hay in the present experiment. The grass hay apparently was more palatable than the initial-bloom alfalfa, yet the amount of grass hay consumed per unit of milk and butterfat production was higher than the amount of initial-bloom hay.

During the present experiment grasshoppers were a serious menace to the quality of the hay crop. They damaged certain cuttings more than others, particularly the leaves and blossoms. On the stems of alfalfa hay that has been damaged by grasshoppers will be found spots of brown stain said to be excreta from the grasshopper. It is the opinion of many farmers in the Huntley region that hay thus stained is unpalatable to cattle. How much this factor affected consumption in this experiment is not known.

Table 13 shows the changes in the average daily consumption of hay as the cuttings were fed throughout the lactation period, by individual cows and by groups. Figure 5 shows the relative daily consumption by the three groups on the three different stages of hay.

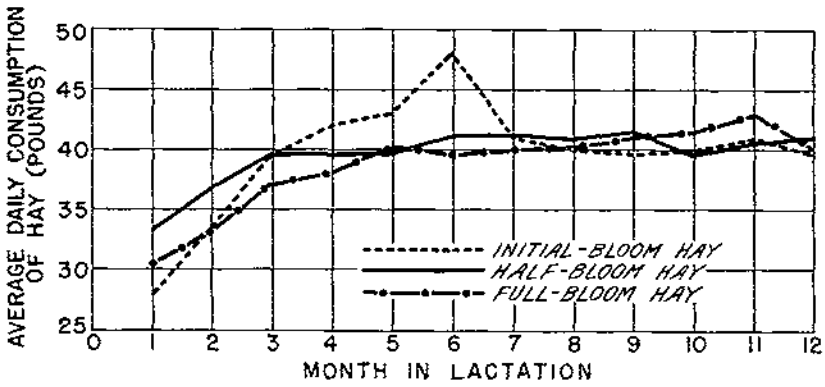

FIGURE 5.—Relative daily consumption of the initial-bloom, half-bloom, and full-bloom hay throughout the lactation period.

TABLE 13.—*Average daily hay consumption by months in lactation of the cows fed alfalfa hay cut at different stages of maturity*

COWS FED INITIAL-BLOOM HAY

Month of lactation period	Cow 88		Cow 98		Cow 96		Average daily hay consumption (3 cows)
	Cutting fed	Amount consumed	Cutting fed	Amount consumed	Cutting fed	Amount consumed	
		Pounds		*Pounds*		*Pounds*	*Pounds*
First	First, 1935	27.7	First, 1935	18.5	First, 1936	36.9	27.7
Second	do	35.5	do	23.3	do	41.9	33.6
Third	do	43.6	do	32.5	do	42.5	39.5
Fourth	do	44.7	do	40.6	do	41.0	42.1
Fifth	do	45.4	do	41.7	Second, 1936	41.3	42.8
Sixth	Second, 1935	58.0	Second, 1935	45.9	do	40.2	48.0
Seventh	do	43.1	do	40.4	do	39.2	40.9
Eighth	do	40.4	do	39.8	Third, 1936	40.1	40.1
Ninth	Third, 1935	39.9	Third, 1935	40.4	do	39.1	39.8
Tenth	do	38.9	do	39.9	do	41.1	40.0
Eleventh	do	38.4	do	40.9	do	43.3	40.9
Twelfth	First, 1936	39.5	First, 1936	41.5	First, 1937	38.2	39.7

COWS FED HALF-BLOOM HAY

Month of lactation period	Cow 95		Cow 96		Cow 88		Cow 311		Average daily hay consumption (4 cows)
	Cutting fed	Amount consumed	Cutting fed	Amount consumed	Cutting fed	Amount consumed	Cutting fed	Amount consumed	
		Lb.		*Lb.*		*Lb.*		*Lb.*	*Lb.*
First	First, 1935	23.8	First, 1935	23.7	First, 1936	44.1	First, 1936	40.4	33.0
Second	do	31.4	do	31.2	do	44.6	do	41.5	36.9
Third	do	36.5	do	37.1	do	40.8	do	40.8	38.8
Fourth	Second, 1935	41.3	do	31.9	do	41.4	do	40.0	39.4
Fifth	do	39.6	do	35.8	Second, 1936	43.3	Second, 1936	39.9	39.7
Sixth	Third, 1935	39.2	do	36.1	do	47.3	do	43.1	41.4
Seventh	do	38.0	Second, 1935	35.3	Third, 1936	49.1	Third, 1936	43.8	41.6
Eighth	do	37.9	do	37.8	do	44.5	do	43.8	41.0
Ninth	First, 1936	41.4	Third, 1935	38.0	do	43.8	do	42.3	41.6
Tenth	do	42.9	do	37.9	First, 1937	39.5	First, 1937	38.7	39.8
Eleventh	do	45.1	do	37.9	do	39.6	do	39.6	40.6
Twelfth	do	44.6	First, 1936	41.2	do	39.1	do	39.6	41.1

TABLE 13.—*Average daily hay consumption by months in lactation of the cows fed alfalfa hay cut at different stages of maturity*—Continued

COWS FED FULL-BLOOM HAY

Month of lactation period	Cow 97		Cow 301		Cow 95		Cow 316		Average daily hay consumption (4 cows)
	Cutting fed	Amount consumed	Cutting fed	Amount consumed	Cutting fed	Amount consumed	Cutting fed	Amount consumed	
		Lb.		*Lb.*		*Lb.*		*Lb.*	*Lb.*
First	First, 1935	26.2	First, 1935	23.5	First, 1936	42.8	First, 1936	29.5	30.5
Second	do	31.0	Second, 1935	28.7	do	42.5	do	30.0	33.1
Third	do	45.3	do	32.9	do	36.7	do	33.3	37.1
Fourth	do	41.0	do	35.2	Second, 1936	37.4	Second, 1936	39.4	38.3
Fifth	Second, 1935	39.6	do	36.0	do	42.5	do	42.2	40.1
Sixth	do	38.5	First, 1936	30.0	do	43.2	do	37.3	39.5
Seventh	do	38.5	do	40.3	First, 1937	43.8	First, 1937	37.3	40.0
Eighth	First, 1936	39.7	do	43.2	do	39.8	do	38.5	40.3
Ninth	do	40.7	do	45.4	do	39.3	do	39.6	41.3
Tenth	do	42.8	do	43.6	do	41.6	do	38.1	41.5
Eleventh	do	45.2	do	44.4	do	43.4	do	38.6	42.9
Twelfth	do	43.5	do	43.5	do	40.5	do	33.2	40.2

It was shown previously that the first cuttings were usually inferior in chemical composition to the later cuttings. It is not surprising then to note (table 13) that the cows increased their daily hay intake as they were shifted from the first to the later cuttings, but it is surprising to note that hay consumption often increased (or decreased only slightly) when the cows were again shifted to first-cutting hay near the end of the lactation period.

The first-cutting hay fed at the end of the lactation periods was newly made hay, since it was from the crop of the year following the start of the lactation period (table 13). Table 14 shows the amount of this cutting fed to each cow, the percentage consumed, and the average daily consumption, as compared to the other cuttings.

On the average the cows consumed a higher percentage of the first-cutting hay that was fed at the end of the lactation period than of the first-cutting hay fed at the start of the lactation.

Moreover, the percentage of the first-cutting hay consumed at the end of the lactation was usually higher than when hay from the same cutting was later fed to other cows at the start of a lactation. For example, cows 88 and 98 in the initial-bloom hay group (table 14) consumed 94.6 and 97.1 percent, respectively, of the first-cutting, 1936, hay that was fed at the end of the lactation period; whereas cow 96 starting on hay from the same cutting at a later date consumed only 93.8 percent. The same trend holds true for the first cuttings of the half- and full-bloom stages.

Several possible explanations are suggested for the relatively high consumption of the first cutting at the end of the lactation period. One is that the cows that had been on hay for the greater part of a lactation period were doubtless thoroughly accustomed to the hay ration and for this reason ate more hay than cows just starting on the hay ration. Also, the cows, after being fed on rather fine, leafy hay for extended periods, may have craved the more stemmy and coarser kinds like the first cuttings. It should be borne in mind that an alfalfa-hay ration is highly restricted. Previous experiments by the Bureau (*6*) showed that cows restricted to alfalfa hay for long periods

TABLE 14.—*Amounts of hay from different cuttings that were fed to dairy cows in the feeding trials with alfalfa cut at different stages of maturity, the amounts consumed, and the average daily consumption*

HAY CUT AT THE INITIAL-BLOOM STAGE

Cow No.	Hay from cutting made in the year indicated													Hay obtained from the first cutting of following year			
	First cutting					Second cutting				Third cutting							
	Year cut	Amount offered	Amount consumed	Percentage consumed	Average daily consumption	Amount offered	Amount consumed	Percentage consumed	Average daily consumption	Amount offered	Amount consumed	Percentage consumed	Average daily consumption	Amount offered	Amount consumed	Percentage consumed	Average daily consumption
		Lb.	*Lb.*	*Pct.*	*Lb.*	*Lb.*	*Lb.*	*Pct.*	*Lb.*	*Lb.*	*Lb.*	*Pct.*	*Lb.*	*Lb.*	*Lb.*	*Pct.*	*Lb.*
88	1935	6,258	5,777	92.3	38.3	4,692	4,444	94.7	44.0	3,507	3,368	96.0	40.1	1,220	1,154	94.6	39.8
98	1935	4,464	4,105	92.0	32.1	4,379	4,144	94.6	41.0	3,586	3,386	94.4	40.3	2,204	2,199	97.1	42.3
96	1936	8,091	7,588	93.8	41.0	3,911	3,480	89.0	40.5	2,901	2,635	90.8	39.3	1,118	1,032	92.3	38.2
Total		18,813	17,470	92.9	[1] 38.2	12,982	12,068	93.0	[1] 41.9	9,994	9,389	93.9	[1] 40.0	4,602	4,385	95.3	[1] 40.6
HAY CUT AT THE HALF-BLOOM STAGE																	
95	1935	2,695	2,329	86.8	27.5	4,005	3,791	94.7	39.9	2,848	2,619	92.0	38.0	5,166	5,012	97.0	43.2
96	1935	5,484	5,063	92.3	33.5	3,707	3,472	93.7	36.5	2,850	2,625	92.1	38.0	2,137	2,061	96.4	41.2
88	1936	6,073	5,764	94.9	43.7	3,278	3,104	94.7	47.0	3,599	3,424	95.1	45.1	3,926	3,588	91.1	39.4
311	1936	6,220	5,813	93.5	40.7	3,015	2,742	91.0	41.5	3,529	3,326	94.2	43.8	3,415	3,142	92.0	39.3
Total		20,472	18,979	92.7	[1] 37.1	14,005	13,109	93.6	[1] 40.7	12,826	11,994	93.5	[1] 41.4	14,644	13,803	94.3	[1] 41.0
HAY CUT AT THE FULL-BLOOM STAGE																	
97	1935	2,085	1,853	88.9	22.6	6,300	5,925	94.1	45.9					6,758	6,504	96.2	42.2
301	1935	665	547	82.3	21.9	4,477	4,157	92.9	32.2					9,342	8,968	96.0	42.5
95	1936	3,525	3,248	92.1	40.1	3,794	3,497	92.2	41.1					8,818	8,240	93.5	41.4
316	1936	2,565	2,225	86.7	29.6	3,589	3,231	90.0	38.5					8,609	7,800	90.6	37.9
Total		8,840	7,873	89.1	[1] 29.9	18,160	16,810	92.6	[1] 39.4					33,527	31,512	94.0	[1] 40.9

[1] Weighted average.

crave other kinds of roughage, and that the refused portion of the alfalfa is not always the stems but may be the leafy portion. The changes from one cutting to another, and especially the shifts from a late cutting of one year to a first cutting of the following year, probably afforded some variety in the ration, which may in itself have caused the increased consumption of the poorer cuttings.

The daily consumption in pounds per cow averaged 38.2, 41.9, and 40.0 respectively, for the first, second, and third cuttings at the initial-bloom stage; 37.1, 40.7, and 41.4 for the first, second, and third cuttings at the half-bloom stage; 29.9 and 39.4 for the first and second cuttings at the full-bloom stage. When the cuttings are grouped without regard to the stage of growth, the average was 38.3 pounds for first cutting, representing, 2,453 cow-days; 40.5 pounds for second cutting, representing 1,037 cow-days; and 40.7 pounds for third cutting, representing 525 cow-days.

When the hay consumption is compared from the standpoint of the U. S. grade of the hay, without regard to the subclassification of the grade for leafiness or color, it is found that U. S. No. 1 hay was consumed at the average rate of 40.4 pounds per cow per day for 71 cow-months, as compared to an average of 38.4 pounds for U. S. No. 2 hay for 56 cow-months. Only two lots of hay were graded as U. S. No. 3, and the daily consumption averaged 33.4 pounds per cow for 5 cow-months.

Considering the hay-consumption data from all angles, it is concluded that there was little difference in the amount of hay the cows consumed by lactation periods or by months in lactation on the three stages of hay. From the standpoint of the least hay consumed per unit of milk and butterfat production, the initial-bloom ranked first, half-bloom second, and full-bloom stage third. The palatability of the three different stages of hay, as measured by the percentage consumed of the amount fed, was practically the same.

NUTRIENT CONSUMPTION

The total consumption of digestible nutrients by the individual cows when fed for an entire lactation period on initial-, half-, or full-bloom hay, and the average for each group, are shown in table 15. The total digestible nutrient requirements are also shown, together with the percentage of requirements consumed.

All cows consumed more than enough hay to meet their nutrient requirements for maintenance and for the amount of milk and butterfat they produced during the lactation period. On an average the cows fed initial-bloom hay exceeded their requirements by 7.2 percent, the half-bloom group by 10.4 percent, and the full-bloom group by 6.5 percent. All three groups increased in average body weight during the lactation period, but the average increase was considerably greater for the half-bloom and full-bloom groups.

Of more significance, however, is the amount of milk each group produced from the nutrients consumed above maintenance requirements—that is, from the nutrients that were theoretically available for milk production. When the actual quantity of milk produced is converted to a uniform 4-percent-fat basis, according to the formula of Gaines (*3*), the amount produced per pound of available nutrients is 2.71 pounds for initial-bloom, 2.49 for half-bloom, and 2.67 for

TABLE 15.—*Comparative consumption of total digestible nutrients and nutrient requirements by 3 groups of cows fed alfalfa hay cut at different stages of maturity*

Cow No.	Stage of hay and cuttings	Hay consumed	Average body weight	Gain (+) or loss (−) in body weight	Digestible nutrients required for—			Total digestible nutrients consumed in hay	Excess of total digestible nutrients	Percentage consumed of nutrients required	Milk produced [2] per pound of total digestible nutrients consumed above maintenance requirements
					Maintenance	Production	Total [1]				
		Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Percent*	*Pounds*
88	Initial bloom (3 cuttings, 1935, and first cutting, 1936	14,643	1,404	+77	3,801	3,422	7,313	7,648	+335	104.6	2.81
98	do	13,792	1,363	−72	3,789	3,302	7,091	7,203	+112	101.6	3.00
96	Initial bloom (3 cuttings, 1936, and first cutting, 1937)	14,735	1,236	+74	3,482	3,143	6,625	7,696	+1,071	116.2	2.32
Average (3 cows)		14,390	1,334	+26	3,721	3,289	7,010	7,516	+506	107.2	2.71
95	Half bloom (3 cuttings, 1935, and first cutting, 1936)	13,701	1,308	+126	3,657	2,454	6,111	6,856	+745	112.2	2.37
96	do	13,221	1,270	−5	3,570	2,753	6,323	6,587	+264	104.2	2.79
88	Half bloom (3 cuttings, 1936, and first cutting, 1937)	15,765	1,376	−23	3,825	3,169	6,994	7,855	+861	112.3	2.41
311	do	15,021	1,385	+241	3,847	2,798	6,645	7,484	+839	112.6	2.37
Average (4 cows)		14,442	1,335	+85	3,725	2,794	6,519	7,195	+676	110.4	2.49
97	Full bloom (2 cuttings, 1935, and first cutting, 1936)	14,282	1,296	−70	3,628	2,307	5,935	6,709	+774	113.0	2.31
301	do	13,715	1,242	+78	3,500	2,837	6,337	6,445	+108	101.7	2.94
95	Full bloom (2 cuttings, 1936, and first cutting, 1937)	14,985	1,372	+89	3,811	2,811	6,622	7,038	+416	106.3	2.66
316	do	13,256	1,198	+145	3,387	2,528	5,915	6,229	+314	105.3	2.75
Average (4 cows)		14,060	1,277	+60	3,582	2,621	6,203	6,905	+402	106.5	2.67

[1] Morrison feeding standard used as basis for calculation.
[2] Corrected to 4-percent butterfat basis.

full-bloom hay (table 15). On this basis of comparison the initial-bloom hay appears to be superior to both the half-bloom and full-bloom hay for milk production, and apparently the full-bloom hay was superior to the half-bloom hay. However, the cows in the full-bloom group were dry for a much longer period than the half-bloom group, prior to freshening for this experiment, and this may account for the surprising difference in the way these groups utilized their available nutrients. At the start of the lactation period the group on full-bloom hay averaged about 46 pounds lighter in body weight than the group on half-bloom hay. The two groups were gaining at about the same average rate until the eighth month in lactation, when the average gain for the half-bloom group exceeded that for the full-bloom group (table 16 on page 45, and figure 6 on pages 44.)

A lack of consistency in the results for utilization of nutrients is apparent in some of the individual records, especially with cows that had two records on hay. Cow 88 when fed initial-bloom hay during a yearly lactation record (begun in 1935) produced 2.81 pounds of milk for each pound of total digestible nutrients consumed above maintenance requirements, and when she was fed half-bloom hay (1936) the ratio was 2.41 to 1. On the other hand, cow 96 when fed half-bloom hay (1935) had a ratio of 2.79 to 1; and when on initial-bloom hay (1936), only 2.32 to 1. Cow 95 when fed half-bloom hay (1935) had a ratio of 2.37 to 1, and when she was fed full-bloom hay (1936) 2.66 to 1.

On the whole, the nutrients furnished by the hay cut at the initial-bloom stage appeared to be more efficient for milk production than the nutrients from the hay cut at the half-bloom and full-bloom stages, with rather wide variations between individual cows of each group. More cows in the groups probably would have eliminated some variations that were due to the small number of individuals, and would have given more uniform results.

CONSUMPTION OF CALCIUM AND PHOSPHORUS

Facilities for balance experiments were not available at Huntley to compare the possible mineral deficiencies of the three hay rations. Steamed bonemeal was made available to all cows in this experiment, to offset a probable shortage of phosphorus. In a previous experiment (*6*), cows that were fed for long periods on alfalfa hay exclusively ate little if any of the bonemeal offered as a supplement. Although no attempt was made to measure bonemeal allowed the cows in this experiment, it was observed that but little bonemeal was consumed.

In the former experiment the 15 Holstein cows made 24 lactation-period records averaging 10,702 pounds of milk and 376 of butterfat. They consumed an average of 14,352 pounds of alfalfa hay which contained on the average 1.46 percent of calcium and 0.191 of phosphorus (dry-matter basis). During their lactation periods they consumed in the alfalfa hay 88 percent of their requirements for phosphorus, according to the standard suggested by Huffman and associates (*7*). It was concluded that they did not suffer a shortage of calcium or phosphorus on the alfalfa hay ration when the amount they consumed during their dry periods was taken into consideration.

The 3-year average for percentage of calcium in the hay of this

experiment was as follows: Initial bloom 1.355, half bloom 1.251, and full bloom 1.259. The phosphorus content averaged: Initial bloom 0.196, half bloom 0.202, and full bloom 0.155. On the lactation-period basis, the cows on initial-bloom hay consumed 81 percent of their phosphorus requirements, aside from any bonemeal they might have consumed, the cows on half-bloom hay, 99, and the cows on full-bloom hay, 78. This result, together with those of the other experiment noted, would warrant the assumption that the deficiency of phosphorus in the hay ration would be offset by a slight consumption of bonemeal and by storage of excess phosphorus in the body during dry periods.

Relative Changes in Body Weight

It is of interest to know the relative effect, on body weight, of feeding initial-, half-, or full-bloom alfalfa as the sole ration.

Various factors, including age, days of pregnancy, length of dry period, system of feeding during the previous lactation and dry period,

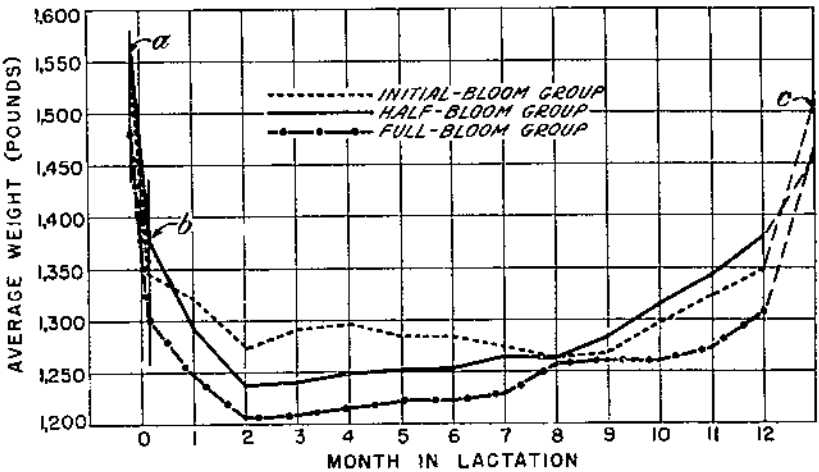

Figure 6.—Precalving, after-calving, and average monthly body weights of cows when fed alfalfa hay cut at different stages of maturity: *a*, Precalving weight; *b*, after-calving weight; *c*, precalving weight following lactation.

may have affected the gains or losses in weight during the lactation on the experimental ration, and there is no accurate method known for determining the true effect of these factors. Differences in the prior dry period or prior ration are more significant than differences in age or pregnancy period, however. For this reason the data given in table 16, on the average monthly weights during the experimental lactation periods, include the precalving and after-calving weights prior to starting on the experimental rations, also the precalving weights following the experimental feeding periods. Figure 6 shows the weight curves.

Before going on the initial-bloom hay, cow 88 had been on a ration of roughage alone (alfalfa hay, silage, and pasture) during the preced-

TABLE 16.—*Body weights by months in lactation of the cows fed alfalfa hay cut at different stages of maturity*

Cow No.	Stage of hay and cuttings	Precalving weight	After-calving weight	Average body weight by months in lactation												Precalving weight following lactation period
				First	Second	Third	Fourth	Fifth	Sixth	Seventh	Eighth	Ninth	Tenth	Eleventh	Twelfth	
		Lb.	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*
88	Initial bloom (3 cuttings, 1935, and first cutting, 1936).	1,602	1,416	1,366	1,346	1,374	1,345	1,289	1,297	1,302	1,276	1,263	1,317	1,381	1,443	1,556
98	do	1,616	1,399	1,399	1,275	1,260	1,289	1,292	1,288	1,271	1,260	1,265	1,296	1,314	1,327	(1)
96	Initial bloom (3 cuttings, 1936, and first cutting, 1937).	1,373	1,226	1,199	1,201	1,236	1,256	1,275	1,271	1,251	1,258	1,273	1,277	1,273	1,273	1,464
Average (3 cows)		1,540	1,347	1,321	1,274	1,290	1,297	1,285	1,285	1,275	1,265	1,267	1,297	1,323	1,348	1,510
95	Half bloom (3 cuttings, 1935, and first cutting, 1936).	1,661	1,474	1,245	1,221	1,236	1,241	1,237	1,249	1,253	1,262	1,288	1,304	1,328	1,371	1,446
96	do	1,450	1,272	1,272	1,206	1,193	1,173	1,174	1,133	1,151	1,156	1,180	1,207	1,225	1,267	1,373
88	Half bloom (3 cuttings, 1936, and first cutting, 1937).	1,556	1,389	1,389	1,300	1,293	1,317	1,334	1,331	1,342	1,312	1,300	1,321	1,340	1,363	(1)
311	do	1,556	1,361	1,264	1,229	1,241	1,261	1,271	1,300	1,315	1,325	1,366	1,424	1,469	1,505	1,588
Average (4 cows)		1,556	1,374	1,293	1,239	1,241	1,248	1,254	1,253	1,265	1,264	1,284	1,314	1,341	1,377	1,469
97	Full bloom (2 cuttings, 1935, and first cutting, 1936).	1,593	1,396	1,331	1,215	1,210	1,213	1,203	1,200	1,186	1,196	1,207	1,213	1,237	1,261	1,418
301	do	1,537	1,357	1,203	1,151	1,164	1,172	1,185	1,190	1,211	1,235	1,233	1,231	1,250	1,281	1,350
95	Full bloom (2 cuttings, 1936, and first cutting, 1937).	1,446	1,327	1,327	1,312	1,297	1,294	1,305	1,320	1,333	1,348	1,369	1,387	1,399	1,416	1,560
316	do	1,339	1,128	1,125	1,140	1,164	1,186	1,196	1,172	1,191	1,243	1,239	1,208	1,203	1,270	1,552
Average (4 cows)		1,479	1,302	1,247	1,205	1,209	1,216	1,222	1,221	1,230	1,256	1,262	1,260	1,272	1,307	1,470

[1] Weight not available.

ing lactation period; cow 96 had been on half-bloom hay, so this was her second consecutive lactation record on alfalfa hay alone; and cow 98 had been on a full-feed ration. The latter cow aborted during her preceding lactation so her dry period (169 days) was rather long (table 9, p. 27).

Before going on the half-bloom hay, cows 95 and 311 had been on full feed during the preceding lactation; cow 96 had been on roughage alone, and cow 88 had been on the initial-bloom hay, making this her second consecutive lactation on alfalfa hay alone.

Before going on the full-bloom hay, cows 97 and 301 had been on full feed during the preceding lactation; both aborted while on the full-feed lactation and therefore had had extremely long dry periods (333 and 419 days). Cow 95 had been on half-bloom hay, and cow 316 on full feed during the preceding lactation. Difficulty in getting cow 316 with calf for the lactation on full-bloom hay (she was bred six times before conception) accounts for her long dry period of 276 days. Thus, the full-bloom group had a considerable advantage over the other groups, in length of dry period and the plane of feeding during the preceding lactation.

On the experimental hay rations, all three groups lost weight rather heavily during the first 2 months of the lactation period, after which the half- and full-bloom groups made gradual gains until the eighth month. The initial-bloom group gained somewhat more rapidly than the others for the third and fourth months, but lost weight during the next 4 months. After the eighth month the full-bloom group gained materially less than the other groups.

The average net gain in weight from the first to the twelfth month was 27 pounds per cow for the initial-bloom group; 84 for the half-bloom group; and 60 for the full-bloom group. A comparison of the precalving weights before and following the lactations on alfalfa shows there was an average gain in live weight of 22 pounds by the two cows in the initial-bloom group for which comparative weights are available, a loss of 87 pounds by the three cows in the half-bloom group, and a loss of only 9 pounds by the four cows in the full-bloom group.

COMPARATIVE COSTS OF PRODUCING THE HAY

Detailed records were kept of the actual costs of various operations for producing the alfalfa hay cut at the different stages of maturity. From these records the costs in table 17 were calculated. The rates at which labor, use of tractor, and gasoline and oil were charged represent average costs during the 3 years of this experiment. The yearly charge for water for irrigation was $1.25 per acre. No charge was made for use of equipment other than a tractor. The land rental, which was $15 per acre per cropping year, is included in the production costs. The seeding costs are not included, because the experimental field when rented had been seeded several years before then and there was no record of them. The total costs in table 17 with the exceptions noted, cover all field operations including hauling and stacking the hay near the barn or placing it in the mow. They do not cover the feeding operations.

TABLE 17.—*Comparative costs of producing alfalfa hay, costs of nutrients, and the amount of milk produced per acre, when 3 plots were cut at different stages of maturity* [1]

Year	Initial-bloom stage				Half-bloom stage				Full-bloom stage			
	Cost per acre	Cost per ton	Cost per 100 pounds total digestible nutrients	Milk [2] produced per acre	Cost per acre	Cost per ton	Cost per 100 pounds total digestible nutrients	Milk [2] produced per acre	Cost per acre	Cost per ton	Cost per 100 pounds total digestible nutrients	Milk [2] produced per acre
	Dollars	*Dollars*	*Dollars*	*Pounds*	*Dollars*	*Dollars*	*Dollars*	*Pounds*	*Dollars*	*Dollars*	*Dollars*	*Pounds*
1935	31.89	6.47	0.621	.....	33.16	6.91	0.694	.....	27.46	8.94	0.917	.....
1936	30.54	8.03	.768	.....	32.33	8.20	.817	.....	30.28	8.23	.877	.....
1937	34.08	7.25	.700	.....	31.91	7.08	.791	.....	30.87	8.43	.893	.....
Average	32.17	7.27	.696	6,330	32.48	7.40	.767	5,254	29.54	8.53	.906	3,970

[1] In calculating the costs, the following values were used: Tractor use, $0.75 per hour; man labor, $0.30 per hour; horse labor, $0.15 per hour; land rental, $15 per acre per year; water rental, $1.25 per acre per year; gasoline, $0.15 per gallon; and oil, $0.20 per quart. Seeding charges not included.

[2] Converted to 4-percent fat basis and calculated from the average milk production and hay consumption of the 3 groups of cows for 2 lactation years, and the average yield of hay per acre for the 3 cropping seasons.

The average yearly cost of the hay obtained per acre amounted to $32.17 for the initial-bloom, $32.48 for the half-bloom, and only $29.54 for the full-bloom hay. The lower per-acre costs for the full-bloom hay were largely due to the fewer cuttings made in a year. The average cost per ton of hay obtained was $7.27 for the initial-bloom, $7.40 for the half-bloom, and $8.53 for the full-bloom hay.

Of particular interest are the comparative costs of producing 100 pounds of total digestible nutrients, which amounted to 70 and 77 cents, respectively, for the initial- and half-bloom hay as compared to 91 cents for the full-bloom hay.

When the actual quantity of milk produced per acre was corrected to a uniform basis of 4-percent butterfat content, the calculated yield was 6,330 pounds for the initial-bloom plot, 5,254 pounds for the half-bloom, and 3,970 pounds for the full-bloom plot. Twenty percent more milk per acre was produced by cutting at the initial-bloom stage than by cutting at the half-bloom stage, and 60 percent more than by cutting at the full-bloom stage. On the above basis, 100 pounds of milk was produced at a feed cost of 51 cents by the initial-bloom hay, 62 cents by the half-bloom hay, and 74 cents by the full-bloom hay.

SUMMARY AND CONCLUSIONS

This experiment was undertaken primarily to determine the comparative effect on the yield, stand, and feeding value for milk production of irrigated alfalfa cut for hay at three different stages of maturity. The stages at which the alfalfa was cut were: Initial-bloom stage, when not more than 10 percent of the plants were in bloom; half-bloom stage, when approximately 50 percent of the plants were in bloom; and full-bloom stage, when 90 to 100 percent of the plants were in bloom. The field work of the experiment was carried

out under practical dairy-farming conditions on a 15-acre field of alfalfa that had a uniform stand and had been seeded 2 years previously. The field was divided into three 5-acre plots. On one the alfalfa was cut at the initial-bloom stage, on another at the half-bloom stage, and on the other at the full-bloom stage.

Comparative yields of hay and nutrients on the three plots were determined for the 3 years, 1935, 1936, and 1937, and observations were made during these 3 years and also in the spring of 1938 on the cumulative effect on the stand. Data were also obtained on the chemical analysis, color, leafiness, and grade of the hay produced; also on the comparative costs of production.

When all factors are taken into consideration, cutting the alfalfa at the three stages of maturity, as practiced in this experiment over a 3-year period, had no significant effect on the stand. Plant counts made in the spring following the 3-year cropping period showed that the number of plants per acre and the vigor of the plants was practically the same for the three plots.

In average crude-protein content there was little difference between the hay cut at initial-bloom and that cut at half-bloom stage; the average of 3 years' results was 18.24 percent for the former and 18.29 percent for the latter. The hay cut at the full-bloom stage was markedly lower in protein, averaging 15.71 percent for all full-bloom cuttings, or 2.56 percent less than the two earlier stages. The first cuttings of all stages were lower in crude-protein content than the later cuttings.

With but few exceptions the crude-fiber content was lower for the initial-bloom and half-bloom cuttings than for the full-bloom cuttings. The 3-year average for the initial- and half-bloom hay was 28.86 and 28.45 percent, respectively, as compared to 32.68 percent for the full-bloom hay. In most cases the crude-fiber content of the hay obtained from each plot decreased with each successive cutting during the growing season. The proportion of stems in the hay had a direct bearing on the percentage of crude fiber.

The calcium content had a tendency to be somewhat higher for the hay cut at the initial-bloom stage than for the hay cut at the later stages. There was little difference between the initial-bloom and half-bloom stages in the phosphorus content, but the full-bloom stage was distinctly lower.

The 5-acre plots cut at the initial- and half-bloom stages furnished three typical cuttings each season, and the full-bloom plot furnished two typical cuttings each season.

The average (3-year) yields of field-cured hay in pounds per acre were: Initial-bloom plot, 8,938; half-bloom plot, 8,888; and full-bloom plot, 6,940. Considering the 3-year average yield of the initial-bloom plot as 100, the half-bloom plot yielded 99.4 percent as much, and the full-bloom plot only 77.7 percent as much as the initial-bloom plot. On the initial- and half-bloom plots, the first cuttings averaged approximately 49 percent of the total yield for the 3 years, the second cuttings about 27, and the third cuttings about 24. The first cuttings of the full-bloom plot comprised about 55 percent of the total yield, the second cuttings 31, and the third cuttings, none of which reached the typical full-bloom stage, 13.

The average yield of crude protein obtained per acre when the hay was cut at the initial-bloom stage was 1,427 pounds, as compared

to 1,381 pounds for the half-bloom stage and 977 pounds for the full-bloom stage. Cutting at the full-bloom stage produced 68.4 percent as much crude protein as cutting at the initial-bloom stage.

The average quantity of digestible nutrients produced by the initial-bloom plot for 3 years was 4,660 pounds per acre per year, as compared to 4,413 pounds for the half-bloom plot and 3,269 pounds for the full-bloom plot. The half-bloom plot produced 94.7 percent and the full-bloom plot 70.2 percent as much total digestible nutrients per acre as the initial-bloom plot.

In color, the hay cut at the initial- and half-bloom stages averaged 73 percent green color for the 3 years as compared to 64 percent for hay cut at the full-bloom stage. As a rule the first cutting of each stage contained less green color than later cuttings. The hay cut at the initial- and half-bloom stages averaged 46 percent leaves as compared to 41 percent for hay cut at the full-bloom stage.

Digestion trials were conducted with sheep, using hay of the three stages produced during 1937. The average digestion coefficient for crude protein was 77.7 percent for the initial-bloom hay; 77.1 for the half-bloom hay; and 75.4 for the full-bloom hay. The average digestion coefficient for crude fiber was 47.7, 41.4, and 38.3 percent, respectively, for the initial-, half-, and full-bloom hay.

Feeding experiments were conducted with three groups of Holstein cows, each of which was fed exclusively on alfalfa hay produced at the initial-, half-, or full-bloom stage. Eight different cows were used in the feeding trials, and completed a total of 11 yearly production records, 5 cows making 1, and 3 making 2 records on the alfalfa-hay rations. All the cows had previously made official records on full feed.

The 3 cows that completed a 365-day lactation record when fed the initial-bloom hay as their only feed produced an average of 11,099 pounds of milk and 404 pounds of butterfat (calculated to a mature-age basis), which was 55.7 percent as much milk and 59.1 percent as much butterfat as they produced under full-feed conditions. The 4 cows on half-bloom hay averaged 9,763 pounds of milk and 345 pounds of butterfat (mature-age basis), which was about 51 percent as much milk and butterfat as they produced when on full feed. The 4 cows on full-bloom hay produced an average of 8,981 pounds of milk and 331 pounds of butterfat (mature-age basis), which was about 47 percent of their production on full feed.

The consumption of the 3 stages of hay was about the same. The 3 cows on initial-bloom hay consumed an average of 14,390 pounds during the lactation period, or 39.4 pounds per cow per day. The 4 cows on half-bloom hay averaged 14,442 pounds for the lactation period, or 39.6 pounds daily, and the 4 cows on full-bloom hay averaged 14,060 pounds for the lactation period, or 38.5 pounds daily. Each group refused only about 7 percent of the hay offered. Less initial-bloom hay was consumed per pound of milk and butterfat produced, than of half-bloom or full-bloom hay.

On all stages of hay, the average hay consumption was lower for the first than for later cuttings, indicating that the first-cutting hay was less palatable. This was also indicated by the relative composition of the cuttings. The superiority of the later to the first cuttings, all stages, was also shown by increased production resulting from shifting the cows from first cuttings to later cuttings.

The nutrients furnished by the hay cut at the initial-bloom stage appeared to be more efficient for milk production than the nutrients from the hay cut at the later stages, but there was lack of consistency between the results for individual cows fed hay cut at the half-bloom or full-bloom stage. The groups of cows were probably too small to overcome individual variations in this respect.

The comparative costs per ton of the hay produced on the 3 plots over a 3-year period were as follows: $7.27 for the initial-bloom, $7.40 for the half-bloom, and $8.53 for the full-bloom plot. The average cost of producing 100 pounds of total digestible nutrients was 70 and 77 cents, respectively, for the initial- or half-bloom plot as compared to 91 cents for the full-bloom plot. When the actual quantity of milk produced was corrected to a uniform basis of 4-percent butterfat, the calculated amount of milk produced per acre was 6,330 pounds for the initial-bloom plot, 5,254 for the half-bloom plot, and 3,970 for the full-bloom plot.

Considering all phases of this experiment, it is evident that alfalfa hay cut at the initial- or half-bloom stage is markedly superior in all respects to alfalfa cut at the full-bloom stage. While cutting at the initial-bloom stage has some advantages over cutting at the half-bloom stage, especially in yield of total digestible nutrients, the advantages are too slight to have any great significance, especially when considered from the practical standpoint. The line of demarkation, or the change that takes place in the plant between the initial-bloom and the half-bloom stage is rather indistinct; and cutting at either stage, or between the two stages, would be good practice.

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