A NUTRITIONAL ASSESSMENT OF METHODS OF HARVESTING SUMMER FORAGE FOR DAIRY COWS

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A NUTRITIONAL ASSESSMENT OF METHODS OF HARVESTING SUMMER FORAGE

By K. E. Harshbarger, E. E. Ormiston, J. R. Staubus, and R. V. Johnson

Nutrients obtained by cows grazing good pastures have been considered to be of high quality and relatively inexpensive. Therefore less effort has been made to improve the yields of forage plants than has been made with grain crops (13[1]). However, two alternatives to grazing have become established that have increased forage yields because they are more effective methods of harvesting than is grazing. One of these methods, called soiling, consists of harvesting green forage and transporting it to a barn lot where it is fed to cows. This procedure is not new but has become economically feasible in Illinois only since the development of the forage harvester, which has greatly reduced the high labor requirement and drudgery that were inherent in the system previously used.

The use of a soiling system may have one or more of the following advantages over grazing:

- Yields of forage from tall-growing crops are increased.
- Isolated fields may be used for the production of green forages.
- Less fencing is needed.
- A drinking water supply does not have to be available for all fields.
- More extensive use is made of machinery and facilities.

These advantages may be offset, however, by the following disadvantages:

- Forage should be harvested once or twice each day to prevent excessive heating because cows eat less of the green material after it has begun to heat. Such a harvesting schedule is inconvenient and often conflicts with other farm work.
- If the proper lots and machinery are not available on the farm, a considerable outlay of capital is required.
- Additional sources of forage must be on hand to feed the cows during periods when the fields are too soft to carry the harvesting machinery.
- Manure removal becomes a year-round job and must be well managed or flies and odor become a serious problem.

[1] Number refers to biblography.

The other method is year-round silage feeding. It has been used for some time in western states but has not been established in Illinois as long as soiling. Year-round silage feeding has most of the advantages of soiling plus the following advantages of its own:

- Double use is made of existing silos.
- Forage plants can be harvested at the optimum state of nutrient production.
- Forage is harvested only three or four times a season. Daily harvests are thus eliminated and intervening rainy spells do not interfere with daily feeding procedures. However, this system also requires an additional outlay of capital if additional storage space for silage must be provided.

This bulletin reports data on three sets of summer feeding experiments. The first compared soilage with rotational grazing. Data on forage yield, feed consumption, liveweight, and milk production were recorded and analyzed. The second compared soilage with silage with respect to the same variables. The importance of hay as a roughage supplement to grazing during the "summer slump" has suggested that hay may also be needed as a supplement to soilage and to silage. The third experiment therefore compared soilage with silage, with and without supplemental hay, with respect to feed consumption and milk production.

Review of Literature

A study of the literature indicates that there have been three periods of active interest in soiling in the United States. The first period occurred about the turn of the century, the second in the 1920's, and the third followed the introduction of the mechanical forage harvester in the 1950's (14).

Early tests of soiling versus pasture demonstrated that higher yields of forage could be obtained by using soiling procedures, but the large amount of hand labor involved made this process too expensive. Otis (20) reported in 1900 that dairy cows that were fed a series of forage crops harvested by soiling yielded over four times as much milk as dairy cows fed ordinary Kansas pasture. The increase in yield was measured as increased carrying capacity of the forage land rather than increased yield per cow. Woll *et al.* (27) tested the response of dairy cows to a series of soiling crops and to carried-over corn silage through three summer seasons. They observed that similar production was obtained from both feeding regimens but stated that there was an advantage in feeding corn silage because less labor was required and all of the crop was harvested at the optimum time with a minimum of waste.

During the 1920's, workers at Iowa (7, 16, 18) and Nebraska (6) continued to test soilage versus corn silage as a supplement to summer pasture. Both groups came to the conclusion that partial soiling was much more desirable than continuous soiling in those states because of the high labor costs involved and the availability of pasture. However, they also observed that carried-over corn silage was equally capable of providing supplemental roughage when pastures were dormant and that production could be maintained at less cost with silage than with soilage.

Graves *et al.* (8) and Tretsven (26) were the first to compare similar crops from similar fields. Graves *et al.* observed that the total yields of dry matter and of milk per acre were each amazingly similar whether the crop (grasses) was grazed, made into hay, cut and hauled to the cows, or ensiled. The critical factor involved was that of harvesting as much of the crop as possible at its optimum stage of maturity. Labor economy, however, was in favor of grazing and against soiling. Tretsven observed no material increase in milk production when soilage was substituted for good irrigated pasture. He felt that too much labor was involved in soiling to allow it to be practical except in special cases.

The substitution of mechanical forage harvesters and self-feeding or self-unloading wagons for the large amount of hand labor formerly required in a soiling regimen has caused renewed interest in soiling.

Mechanical forage harvesters and self-unloading wagons have reduced the amount of hand labor required for soiling operations.

Smith and Keyes (25) compared 10-day rotational grazing, 1-day rotational grazing, and soiling on irrigated grass pastures. They observed that calculated total digestible nutrients (TDN) and milk yields per acre were very similar under their management conditions. However, labor costs in harvesting the grass and moving the fence each day were such that the feed cost per 100 pounds of fat-corrected milk (FCM)[1] were \$1.19, \$1.29, and \$1.55 for 10-day rotational grazing, 1-day rotational grazing, and soiling, respectively.

Henderson *et al.* (9) observed no difference in production of FCM per cow by cows grazed or fed soilage. However, the carrying capacity and FCM production per acre were considerably increased by soiling. Owens *et al.* (21) observed similar results when grazing and soiling Sudangrass pastures. Porter and Skaggs (22) reported that the additional forage obtained under a soiling regimen was not great enough to cover the labor and machinery cost when used on irrigated pasture land.

Kennedy, Reid, and Anderson (15) compared six-paddock grazing, three-paddock grazing, and strip-grazing with soiling. They observed that milk production per acre was as high or higher for the three-paddock system than for any of the other grazing systems. Larger quantities of excess forage were harvested from the soilage plots, but the authors doubted that this additional forage (approximately 1,400 pounds of dry matter per acre) would pay for the extra cost of the operation. It must also be remembered that milk production per acre is dependent both upon production per cow and upon the number of cows per acre. In the Kennedy, Reid, and Anderson study, in which the strip-grazed cows were the pace-setters, the three-paddock group appeared to be short of feed about 25 percent of the time, but the records of milk production failed so show that such a deficiency existed. Therefore, Kennedy *et al.* cautioned against understocking and thereby introducing bias in grazing experiments in which milk production per acre is the criterion of comparison.

The renewed interest in soiling that followed the development of mechanical forage harvesters again drew attention to the disadvantages of this system and again led to a comparison of soilage with silage.

Eichers and Engene (4) reported that milk production per cow and per acre were similar when soilage or silage was fed as the sole roughage. Their carefully kept records of labor requirements indicated that, considering the experimental period as a whole, the average daily labor requirement was slightly higher for silage feeding when

[1] FCM is used in this bulletin to mean fat-corrected milk. It is equivalent to milk containing 4 percent fat and is calculated by Gaines' formula ($FCM = 0.4 \times$ milk yield in pounds $+ 15 \times$ milk-fat yield in pounds).

silo-filling time was prorated across the whole period. However, the time required for daily silage feeding was only about half that required for soilage feeding. Therefore, silage may still have had the advantage in overall farm operations because a major portion of the labor load occurred in a period of a few days and the labor requirement for feeding roughage was lower during the peak labor periods of other operations.

Foreman *et al.* (5) reported significantly higher production of FCM on second- and third-cutting soilage than from first-cutting silage from the same field. However, more FCM per pound of calculated TDN was produced from silage than from soilage. They postulated that this difference was due to higher estrogenic activity in the first-cutting forage, even after ensiling, than in subsequent cuttings.

Since many commercial dairy farmers adopted full or partial soiling regimens before research results were available from experiment stations, a considerable portion of the literature has been compiled by surveys of such farmers. Hoglund (11, 12) published the results of several such surveys. Michigan farmers reported an increase of about 20 percent in carrying capacity of pastures due to soiling, but the increased production was very nearly balanced by increased costs. Therefore, Hoglund felt that the proper time to use a soiling system would be when labor was available and land limited. Thus the size of the dairy operation could be increased without an increase in farm size. In visiting these farms, he observed that soiling required a higher level of managerial ability and that the increase in milk production per cow that was observed in some cases occurred because farmers saw exactly what the yield of their forage fields was, and thus began supplemental feeding at the proper time instead of waiting for the reduced forage production to show up as lowered daily milk production.

Cash and Fryman (3) reported similar results from a survey of Illinois farmers who were using soiling systems. They concluded that the real problem involved was the availability of land versus the availability of capital (equipment) and labor.

H. J. Larsen (17), in reviewing pasture work from several Midwest experiment stations, presented one of the strongest cases in favor of year-round stored feeding and soiling. He is of the opinion that the cow as a forage harvester is definitely on the way out and that the pressure for larger and more efficient dairy farms will bring about the exclusive use of mechanical forage harvesters, either for soiling or summer silage feeding. He is confident that the management and capital problems will be solved under the impetus of higher production per acre of tillable land, thus leaving the untillable land for livestock with less demanding requirements for energy and protein.

Comparison of Pasture and Soiling

Grazing is a widely used method of harvesting forage crops for summer feeding on Illinois dairy farms. Because of the importance of grazing, the first trial compared soiling with grazing. Four adjacent grass-legume pasture fields were used in the trial. Plots 1 and 4 were soiled (the forage was chopped with a mechanical forage harvester and hauled to the cows) and plots 2 and 3 were grazed. The fields were not irrigated, but rainfall was above normal.

The forage consisted of alfalfa, timothy, sparse Ladino, and volunteer bromegrass on plots 1 and 2, and alfalfa, timothy, and abundant Ladino on plots 3 and 4. Plots 2 and 3 were subdivided by constructing a temporary fence on the center line of each plot. This provided four subplots for alternate grazing, each containing 2.25 acres. Each subplot was grazed by 15 cows (7 Holsteins, 4 Brown Swiss, 2 Guernseys, and 2 Ayrshires) one week within each four-week period. The experimental period was 12 weeks long. After each subplot was grazed, it was clipped to control weeds and to eliminate mature forage. Plots 1 and 4, each containing 4.5 acres, were used together to feed 15 cows. The forage was chopped twice daily and each plot was used for a period of two weeks for each cutting. Any forage that remained at the end of the two-week period was removed.

The forage available from each system of harvesting provided the only source of roughage for each group of cows. Although each group included individuals from four dairy breeds, the groups were balanced for initial production, calving dates, breed, and age. Thus direct comparisons could be made of the milk produced and of the changes in body weight. The cows received an 11-percent crude protein grain mixture which was fed at the rate of 1 pound of grain to 4 pounds of FCM. The forage was harvested from the soilage plots twice a day and the loads of chopped forage were weighed. The amount harvested each day was slightly more than needed for feeding. The surplus was fed to animals not on this experiment. At feeding time the soilage was weighed out for each cow individually and fed in individual mangers in a stanchion barn. Records kept of the amounts fed provided exact data on the yield of soilage per acre but provided no forage yield data for those plots that were grazed. Body-weight

Feeding roughage to cows on an individual basis provides research workers with accurate information about consumption. This procedure is not necessary under farm conditions.

measurements were made on the first three days of the trial, on the final three days of the trial, and on one day at the midpoint.

Experimental Results

Under conditions imposed in this trial, the average daily milk (FCM) production of the cows consuming soilage declined 7.8 pounds, and that of the grazing animals declined 8.1 pounds. The difference of 0.3 pound between groups was not significant because such a small difference may represent a randomly distributed (normal) biological difference. The initial average daily milk production (FCM) was 38.3 pounds for the pasture group and 36.9 pounds for the soilage group.

Body weight changes during the 12-week experimental period were also non-significant, being + 18 pounds for the average grazed animal and + 43 pounds for the average soilage-fed animal. Initial body weights averaged 1,221 pounds for cows in the pasture group and 1,224 pounds for cows in the soiling group. Final body weights averaged 1,239 pounds and 1,267 pounds, respectively.

Table 1. — Comparison of Pasture and Soilage: Average Daily Feed Consumption

	Group I (Pasture)	Group II (Soilage)
All cows		
Pasture, 9 acres	ad lib.	....
Green feed, 9 acres	....	131.2 lb.
Dry matter	....	23.9 lb.
Grain	8.7 lb.	8.4 lb.
Highest individual intake of green feed	....	166.9 lb.

The consumption of soilage varied considerably between cows and days. On a per-head basis, the average soilage intake varied from a high of 166.9 pounds to a low of 98.9 pounds a day. However, when forage consumption was related to body size (100 pounds body weight), individual cow and breed differences disappeared (Tables 1 and 2). Soilage consumption tended to decline as the forage approached maturity and to increase again following a change to less mature forage. Such reductions in consumption were reflected as reduced milk production and pointed up the necessity for good management of crops to be used as soilage.

Table 3 shows that the 15 cows receiving soilage consumed less than 75 percent of the green forage harvested in plots 1 and 4. This surplus forage would have been enough to have fed five more cows throughout the period and would have increased the apparent carrying capacity of the plots by one-third. Some research workers, on the basis of similar data, have suggested that surplus forage can be considered as return on the additional capital and labor invested in the soiling system. In this experiment, the production of the cows grazing plots 2 and 3 was equal to that of the soilage group, and any excess forage left on these plots was clipped and left in the field. That means that

Table 2. — Comparison of Pasture and Soilage: Green Feed Consumed per Day

Breed	Average weight	Fresh green feed	Dry matter per 100 lb. liveweight
	lb.	*lb.*	*lb.*
Holstein	1,302	144	2.09
Brown Swiss	1,259	129	1.94
Ayrshire	969	109	2.13
Guernsey	1,155	116	1.90

Table 3. — Comparison of Pasture and Soilage: Green Feed Produced

Period	Plot 1	Plot 4	Total
	lb.	*lb.*	*lb.*
I	38,495	41,995	80,490
II	15,380	36,795	52,175
III	52,150	47,300	99,450
Total produced	106,025	126,090	232,115
Amount fed	....	....	165,336
Surplus	....	....	66,779

the maximum carrying capacity of the grazed plots was not measured. Some caution must therefore be observed in projecting results to practical situations from experiments in which predetermined stocking rates are used and in attempting to determine the response of pasture crops to mechanical harvesting.

The evidence of this experiment indicates that milk cows are dependent upon a proper supply of nutrients for milk production. The method of harvesting the forage is independent of the need for nutrients.

Comparison of Soilage and Silage

A year-round silage feeding program has been advanced as a possible means of overcoming the need for the high level of management and the twice-a-day harvesting necessary for a successful soiling program while at the same time retaining the advantages of mechanical harvesting over grazing.

Whether these advantages make silage preferable to soilage depends on two other factors. The first is that conditions vary from one farm to another, and these advantages may not be as important in some cases as they are in others. The second is that a management choice between the two methods should be based on a knowledge of the nutritional value, as well as of the convenience, of each. The following experiment was designed to compare the nutritional value of the two methods, both with respect to forage yield per acre and with respect to the weight and milk production of the cows.

A field was divided into 2 equal plots. Equal areas of nearly pure stands of each of three varieties of alfalfa (DuPuits, Vernal, and Ranger) were grown on each plot. One of the plots was harvested as silage and the other as soilage. Harvesting dates were scheduled so that first-crop silage was fed concurrently with first-crop soilage

Table 4. — Comparison of Soilage and Silage: Description of Animals in Experiment

	Soilage	Silage
Average weight (May 16, 17, and 18)	1,254 lb.	1,238 lb.
Average age at previous freshening	4 yr. 4 mo.	4 yr. 8 mo.
Average days in milk	107	107
Average FCM per cow per day	41.1 lb.	44.6 lb.

and second-crop silage was fed concurrently with second- and third-cutting soilage. Such a schedule provided the best test of the various cuttings, both as silage and soilage.

Two groups of 13 milking cows each were used in this experiment. Each group was made up of 8 Holstein, 3 Brown Swiss, and 2 Ayrshire cows (Table 4). These groups were balanced according to milk production, body weight, age, and days in milk since previous calving. Both groups were fed soilage from May 15 to 31. This was done to provide a preliminary green forage feeding period for both groups while the first-cutting silage was undergoing fermentation in the silo.

The silage group was then fed silage for one week and the test period began on June 8.

All of the cows were fed individually in the barn during the experimental period so that feed consumption could be measured precisely. Each cow was fed all the forage she would consume without undue waste and the orts were assessed accurately against each day's feeding.

An 11-percent crude protein concentrate mixture was fed to each cow according to the amount of FCM that she produced. Milk production was calculated each week from daily milk weights, and the weekly fat percentage was obtained from a three-day composite sample. Concentrates were then fed at a ratio of 1 pound of concentrate to 4 pounds of FCM based on the previous week's production.

Each load of chopped forage was sampled, whether it was fed as soilage or stored as silage. Silage samples were taken at each feeding. All samples were stored in airtight containers at 5° C. until their dry-matter content could be determined by drying to constant weight at 85° C. Crude protein analyses were run according to the A.O.A.C. method.

Heavy rainfall that caused the fields to become too soft to carry the harvesting machinery made it impossible to harvest soilage on ten different occasions. At these times the soilage-fed cows were turned out to pastures that had a similar plant population to that of the soiling plot, and consumption was estimated to be the same as when the cows were fed soilage in the barn.

Body weight measurements were made on 2 or 3 consecutive days at the beginning and end of the preliminary period, when a change was made from first- to second- and from second- to third-cutting forage, and at the end of the experimental period.

Experimental Results

The forage yields of the two plots were weighed before being fed or ensiled. The yield of dry matter per acre was exactly the same for both plots (Table 5), and the yield of crude protein varied only slightly when expressed on the basis of soilage versus green material ensiled. Such close agreement is a measure of the quality of the plots and an indication that the three mechanical cuttings yielded approximately the same amount of total forage. However, it must be stated that under the conditions of this experiment, the area that was harvested for silage showed considerable recovery and had a uniform stand of forage that could have been grazed at the end of the experiment, whereas the plot that had been soiled showed only a very slight recovery.

The conventional silos that were used for storing the harvested forage were not adapted for use in obtaining precise measurements of run-off, gaseous losses due to various oxidative processes during fermentation, and top spoilage. Comparisons of the input-output data

Table 5. — Comparison of Soilage and Silage: Yields of Forage and Dry Matter

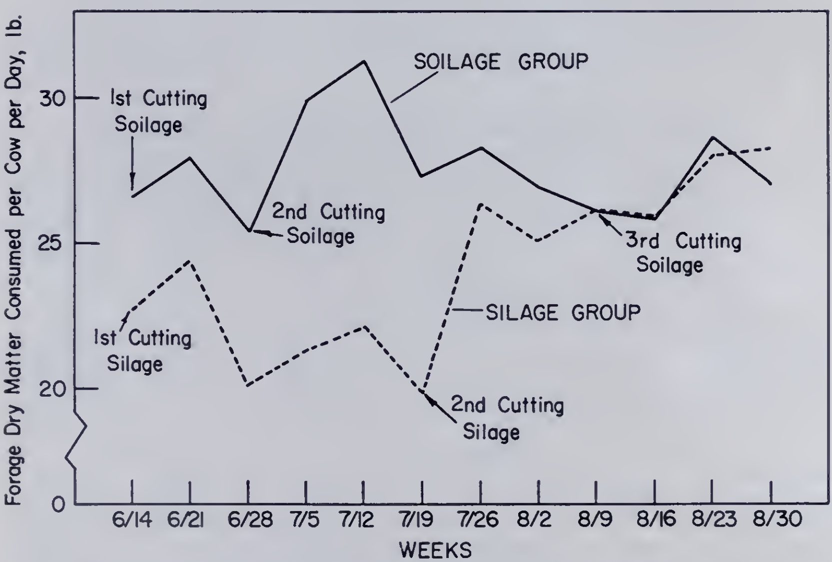
	Fresh weight, pounds	Percent dry matter	Dry matter, pounds
Soilage (9.65 acres)			
First cutting	129,185	20.38	26,331
Second cutting	90,825	24.46	22,218
Third cutting	57,825	22.31	12,921
Total	277,835	.....	61,470
Yield per acre	28,791	.....	6,370
Silage[a] (9.8 acres)			
First cutting	93,960	20.02	18,811
Second cutting (wilted)	65,212	37.54	24,482
Third cutting (wilted)	55,090	34.74	19,137
Total	214,262	.....	62,430
Yield per acre	21,863	.....	6,370

[a] Green forage before ensiling.

would indicate approximately a 15-percent loss in dry matter due to ensiling. This agrees with similar data from other stations. The crop was wilted before ensiling, and no preservative was used.

Feed consumption data obtained during the 84-day experimental period indicate that the cows on soilage consumed 3½ more pounds of dry matter per day than those fed silage (Table 6). However, concentrate consumption and protein intake were similar. The major difference between the two groups apparently was the smaller consumption of dry matter by the silage-fed group.

This difference in dry-matter consumption did not appear as a difference in body weights. Both groups showed an increase in body weight during the experimental period. However, it is interesting to note that the silage-fed cows lost weight when fed first-cutting silage and gained weight on second-cutting silage. This response was probably due to a higher palatability of the second-cutting silage because it was harvested at a somewhat more desirable stage of maturity and in a period of good drying weather that allowed proper wilting. The first-cutting silage was stored too wet because of its early stage of maturity and the poor drying weather when it was cut. The response to these variables can be seen in the graph below.



Throughout the experimental period the cows in the soilage group consumed an average of 3.4 pounds more dry matter per day than did those in the silage group.

Table 6. — Comparison of Soilage and Silage: Feed Consumption and Milk Production (84-day Period)

	Soilage group	Silage group
Feed consumption (pounds)		
Soilage fed	126,154.4	....
Soilage consumed per cow per day[a]	115.5	....
Silage fed	....	87,597.4
Silage consumed per cow per day	....	80.2
Forage dry matter consumed per cow per day	27.6	24.2
Concentrate consumed per cow per day	9.2	9.1
Milk production (pounds)		
FCM produced	36,881.1	36,770.3
Average FCM per cow per day	33.8	33.7
Preliminary week, FCM per cow per day	40.4	40.1
Final week, FCM per cow per day	30.9	30.2
Decline in FCM per cow	9.5	9.9

[a] Includes estimate of forage consumed from pasture when soilage could not be harvested.

Milk production, as shown in Table 6, was similar between groups. The soilage-fed cows declined 9.5 pounds and the silage-fed cows 9.9 pounds in average daily FCM production per cow. Such a difference is too small to be significant. Thus we are confronted with similar milk production on a reduced intake of dry matter. This response has been observed at other experiment stations, but no concrete evidence has been obtained to explain it. Foreman *et al.* (5) have postulated a difference in estrogenic activity between first-cutting silage and second-cutting soilage from the same field. In order to use that explanation for this experiment, it would be necessary to postulate a difference in estrogenic activity with the stage of maturity of the forage.

It is possible that a portion of this difference can be explained by a production during the ensiling process of volatile products that were lost during the dry matter determination. However, checks run at different drying temperatures and toluene distillations failed to support this possibility.

Another postulation is that some product was formed during ensiling that was capable of increasing the efficiency with which other nutrients were used. Such a product could be lactic acid, the major acid formed. It is logical to assume that the lactic acid in silage would be converted by the rumen bacteria to propionic acid. Armstrong and Blaxter (1) have shown that under certain conditions the addition of propionate to an infusion of acetate reduces the heat increment observed when acetate is infused alone. Although their evidence did not bear directly upon dairy cattle, similar studies with cows might explain the difference in utilization of dry matter by dairy cows.

This experiment again showed that milk production depends on the quality and quantity of the nutrients fed and that the method of supplying nutrients affects milk production only as it affects these factors. The quality of the soilage and silage used in this experiment was practically the same. The forage for both came from plots that yielded the same amount of dry matter per acre. No analysis was made of the differences in labor and other costs.

Comparison of Soilage and Silage With and Without Supplemental Hay

Before a dairy farmer decides to convert his grazing regimen to one that uses soiling techniques or that calls for year-round silage feeding, he needs to know if supplemental hay feeding would increase

Wagons with drop-down sides are used both to haul and feed soilage. Green forage is thus fed with a minimum of manual labor. Such wagons can be parked in numerous places in the feeding lot and reduce the mud hazard in wet weather.

the amount of milk produced by the cows. Some barn-feeding trials (2, 19) have indicated that cows consume more dry matter per day when provided with some hay and produce more milk than when fed silage as the sole source of roughage, whereas other tests (10, 24) have shown similar responses or slight advantages in favor of silage as the sole roughage. Unfortunately, the palatability, or acceptability, of each individual batch of silage may play a very significant role in this response, and measurements of such differences are extremely diffcult or impossible to make at the present time.

An experiment was designed to measure the effect of supplemental hay feeding in Illinois. Four groups of 11 cows (2 Ayrshires, 3 Brown Swiss, and 6 Holsteins in each group) were balanced in such a manner that production, age, breed, body weight, and date at last calving were similar between groups. Group I received silage as the sole source of roughage, group II received silage plus hay, group III received soilage, and group IV received soilage plus hay. Hay was fed to groups II and IV at a rate that provided 5 pounds a day for each Ayrshire and 6 pounds a day for each Brown Swiss and Holstein. Periods I and II were 28 days long. Period I covered the time when

Self-unloading wagons provide a convenient method for unloading soilage into stationary feed bunks. One such wagon can be used to haul forage for cattle in several lots, whereas a self-feeding wagon is needed for each lot.

the first-cutting forage was fed, and period II covered the feeding of second-cutting forage. Period III was only 13 days long, due to a shortage of third-cutting soilage. The entire daily allowance of hay was fed in a single feeding during the morning. All cows were fed a mixture of 11-percent crude protein concentrate at the rate of 1 pound for each 4 pounds of FCM on the basis of the previous week's production. During periods of inclement weather or periods of machinery breakdown, the soilage-fed cows were fed silage because this provided forage of similar composition and allowed precise measurement of intake. All cows were fed individually in a stanchion barn to facilitate measuring feed consumption and orts. All groups were allowed to exercise daily in a drylot.

Twenty acres of second-year alfalfa forage were divided into two ten-acre plots to provide the forage for the cows. Silage was first cut from May 25 to 27, and soilage harvesting began on May 28. The first growth of the soilage plot was rank, and daily harvesting proceeded at a slow rate that allowed some second-growth forage to be harvested with the first-cutting soilage. This simultaneous harvesting of mature first-crop forage and immature second-crop forage severely limited the recovery observed on this plot and pointed up one of the major management problems of a soiling system. The second cutting of silage was made on July 2 and 3 and the third cutting on August 4. The silage crop was cut, allowed to wilt in the field for about two hours, chopped, hauled to the farmstead, and blown into the silo without any additive being applied. Some of the soilage fed during the second and third cutting periods was of necessity harvested from the silage plot because of the slow recovery of the soilage plot after the first cutting. Though this difficulty made it impossible to estimate precisely the yield of forage under each system, it would have little if any effect upon the assessment of the nutritional response of the dairy cows to the forage harvested by the two different methods.

The hay fed during the experiment was average- to good-quality alfalfa containing a small percentage of grass and 13.3 to 14.5 percent crude protein on a dry-matter basis.

Experimental Results

Table 7 shows the quantities of the various feeds consumed by each group of cows. The inclusion of hay in the ration increased the rate of roughage dry-matter intake on both silage and soilage. Group I, the group receiving silage as the sole roughage, consumed the least dry matter from roughage, and the intake of roughage dry matter

Table 7. — Comparison of Soilage and Silage With and Without Supplemental Hay: Dry Matter Intake and FCM Production per Cow per Day

	Group I (Silage without hay)	Group II (Silage with hay)	Group III (Soilage without hay)	Group IV (Soilage with hay)
Dry-matter intake per cow per day (pounds)				
Period I				
Silage or soilage	21.9	20.1	29.0	25.3
Hay	....	4.7	....	4.3
Grain	10.7	11.4	10.7	10.7
Total	32.6	36.2	39.7	40.3
Period II				
Silage or soilage	21.0	19.5	28.8	24.8
Hay	....	4.9	....	4.5
Grain	10.1	10.6	9.7	9.7
Total	31.1	35.0	38.5	39.0
Period III				
Silage or soilage	24.0	21.9	29.4	26.4
Hay	....	4.7	....	4.2
Grain	9.4	9.6	9.4	9.3
Total	33.4	36.2	38.8	39.9
Average				
Silage or soilage	21.9	20.2	29.2	25.3
Hay	....	4.8	....	4.3
Grain	10.2	10.8	10.0	10.1
Total	32.1	35.8	39.2	39.7
FCM production per cow per day (pounds)				
Initial	49.1	51.6	49.2	48.5
Period I	44.1	46.8	41.6	42.8
Period II	40.4	41.9	40.5	40.5
Period III	36.2	37.8	37.6	37.5
Average	40.6	43.1	40.4	40.8

increased per group in each of the other groups from II to IV. However, supplemental hay feeding increased the dry-matter intake of the soilage fed group only slightly. The major reason for the difference in the rate of dry-matter intake between periods by the silage-fed cows was the dry-matter content of the silage. The harvesting procedures were similar for each harvest, but variations in the drying conditions caused the second cutting to be the dampest and the third cutting the driest. Since the feeding guide was based on pounds of silage, dry-matter consumption tended to follow dry-matter content. Concentrate feeding was nearly equal between groups with groups I, II, III, and IV consuming concentrates in a ratio of 1 pound of concentrate to 3.52, 3.47, 3.64, and 3.55 pounds of FCM, respectively.

Since neither groups II nor IV consumed all of the hay that they were offered, there apparently was no compelling dry-roughage hunger in these groups.

The cows in all groups gained relatively little weight. The average gains were 14 pounds, 34 pounds, 21 pounds, and 15 pounds for groups I, II, III, and IV, respectively. Therefore, the rations appeared equal as indicated by body-weight changes.

The initial FCM production of group II was higher than the others and remained so throughout the period (Table 7). However, when an analysis of covariance was performed to mathematically adjust for the initial difference, the observed differences were not significant. Therefore, under the conditions imposed in this experiment, the supplemental feeding of dry roughage and the concurrent increase in dry-matter intake from roughage did not increase the amount of FCM produced.

The reason for similar production of fat-corrected milk by the soilage-fed cows on smaller intake of dry matter is unexplained in this experiment.

Discussion

In all the comparisons, milk production appeared to be quite independent of the form of the roughage and of the method used in providing it. The important factor appeared to be the providing of enough nutrients from a palatable source regardless of form or method. Therefore, the summer feeding of dairy cows is a problem in availability of land, capital, and labor, any of which may differ from farm to farm.

Properly managed grazing must still be considered to be the best method of forage harvesting when an abundance of grazing land, part of which is not suitable for mechanical harvesting, is available and when labor and capital are limited.

Mechanical harvesting of forage is preferable when land is a limiting factor and when capital and labor are plentiful. This technique makes it possible to harvest the entire amount of green matter produced without wastage due to selective grazing, trampling, or fouling of the forage. These wastes are most severe on tall-growing plants. Mechanical harvesting also permits the number of cows to increase beyond the point where the distance to pasture becomes a limiting factor and allows the harvesting of green forage on distant or isolated fields.

Field damage of this type is the result of harvesting soilage when the field was soft. The use of supplemental roughage sources prevents such damage.

Rainy weather and heavy traffic around bunks in an unpaved lot soon cause the feeding area to become muddy. A concrete apron around the bunk will correct this situation.

Soiling has the drawback that the level of management required to harvest crops at peak value, to provide supplemental feed for periods of adverse weather and of machinery breakdown, and to handle cows in drylot is more exacting than for conventional grazing systems. Daily harvesting, preferably twice a day, is time consuming and is likely to interfere with other farm operations during periods of peak labor demands. Capital investments for equipment are usually increased. Soiling does have the advantage of eliminating the loss of dry matter that normally occurs in silage, and in the long run, as Eichers and Engene (4) showed by prorating the labor time spent on silo filling, soilage does not require more labor than silage. In many cases, however, these advantages do not offset the disadvantages just mentioned.

Year-round feeding of silage can be used to retain many of the advantages of soiling without the operation of harvesting forage daily and without its being so much at the mercy of the weather. The capital investments in silos may be increased, but year-round use and two fillings a year provide more efficient use of the capital invested in silos and in silo-filling equipment.

Therefore, a single method of harvesting forage cannot be recommended. Each farmer should select the method of harvesting summer forage which he feels is appropriate to his resources, basing his decision on such factors as forage requirements, labor supply, facilities at hand, topography of his farm, and availability of capital.

Summary

Three sets of summer feeding experiments were run studying the feeding value of soilage or green chop. The first compared soilage with rotational grazing using two groups of 15 milking cows each. There was no significant difference between the two groups in milk production, feed consumption, or body weight changes. The second compared soilage with silage using two groups of 13 milking cows each. Forage yields were the same from both plots on a dry-matter basis; however, the silage plot showed better recovery at the end of the experiment, offsetting the normal loss of dry matter that occurs in silage. The soilage-fed group consumed nearly 3½ more pounds of dry matter per day, but there were no significant differences in milk production or in body-weight changes. The third experiment compared soilage and silage both with and without supplemental hay using four groups of 11 milking cows each. Feeding supplemental hay increased

dry-matter consumption slightly on both the soilage and silage diets but caused no significant increase in milk production. No analysis of differences in labor or other costs was made in these experiments.

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APPENDIX TABLE 1. — Comparison of Soilage and Pasture

Cow No.	Breed	Weight, lb.			Milk production (FCM), lb.			Feed consumption, lb.		
									Soilage	
		Initial	Final	Gain	Initial per day	Total	Final per day	Grain	Fresh	Dry
					Group I — Pasture					
1,189	Guernsey	1,118	1,072	−46	31.7	2,408.9	15.0	574	......	.....
1,294	Br. Swiss	1,540	1,546	6	51.4	3,689.5	41.5	924	......	.....
1,298	Guernsey	1,027	1,061	34	31.7	1,786.1	13.6	553	......	.....
1,362	Br. Swiss	1,381	1,437	56	33.4	2,713.9	32.0	700	......	.....
1,396	Holstein	1,519	1,565	46	35.9	2,471.6	25.0	714	......	.....
1,414	Br. Swiss	1,295	1,333	38	34.8	2,890.2	33.9	756	......	.....
1,426	Holstein	1,348	1,320	−28	44.9	2,509.5	26.3	714	......	.....
1,432	Holstein	1,306	1,290	−16	32.4	2,531.1	29.8	651	......	.....
1,451	Holstein	1,370	1,358	−12	57.0	4,242.5	46.7	1,050	......	.....
1,475	Holstein	1,210	1,222	12	28.4	2,067.5	22.3	728	......	.....
1,503	Ayrshire	852	890	38	39.8	2,589.3	29.7	700	......	.....
1,504	Holstein	1,179	1,209	30	48.8	3,454.9	43.4	924	......	.....
1,506	Holstein	1,053	1,077	24	38.9	2,674.6	31.8	900	......	.....
1,507	Br. Swiss	1,118	1,149	31	33.6	2,669.5	32.4	672	......	.....
1,509	Ayrshire	993	1,055	62	33.3	2,425.2	29.1	638	......	.....
Average		1,221	1,239	18	38.3	2,741.6	30.2	733	......	.....
					Group II — Soiling					
1,233	Holstein	1,446	1,555	109	40.6	2,610.7	29.1	728	13,946	2,540
1,249	Br. Swiss	1,319	1,368	49	45.8	3,417.0	40.6	924	12,520	2,280
1,292	Holstein	1,429	1,485	56	35.3	2,203.2	23.5	630	11,399	2,076
1,392	Br. Swiss	1,521	1,568	47	27.1	1,954.1	21.5	605	10,882	1,981
1,393	Ayrshire	1,061	1,060	−1	41.5	2,798.6	28.1	672	9,927	1,808
1,437	Guernsey	1,207	1,232	25	38.0	2,625.2	31.8	714	9,452	1,721
1,440	Br. Swiss	1,195	1,222	27	41.5	2,641.7	29.6	812	9,750	1,775
1,442	Holstein	1,292	1,328	36	38.1	2,458.4	25.5	808	10,665	1,942
1,454	Holstein	1,318	1,419	101	48.6	3,883.2	53.2	987	14,020	2,553
1,482	Ayrshire	870	882	12	28.7	1,892.1	20.9	518	8,305	1,512
1,496	Br. Swiss	1,237	1,241	4	32.4	2,262.1	25.6	588	10,128	1,844
1,499	Holstein	1,158	1,230	72	27.7	2,029.9	23.1	595	10,767	1,961
1,501	Guernsey	1,071	1,107	36	26.5	1,711.1	19.4	511	9,992	1,820
1,502	Holstein	1,243	1,277	34	47.1	3,053.8	32.4	804	12,810	2,333
1,510	Holstein	999	1,033	34	34.9	2,546.2	32.0	707	10,774	1,962
Average		1,224	1,267	43	36.9	2,538.6	29.1	707	11,023	2,007

APPENDIX TABLE 2. — Comparison of Soilage and Silage

Cow No.	Breed	Weight, lb. Initial	Weight, lb. Final	Weight, lb. Gain	Milk production (FCM), lb. Initial per day	Milk production (FCM), lb. Total	Milk production (FCM), lb. Final per day	Feed consumption, lb. Grain	Feed consumption, lb. Forage Fresh	Feed consumption, lb. Forage Dry
					Group I — Soiling					
1,292	Holstein	1,338	1,370	32	40.6	3,001.9	36.3	770	10,506	2,511
1,396	Holstein	1,500	1,488	−12	53.0	3,722.5	39.4	1,008	11,921	2,854
1,412	Holstein	1,412	1,556	144	38.3	2,564.7	25.3	735	10,251	2,450
1,486	Holstein	1,245	1,335	90	29.3	1,790.4	15.6	511	10,533	2,520
1,499	Holstein	1,243	1,260	17	35.7	2,172.2	24.4	636	9,182	2,170
1,502	Holstein	1,278	1,315	37	50.5	3,366.2	36.1	920	12,511	2,991
1,554	Holstein	1,000	1,055	55	38.0	2,681.6	31.6	749	9,120	2,181
1,555	Holstein	946	996	50	43.3	3,127.3	34.3	854	7,905	1,893
1,294	Br. Swiss	1,368	1,568	200	24.3	2,367.3	26.4	637	11,702	2,789
1,414	Br. Swiss	1,224	1,218	−6	47.5	3,429.7	34.8	903	9,525	2,280
1,469	Br. Swiss	1,348	1,348	0	43.2	3,305.0	35.9	868	9,161	2,193
1,476	Ayrshire	1,274	1,222	−52	49.6	3,312.9	39.4	892	7,807	1,865
1,553	Ayrshire	883	940	57	32.0	2,046.4	22.4	574	6,030	1,437
Average		1,235	1,282	47	40.4	2,837.5	30.9	774	9,704	2,318
					Group II — Silage					
1,233	Holstein	1,405	1,499	94	50.9	3,701.0	39.5	980	8,821	2,656
1,320	Holstein	1,435	1,535	100	39.1	2,945.8	30.6	791	7,234	2,161
1,332	Holstein	1,510	1,534	23	55.1	3,871.1	39.5	1,092	7,748	2,345
1,426	Holstein	1,329	1,401	72	40.9	2,762.2	28.9	756	7,354	2,232
1,506	Holstein	1,105	1,228	123	24.2	1,559.6	15.1	441	6,978	2,100
1,550	Holstein	1,011	1,121	110	30.4	2,110.6	20.6	602	6,964	2,077
1,552	Holstein	1,050	1,165	115	32.8	2,253.1	25.2	602	6,257	1,900
1,557	Holstein	1,146	1,203	57	41.7	2,877.1	32.3	763	6,394	1,953
1,249	Br. Swiss	1,323	1,367	44	52.6	3,875.7	43.5	1,015	6,685	2,012
1,392	Br. Swiss	1,408	1,399	−9	48.4	3,592.1	40.8	952	6,387	1,921
1,487	Br. Swiss	1,376	1,397	21	38.6	2,652.5	29.4	721	6,710	2,023
1,549	Ayrshire	994	1,038	44	32.7	2,260.5	24.9	616	5,000	1,546
1,560	Ayrshire	1,030	1,094	64	34.0	2,309.0	22.7	645	5,066	1,520
Average		1,240	1,306	66	40.1	2,828.5	30.2	767	6,738	2,034

APPENDIX TABLE 3. — Comparison of Soiling and Silage With and Without Supplemental Hay

Cow No.	Breed	Weight, lb.			Milk production (FCM), lb.			Feed consumption, lb.		
		Initial	Final	Gain	Initial per day	Total	Final per day	Grain	Hay	Silage or soilage
					Group I — Silage without supplemental hay					
1,553	Ayrshire	966	1,031	65	39.8	2,396.4	27.5	622	...	4,943
1,549	Ayrshire	1,072	1,063	−9	46.4	2,823.2	29.3	753	...	5,401
1,620	Br. Swiss	1,088	1,158	70	43.5	2,451.6	33.6	718	...	5,365
1,294	Br. Swiss	1,645	1,605	−40	62.3	4,036.9	42.2	1,071	...	6,557
1,590	Br. Swiss	1,157	1,215	58	35.0	2,316.3	28.7	628	...	6,275
1,233	Holstein	1,496	1,455	−41	58.0	3,056.4	36.7	940	...	7,574
1,528	Holstein	1,476	1,470	−6	44.2	1,984.6	18.6	671	...	6,068
1,548	Holstein	1,138	1,205	67	35.5	1,801.1	21.3	567	...	6,395
1,502	Holstein	1,341	1,318	−23	77.3	4,113.3	49.7	1,189	...	7,248
1,555	Holstein	1,030	1,026	−4	65.7	3,821.2	45.2	1,014	...	5,355
1,613	Holstein	1,185	1,200	15	41.3	2,397.0	32.1	698	...	6,321
Average		1,236	1,250	14	49.9	2,836.2	33.2	807	...	6,136
					Group II — Silage with supplemental hay					
1,521	Ayrshire	1,168	1,209	41	46.3	2,522.3	26.1	705	333	4,948
1,560	Ayrshire	1,236	1,265	29	49.8	2,760.8	27.8	747	334	4,859
1,249	Br. Swiss	1,317	1,334	17	59.1	4,026.8	45.3	1,036	411	6,144
1,487	Br. Swiss	1,482	1,462	−20	46.6	2,807.9	32.2	768	412	6,140
1,617	Br. Swiss	1,139	1,225	86	33.6	2,014.8	27.7	608	379	5,447
1,332	Holstein	1,442	1,470	28	79.9	3,817.2	45.6	1,308	378	6,687
1,493	Holstein	1,234	1,264	30	63.6	3,958.9	46.9	1,098	410	4,982
1,533	Holstein	1,333	1,345	12	65.3	3,960.0	46.8	1,105	402	6,202
1,594	Holstein	1,159	1,197	38	43.7	2,244.9	25.1	727	404	4,960
1,607	Holstein	1,244	1,279	35	48.0	2,601.7	27.1	691	362	6,265
1,593	Holstein	1,152	1,225	73	37.6	1,985.1	22.3	635	386	5,409
Average		1,264	1,298	34	52.1	2,972.8	33.9	857	383	5,640
					Group III — Soilage without supplemental hay					
1,415	Ayrshire	1,099	1,113	14	41.0	2,365.3	27.7	649	...	9,139
1,615	Ayrshire	1,150	1,173	23	41.5	2,291.4	26.9	602	...	9,140
1,611	Br. Swiss	1,131	1,163	32	56.0	3,205.4	43.0	959	...	9,156
1,404	Br. Swiss	1,675	1,661	−14	36.3	2,346.3	26.4	608	...	11,174
1,600	Br. Swiss	1,104	1,138	34	40.1	2,381.2	31.2	697	...	8,674
1,292	Holstein	1,326	1,323	−3	59.9	3,251.7	40.5	904	...	11,973
1,455	Holstein	1,487	1,478	−9	57.3	3,530.0	38.2	918	...	13,055
1,491	Holstein	1,376	1,478	102	40.2	2,011.6	22.3	595	...	11,116
1,540	Holstein	1,339	1,358	19	77.2	3,706.1	47.4	1,140	...	10,483
1,554	Holstein	1,141	1,145	4	62.7	3,465.3	40.9	1,016	...	10,941
1,606	Holstein	1,210	1,240	30	39.6	2,121.2	28.5	615	...	9,548
Average		1,276	1,297	21	50.2	2,788.7	33.9	791	...	10,400
					Group IV — Soilage with supplemental hay					
1,542	Ayrshire	1,002	1,016	14	47.0	2,660.6	30.9	732	303	8,627
1,602	Ayrshire	1,103	1,136	33	35.7	1,980.7	21.8	532	299	7,501
1,414	Br. Swiss	1,213	1,137	−76	69.1	3,732.2	40.9	1,084	392	7,921
1,362	Br. Swiss	1,467	1,483	16	45.7	2,781.3	32.1	726	412	8,678
1,619	Br. Swiss	1,255	1,320	67	34.3	2,070.5	23.8	581	402	8,830
1,320	Holstein	1,465	1,473	9	69.8	3,473.4	35.8	1,010	340	10,294
1,514	Holstein	1,258	1,214	−44	65.3	3,784.9	48.3	1,076	391	10,033
1,557	Holstein	1,210	1,210	0	62.0	3,408.9	39.1	962	264	8,416
1,588	Holstein	1,178	1,193	15	40.2	2,461.7	29.6	677	318	9,473
1,612	Holstein	1,091	1,130	39	48.3	2,782.6	37.1	766	320	8,568
1,310	Holstein	1,517	1,618	101	38.0	1,857.8	21.1	581	395	10,880
Average		1,251	1,266	15	50.5	2,817.7	32.8	793	349	9,020

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