MSU AG FACTS
COOPERATIVE EXTENSION SERVICE

Pros and Cons.

Big-Package Hay Systems

Extension Bulletin E-950, Michigan State University, January 1979

Donald Hillman and Timothy Logan
Department of Dairy Science

Before investing in a system of handling hay crop forages, dairy farmers should consider the relative capability of the system to produce high quality forage. The best harvest system permits early harvesting, reduces weather damage in the field and deterioration in storage.

Weather, unsatisfactory conditions for drying of field cured hay and rain damage are the major deterrents to the production of high quality, first cutting hay in the Northern and Eastern sections of the U.S. The effects of outside storage on losses of dry matter and quality may be quite different in areas of high rainfall than in the more arid areas of the U.S.

One choice dairy farmers have for handling the hay crop is big package haymaking equipment.

This publication reviews information about harvesting and storage losses, effects on the quality of hay and likely effects on milk production and milk income.

While the data here deals particularly with big package haymaking, it applies to any forage handling system that results in a similar quality of product.

Harvesting Losses

Harvesting losses generally refer to the difference between the quantity of forage dry matter available when cut and the quantity placed in storage. Studies comparing big package with other systems of forage handling on this basis are not available. However, other studies have shown that dry matter losses for conventional baling range from 15 to 25% under good drying conditions and energy losses range from 25 to 35%, or approximately 1.6 times the dry matter loss. The higher energy loss is largely because the dry matter lost is mostly leaves which are the most digestible part of the hay crop.

USDA studies showed that 40% of the leaves were lost under good harvesting conditions and 60% were lost when the hay was damaged by rain. Raking at a moisture content above 35% and baling before the hay becomes too dry can reduce harvesting losses.

Harvesting forage at higher moisture content reduces dry matter losses. German studies show that dry matter and energy losses of direct cut silage were only 4%; but 7% dry matter and 18% energy loss when harvested as

Big Package Hay bales stored outside.

SYSTEMS → ANALYSIS
DAIRY

wilted silage, and 14% dry matter and 34% energy loss harvested as field cured hay. These results are similar to earlier USDA results.

Engineers at Kansas State University compared the amount of dry matter recovered per acre when harvested as hay with a Stakhand 30, a Vermeer 605B (except for the 4th cutting when a 706A was used) and a New Holland 276 conventional baler. The results shown in Table 1 indicate that dry matter losses of first cutting alfalfa were about 13% higher for the big package systems. The moisture content of first cutting ranged from 18 to 22% and was 22 to 26% in the second and fourth cutting hay as harvested.

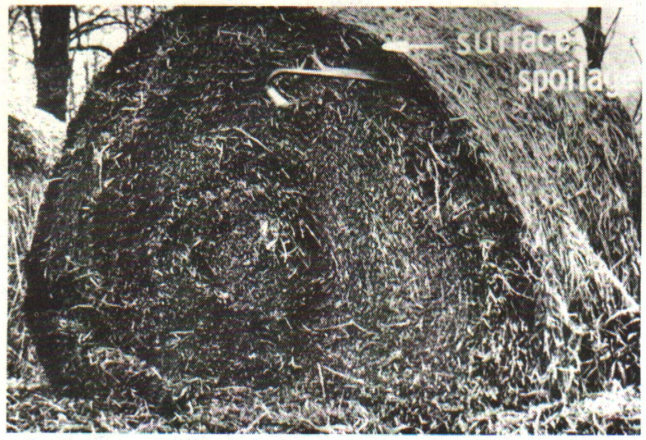
The Kansas research concluded: 1) "when operating in dry, shatter prone alfalfa hay, dry matter losses can be considerably higher with either the stacker or roller baler than for the conventional baler; 2) when the hay was packaged under desirable moisture conditions, no significant differences in dry matter yields occurred." The latter refers to the second and fourth cuttings (Table 1).

Dry matter losses for the conventional baler were not measured in the Kansas study. However, if they were 15 to 25% as reported by other research, which seems reasonable for the dry hay conditions described, then the losses for big package haymaking equipment were within the range of 25 to 40%.

Harvesting losses represent a major cost of producing feed. A system that can reduce harvesting losses at a reasonable cost is desirable.

Further research is needed to accurately evaluate the effects of large package systems on dry matter and energy losses. Delayed harvesting due to unsatisfactory drying conditions for field-curing of hay is another loss factor that must be considered by dairymen in the Northern and Eastern U.S.

Numerous studies have shown that hay crops decline in digestibility at a rate of 0.3 to 0.5 percentage points per day that harvesting is delayed. Similarly, the protein content of alfalfa declines at a rate of about 0.2 percentage point per day between the early bud and late bloom stages of maturity.



Surface spoilage and heat damage can cause interior deterioration and lower quality forage.

The decline in digestibility of forage dry matter (regardless of cause) is of particular concern to dairymen. Several experiments have shown that a delay of 15 days in harvesting after the optimum stage of maturity (1/10 bloom alfalfa) results in a loss of 1,300 lb milk per lactation. This represents a loss of $112 per cow when milk is priced at $8.50 per 100 lb.

The lower milk production is associated with reduced digestibility which results in reduced dry matter consumption. Each 1% reduction in digestibility reduces dry matter intake by 3% (.75 lb/1,000 body wt); reduces milk production by 260 lb per lactation or about $22.00. The extent to which unfavorable weather delays harvest is difficult to assess and quite different some years than others. Nevertheless, in selecting a system, the capability of harvesting at the optimum stage of maturity with minimum interference from the weather is an important consideration.

Rain damage to hay that lays in a swath or windrow

TABLE 1. DM loss caused by harvesting machinery.

Package type	Cutting	DM yield/acre	Increased DM loss	Comments
		lb	%	
New Holland 276	1	2917	0	Very dry leaves compared to stem
Hesston Stakhand 30	1	2537	13.0	
Vermeer 605B	1	2546	12.7	
New Holland 276	2	1524	0	Hot dry windy weather
Hesston Stakhand 30	2	1531	0	
Vermeer 605B	2	1388	8.9	
New Holland 276	4	1179	0	Excellent conditions
Hesston Stakhand 30	4	1108	6.0	
Vermeer 706	4	1177	0	

Trials conducted by Kansas State University.

for several days before baling is another hazard when making first cutting, field-cured hay. Michigan data indicate that about 40% of the first cutting, 30% of the second cutting and 10% of the third cutting received some rain damage in 1969. Reducing the field-curing time can reduce weather damage.

Rain-damage hay averaged 12.9% protein, 36.4% crude fiber and 56.2% digestible dry matter compared to 15.6% protein, 31.4% fiber and 60.2% digestible dry matter for hay that was not rain damaged. The most severely damaged sample was 46% digestible and worthless as feed.

Storage Losses

Field-cured hay stored under cover at 20 to 25% moisture normally loses about 4 to 6% of the dry matter stored. Dry matter losses increase when hay is stored with a moisture content above 25%. This is because of increased oxidation of easily digested carbohydrates (mostly sugars) by bacteria, yeasts and molds with production of carbon dioxide, water and heat. Excessive heating reduces the energy content and digestibility of the protein.

Storage losses of big package stacks, bales and small round bales (outside, uncovered) were studied at Purdue University in 1972 and 1973. The outside, weathered portion ranged from 7 to 22.2% of the DM as shown in Table 2. The digestibility of the weathered portion averaged 36.8% compared to 54.4% for hay in the "core" of the bale and 56.5% when placed in storage. In this study, 4.6 to 17.8% of the potentially digestible dry matter was lost due to outside storage (Table 2). Rainfall during the storage period was approximately 13 inches, about 4.3 inches below normal according to the Purdue study.

The average digestibility of the combined weathered and core portions averages about 51.1% or roughly 3% lower than the core portion which is presumed to be well preserved hay. This slight reduction in digestibility is probably of little importance when fed as a main-

TABLE 2. Weathering losses in grass and legume hay stored outside in various package forms, Southern Indiana-Purdue and Feldun-Purdue Agricultural Centers, 1972 and 1973.[1]

Type of package	Avg. package weight (15% moisture)	Portion of each package weathered[2]	Total digestible nutrients[3] Unweathered core	Total digestible nutrients[3] Weathered outside[4]	TDN loss due to outside storage
	lb	%	%	%	% of total
Grass hay — 1972					
Hesston 10 stack	1195	12.6	53.4	35.1	8.83
Vermeer 605 bale	1089	14.6	54.0	39.4	8.20
Hawk-Bilt 480 bale	560	22.2	54.8	39.7	12.59
Small round bale	35	20.6	55.3	33.0	16.87
Average (big packages)		16.4	54.1	38.1	9.87
Grass hay — 1973					
Hesston 10 stack	1007	9.6	60.0	42.2	6.82
Vermeer 605 bale	1185	7.0	58.9	42.5	4.60
Hawk-Bilt 480 bale	683	16.8	57.9	40.4	11.29
Small round bale	37	20.2	60.0	42.6	13.45
Average (big packages)		11.1	58.9	41.7	7.57
Alfalfa hay — 1973					
Hesston 10 stack	1377	8.1	57.0	33.9	7.36
Vermeer 605 bale	1097	10.7	56.5	34.2	9.14
Hawk-Bilt 480 bale	728	19.6	56.6	31.9	17.75
Average (big packages)		12.8	56.7	33.3	11.42
Average — 1972 and 1973					
Hesston 10 stack		10.1			7.67
Vermeer 605 bale		10.8			7.31
Hawk-Bilt 480 bale		19.5			13.87
Average (overall)		13.47			9.62

[1]*Grass hay stored from June to November 1972, and from June 1972 to February 1973; alfalfa hay stored from August 1973 to February 1974.*

[2]*Separation of hay into weathered and unweathered parts was done by hand.*

[3]*TDN estimated on a basis of in vitro (test tube) dry matter disappearance.*

[4]*It is likely that cattle will entirely reject weathered portion even if part of it is digestible.*

tenance ration to brood cows, or dry dairy cows. The result could be quite different when fed to lactating dairy cows as the only forage. A 3% reduction in digestibility can reduce milk production 2.5 lb per cow daily or approximately 750 lb milk per lactation.

Baled hay that was loaded, transported and stacked by machine but covered with a tarp was compared to big package stacks stored outside without cover in trials at Auburn University in Alabama. The digestibility of the baled hay protected from weather was 53.87% compared to 46.27% for core samples of the big package stack, and 42.37% digestible dry matter for the weathered top samples of moldy hay as shown in Table 3. The data indicate that hay refused by cattle was similar in digestibility to the top sample (1970-71 results).

The increased total loss (compared to covered bales) of dry matter due to weathering of the uncovered stacks was 6.9% of the hay from the core of the stack and 14.3% digestibility. Similar losses from the weathered portion were 23.1% dry matter and 20.3% digestibility.

Storage losses during the second year of the study were reported as 15.03% for conventional bales stored outside under-cover (8.5% rotted) compared to 13.64% for stacks in a steer feeding trial; and, 10.20% for conventional bales vs. 14.68% for stacks in a brood cow feeding trial.

Digestibility of dry matter was reduced about 3% for the baled hay and 6% for the stacked hay compared to the digestibility at harvest.

Feeding Losses

Wastage of hay due to trampling can be severe when cattle are allowed free access to big packages. Purdue studies showed that 23 to 39% more hay was required when big packages were fed on the ground without racks compared to feeding the hay in racks on concrete. Losses in racks on concrete ranged from 2.4 to 4.4%.

Auburn reported losses of 35.2 to 46.5% of the dry matter (based on dry matter at storage) due to trampling when stacks were fed without racks. Feeding losses were reduced by using feeding panels around the stacks. Also, there was no difference in the amount of hay fed per pound of gain when conventional bales were fed on sod and large round bales were fed in panels (9 lb/cwt gain). The amount of hay dry matter per pound gain was reduced 42% when big round bales were fed in panels (Auburn, Circular 216, 1975).

TABLE 3. Comparison of storage losses of covered bales stacked outside and big package stacks not covered.

		Stacked hay		
	Covered baled hay, core sample	Top sample (moldy)	Core sample	Refused hay
	%	%	%	%
1970-71 data				
Dry matter digestibility (*in vitro*) — test tube)	53.87	42.37	46.27	43.17
Protein	10.18	12.58	10.37	10.29
Loss due to outside storage:[1]				
Dry matter, % (base)		23.1	6.9	
Digestible dry matter		20.3	14.3	

[1] *Calculated at MSU from differences in ash content.*
Source: Auburn, Alabama Agr. Expt. Station Bull. 455, 1974.

Economic Comparisons

Several reports have concluded that the cost for harvesting and feeding hay, using mechanized handling of both big package and conventional bales was lower for the big package systems. This is mainly due to the lower labor requirement. Also, the cost per ton is reduced as larger volumes of hay are handled.

Auburn confirmed the above conclusion as illustrated in Figure 1 for some of the systems studied. Data for these and other systems are in Table 4.

However, they concluded that the cost per 100 lb gain of steers and cost per cow and calf wintered was higher for the big package stacks than for conventional bales (Figure 2). This was also true for the big round bales when feeding panels were not used, but costs per

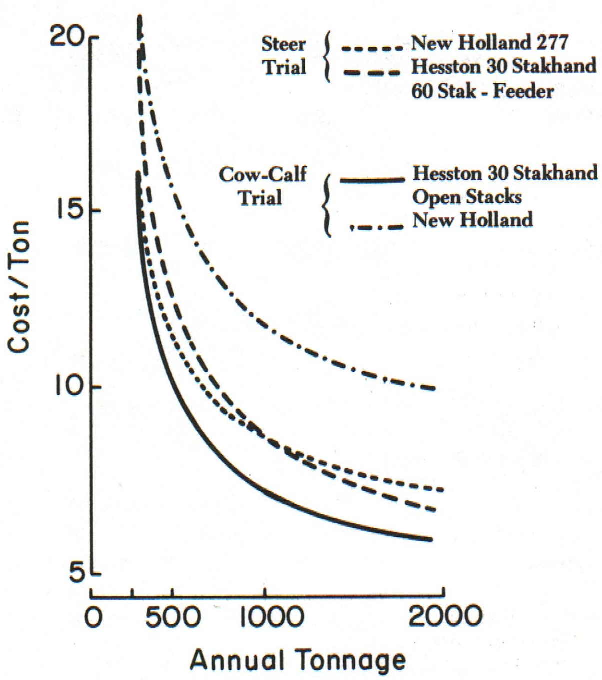


Figure 1. Estimated Total Harvest and Feeding Cost per Ton for Different Forage Harvesting Systems. (Adapted from: Auburn, Alabama, Agr. Exp. Station Bulletin 455, 1974.)

cwt. gain were lower for the round bales when feed wastage was reduced by using panels.

These data emphasize that animal performance and the feeding losses must be considered in selecting a forage management system.

Results of experiments comparing the big package systems and conventional bales in feeding experiments with milking cows are not available. Tentative conclusions must be based on the data in Table 4 and similar research with dairy cattle. Forage quality is much more critical for lactating cows having high energy requirement than for maintaining brood cows. The quality of forage harvested in the above experiments was lower than desirable for dairy cattle. The effects of weathering on high quality hay exposed to heavy rainfall when stored without cover may be considerably greater than shown. Where hay is a minor part of the forage program, quality will be less important.

TABLE 4. Estimated total harvesting and feeding cost per ton for different forage systems.

Haying system	Cost per ton, when average tons harvested per year are			
	250	500	1,000	2,000
System 1—steer feeding with New Holland 277 baler and 1010 Stackliner through feeding	$16.10	$11.09	$ 8.59	$ 7.35
System 2—steer feeding with New Holland 277 baler, 1010 Stackliner and pickup truck	17.86	13.13	10.77	9.59
System 3—steer feeding with Hesston Model 30 Stakhand and Model 60 Stakfeeder	19.68	12.35	8.69	6.85
System 4—steer feeding with Hesston Model 30 Stakhand and Model 30 Stakfeeder	17.77	11.29	8.07	6.45
System 5—brood cows with calves with New Holland 277 baler, 1047 Stackcruiser, and pickup truck	20.91	14.68	11.56	10.01
System 6—brood cows with calves with Hesston Model 30 Stakhand and Model 30 Stakmover—open stacks	15.31	9.77	7.02	5.63
System 7—brood cows with calves with Hesston Model 30 Stakhand and Model 30 Stakmover—panels around stacks	15.96	10.42	7.67	6.28

Source: Auburn University Agr. Exp. Station Bull. 455, 1974.

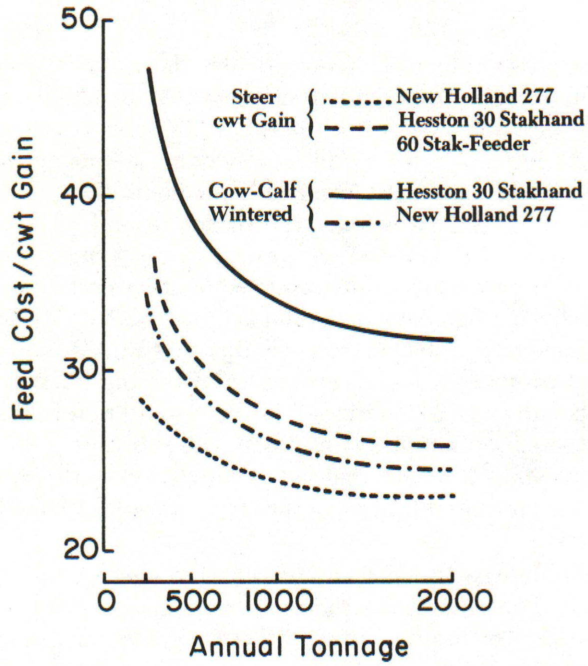


Figure 2. Estimated Total Feed Cost/cwt. Gain and per Cow and Calf Wintered for Different Hay Harvesting and Feeding Systems. (Adapted from: Auburn, Alabama Agr. Exp. Station Bull. 455, 1974.)

CONCLUSIONS

1. Harvesting losses were about 13% higher when either a big package stacker or roller baler were operated in dry, shatter-prone alfalfa hay, compared to a conventional baler. When hay was packaged under desirable moisture conditions, no significant differences in dry matter yields occurred.
2. The weathered, outside portion ranged from 7 to 22% of the hay in big package bales and stacks (averaged 13.5%). Losses appear to be higher for some types of packages than others. The weathered portion is of little value for feed. The digestible nutrient content was reduced 30 to 40%.
3. Storage losses ranged from 8 to 17% of the dry matter stored. Dry matter lost from stacks was 7% higher than from bales covered with a tarpaulin in one study, but similar in another comparison. The extent of rainfall in an area would influence storage losses.
4. The loss of total digestible nutrients due to outside storage, ranged from 6.8 to 23% of the total.
5. Digestibility of hay dry matter was reduced by 1.8 to 7.6% in the core of the stacks due to outside storage. Each 1% reduction in digestibility represents 0.75 lb less dry matter intake/1,000 lb body weight and 220 to 260 lb less milk per lactation.
6. Feeding losses were higher for big packages than for conventional bales. 23 to 46% of the hay was wasted when big packages were fed without a rack.

Losses were reduced to less than 5% when packages were fed in a hay rack or surrounded with feeding panels on concrete.

7. Big package systems require less labor than conventional bale systems. This may be of particular importance in some situations.

8. The cost per ton of hay for large volume harvesting favors the big package systems.

9. Feed efficiency and cost per pound of gain favored the bale system in steer feeding trials. Large round bales resulted in a lower cost gain than conventional bales in a later trial when feeding panels were used but not when cattle were fed on the sod.

In tests with brood cows and calves, more hay was required and wintering cost was higher on the stacked system than with conventional bales.

TABLE 5. Estimated total hay and other feed cost/cwt. gain and/cow and calf wintered, for different systems harvesting and feeding, Auburn Black Belt Substation, 1971-72.

Item of cost	Cost per unit, when average tons harvested per year are			
	250	500	1,000	2,000
System 1—steer feeding with New Holland 277 baler and 1010 Stackliner through feeding				
Total hay cost per cwt gain	$15.67	$12.48	$10.89	$10.11
Other feed cost per cwt gain	12.94	12.94	12.94	12.94
Total feed cost per cwt gain	28.61	25.42	23.83	23.05
System 2—steer feeding with New Holland 277 baler, 1010 Stackliner, and pickup truck				
Total hay cost per cwt gain[1]	16.79	13.78	12.29	11.53
Other feed cost per cwt gain	12.94	12.94	12.94	12.94
Total feed cost per cwt gain	29.73	26.72	25.22	24.47
System 3—steer feeding with Hesston Model 30 Stakhand and Model 60 Stak-Feeder				
Total hay cost per cwt gain[1]	23.21	17.18	14.17	12.65
Other feed cost per cwt gain	12.94	12.94	12.94	12.94
Total feed cost per cwt gain	36.15	30.12	27.11	25.59
System 4—steer feeding with Hesston Model 30 Stakhand and Model 30 Stak-Feeder				
Total hay cost per cwt gain[1]	21.64	16.30	13.66	12.32
Other feed cost per cwt gain	12.94	12.94	13.66	12.94
Total feed cost per cwt gain	34.58	29.24	26.60	25.26
System 5—wintering brood cows with calves with New Holland 277 baler, 1047 Stackcruiser and pickup truck				
Total hay cost per cow wintered[1]	27.69	21.83	18.90	17.44
Creep cost per cow wintered	1.57	1.57	1.57	1.57
Cottonseed meal cost per cow wintered	5.50	5.50	5.50	5.50
Total feed cost per cow wintered	34.76	28.90	25.97	24.51
System 6—wintering brood cows with calves with Hesston Model 30 Stakhand and Model 30 Stakmover—open stacks				
Total hay cost per cow wintered[1]	38.67	29.69	25.23	22.97
Creep cost per cow wintered	3.13	3.13	3.13	3.13
Cottonseed meal cost per cow wintered	5.50	5.50	5.50	5.50
Total feed cost per co wintered	47.30	38.32	33.86	31.60
System 7—wintering brood cows with calves with Hesston Model 30 Stakhand and Model 30 Stakmover—panels around stacks				
Total hay cost per cow wintered[1]	31.78	24.58	21.92	19.22
Creep cost per cow wintered	3.13	3.13	3.13	3.13
Cottonseed meal cost per cow wintered	5.50	5.50	5.50	5.50
Total feed cost per cow wintered	40.41	33.21	29.65	27.85

[1]*Includes $8.53 per ton cost of producing hay as estimated at Black Belt Substation, as well as harvesting and feeding costs as observed and budgeted.*

Auburn University, Ag. Exp. Station Bull. 455, 1974.

This information is for educational purposes only. Reference to commercial products or trade names does not imply discrimination or indorsement by the Cooperative Extension Service. Cooperative Extension Service Programs are open to all without regard to race, color, creed, or national origin. Issued in furtherance of cooperative extension work in agriculture and home economics, acts of May 8, and June 30, 1914, in cooperation with the U.S. Department of Agriculture. Gordon E. Guyer, Director, Cooperative Extension Service, Michigan State University, E. Lansing, MI 48824

2P-2M-1:79-UP, Price 20 cents.

0-11195

Michigan State University Printing