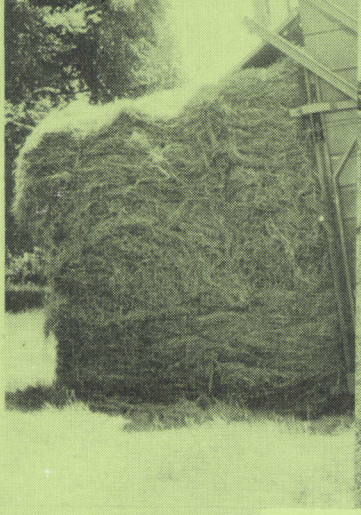

BULLETIN 455/JUNE 1974

Stack and Bale Systems for Hay Handling and Feeding

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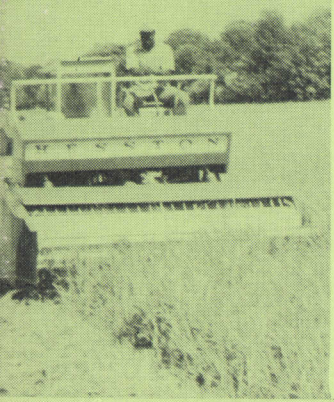

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Stack and Bale Systems for Hay Handling and Feeding

E. S. RENOLL, W. B. ANTHONY, L. A. SMITH, and J. L. STALLINGS*

HAY IS STILL THE MAJOR form of stored roughage used for certain classes of cattle, horses, and sheep. Over many generations of use, hay has been handled in many ways and with various amounts of machinery and labor. High labor requirement has been a major problem through the years, and this has become more critical in recent years.[1,2,3] Scarcity of labor coupled with problems associated with hot weather conditions at hay harvest have led to the design of machines to reduce labor needs.

The research reported in this publication was conducted to evaluate and compare baled hay systems and stacked hay systems for handling and feeding johnsongrass hay. The project was conducted at the Black Belt Substation as a cooperative effort of the Substation and the departments of Animal and Dairy Sciences, Agricultural Engineering, and Agricultural Economics and Rural Sociology. Equipment furnished by the New Holland Machine Division of Sperry Rand Corporation and the Hesston Corporation represented partial support of the Auburn University Agricultural Experiment Station project that was carried out on heavy clay soil.

A preliminary report giving first year's results was published in November 1971.[4]

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* Professor, Department of Agricultural Engineering; Professor, Department of Animal and Dairy Sciences; Superintendent, Black Belt Substation; and Associate Professor, Department of Agricultural Economics and Rural Sociology, respectively. The authors express appreciation to New Holland Machine Division of Sperry Rand Corporation and to Hesston Corporation for their interest and assistance during the hay experiments reported.

[1] COCKREL, CLEM. 1971. Can Hay Make A Comeback in Tennessee? Tennessee Farmer. Feb.

[2] FLOYD, CHARLES S. 1971. Making Hay in the U.S.A. Implement and Tractor. Vol. 86, No. 18.

[3] YOST, LYLE E. 1969. Mechanize Your Haying Jobs. National Live Stock Producer. May.

[4] RENOLL, E. S., W. B. ANTHONY, L. A. SMITH, AND J. L. STALLINGS. 1971. Comparison of Baled and Stacked Systems for Handling and Feeding Hay. Auburn Univ. (Ala.) Agr. Exp. Sta. Prog. Rept. No. 97.

PROCEDURE

The experiment covered a 2-year period. Procedure for the second year was based partially on results from the first year. Each year the experimental plan included four phases: (1) a time study of machines to obtain labor needs and machine capacity, (2) an animal feeding trial, (3) a chemical composition and nutritive value comparison of the hay, and (4) a cost analysis.

Hay Production

The johnsongrass hay fields were located on Sumter and Houston soils, both of which are neutral to alkaline without addition of limestone. Mineral fertilizer was applied in late fall on the basis of soil tests. Amounts of fertilizer used during test years ranged from 400 to 500 pounds of 0-16-8 per acre annually. Sixty pounds of nitrogen in the form of ammonium nitrate was broadcast for each cutting of hay. The hay fields were overseeded with wild winter peas (caley peas) for winter and spring grazing by cattle prior to the harvest of johnsongrass hay.

Moisture conditions were not favorable for hay production during the 1970 test. The hay used for the experiment was second cut. It was harvested in the early bloom stage and yielded 1,694 pounds per acre.

Conditions were different during the 1971 test year, with moisture abundant throughout the year. The result was rapid forage growth that made it difficult to cut hay at proper maturity. Test

FIG. 1. Johnsongrass for the hay studies was cut and conditioned in one operation. Raking was a separate operation.

hay for the brood cow feeding trial was harvested at two different times. Part of it was second cutting and part third cutting. The forage was harvested between the bloom and pre-head stage and yielded 3,105 pounds of hay per acre. Test hay for the steer feeding trial was third growth and was harvested in the bloom stage. It yielded 2,689 pounds per acre.

Description of Machinery[5]

A conventional mower-conditioner and a rake were used to prepare hay for both stack and bale systems. A New Holland 277 baler and the following bale handling machines were used in the various parts of the bale study:

New Holland Stackcruiser 1047. This is a self-propelled bale loader and transport unit that can haul 119 bales. Operated by one man, it is self unloading by the operator and can unload all its bales at one time in a stack on the ground.

FIG. 2. One of the machines used to mechanically handle conventional bales from field to storage area.

New Holland Stackliner 1010. The bale loading and hauling unit is pulled by a tractor and can haul 55 bales. It is operated

[5] The use of manufacturer's names for equipment is for descriptive purposes only and does not constitute endorsement by the Alabama Agricultural Experiment Station.

by one man and can unload all the bales at once in a stack. The machine also is used to retrieve bales from the storage stack, transport them to the feeding area, and unload one bale at a time for feeding.

The machines used in the different parts of the stack study included the following:

Hesston StakHand 30. This machine produces a stack that is approximately 8 feet wide, 14 feet long, and 9 feet high. It is propelled by a tractor and requires one operator. Hay is picked up from the windrow and blown into the machine. The top of the machine serves as a hay compressor, which compresses hay several times during loading. When the machine is loaded, it transports hay to a storage area and unloads compressed stacks. The top of the stack is somewhat rounded to help shed water.

FIG. 3. On the right is a machine used to produce stacks of hay. Left shows stack being discharged from machine at the storage area.

Hesston StakMover 30. This machine is used to move stacks from one location to another. It is powered from the PTO of a tractor and requires one operator. It can pick up a stack, transport it to the desired area, and unload the entire stack intact.

Hesston StakFeeder 60. This machine is similar to the StakMover 30 in that it picks up and transports stacks. It has a slicer-feeder attachment which can slice off and feed a fractional part of the stack and leave the remainder on the machine for subsequent feedings. It is operated from the tractor PTO and requires one operator.

Feeding Trials

Hay from the bale and stack systems was fed to animals to determine hay consumption and utilization, feed efficiency, and animal gain. The feeding studies were conducted during late fall and early winter.

The first year, 1970-71, hay was fed to 52 steers with 26 getting baled hay and 26 stacked hay. The 1971-72 experiment was expanded to include both steer feeding trials and cow-calf studies. In the cow-calf study 38 cows and their calves were used, 19 on baled hay and 19 on stacked hay. A diagram showing the various feeding systems used and the machinery required for each is shown in Figure 4.

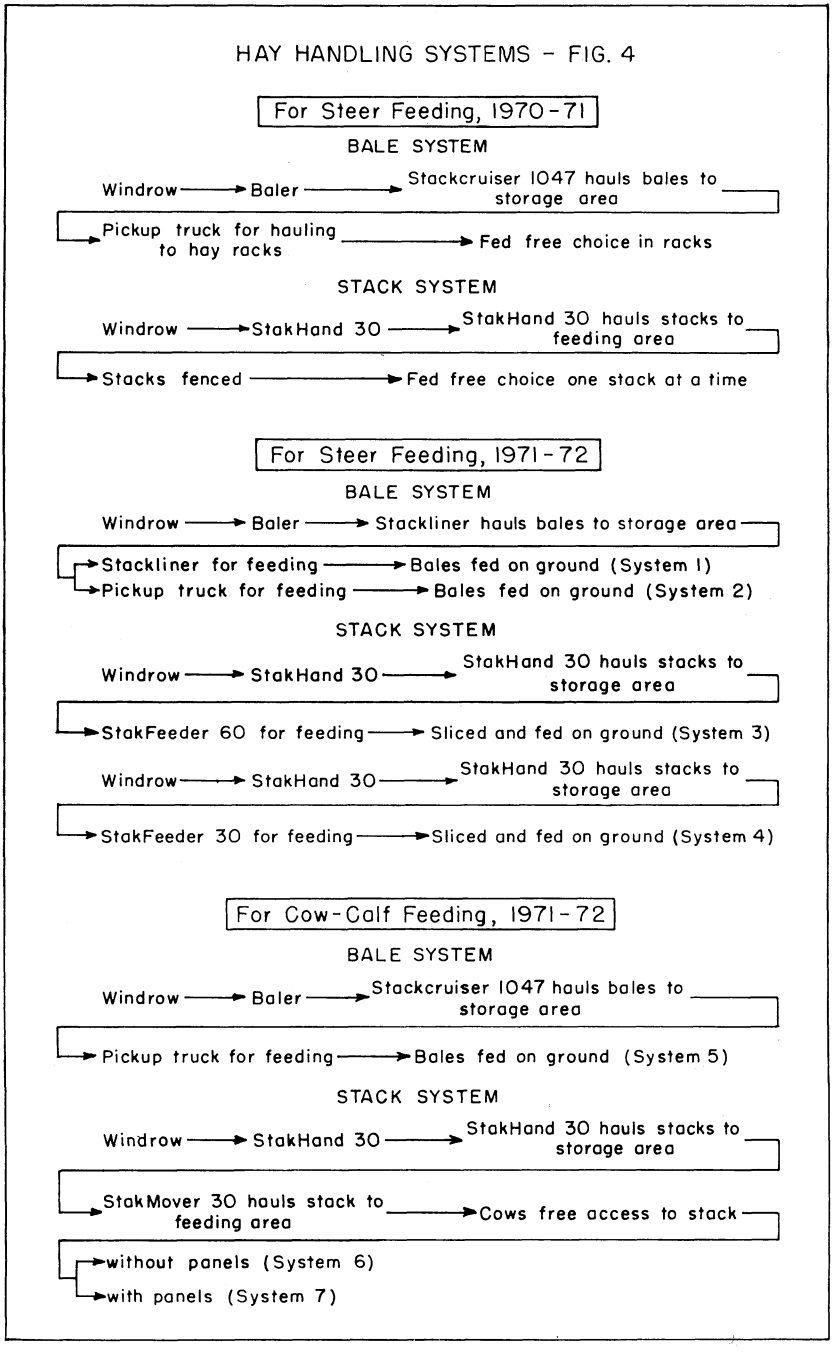
Economic Analysis

Data from the first three phases of the study (time study, feeding trials, and chemical and nutritive value analysis) were used along with information from various secondary sources to make an economic analysis of the different systems studied. Since conditions and costs on commercial farms might be different from those at the Black Belt Substation, various assumptions and syntheses were used to make economic recommendations applicable to a wider variety of farm situations. For example, costs were computed for different assumed amounts of hay cut and fed per year for the systems used and for one system not actually used in the trials.

CONDITIONS AND RESULTS, 1970-71

Machinery Capacity Comparisons

The agricultural engineering phase of the research involved obtaining time study data and capacity values. These measures served as the basis for comparing the two systems of handling hay. The machine study measured the time necessary for each hay handling operation, beginning with the hay in a raked windrow and ending with it in its respective storage area. For the bale system this involved baling the hay with a conventional baler and then loading, transporting, and stacking with the Stackcruiser 1047. For the stack system the StakHand 30 was used to load, transport, and unload hay.


HAY HANDLING SYSTEMS - FIG. 4
For Steer Feeding, 1970-71
BALE SYSTEM
Windrow
Baler
Stackcruiser 1047 hauls bales to storage area
Pickup truck for hauling to hay racks
Fed free choice in racks
STACK SYSTEM
Windrow
StakHand 30
StakHand 30 hauls stacks to feeding area
Stacks fenced
Fed free choice one stack at a time
For Steer Feeding, 1971-72
BALE SYSTEM
Windrow
Baler
Stackliner hauls bales to storage area
Stackliner for feeding
Bales fed on ground (System 1)
Pickup truck for feeding
Bales fed on ground (System 2)
STACK SYSTEM
Windrow
StakHand 30
StakHand 30 hauls stacks to storage area
StakFeeder 60 for feeding
Sliced and fed on ground (System 3)
Windrow
StakHand 30
StakHand 30 hauls stacks to storage area
StakFeeder 30 for feeding
Sliced and fed on ground (System 4)
For Cow-Calf Feeding, 1971-72
BALE SYSTEM
Windrow
Baler
Stackcruiser 1047 hauls bales to storage area
Pickup truck for feeding
Bales fed on ground (System 5)
STACK SYSTEM
Windrow
StakHand 30
StakHand 30 hauls stacks to storage area
StakMover 30 hauls stack to feeding area
Cows free access to stack
without panels (System 6)
with panels (System 7)

Average machine speeds obtained for the 2 years were as follows:

Machine	*Speed, m.p.h.*
Conditioner	6.0
Rake	5.1
Baler	4.2
StakHand 30	
Loading	4.5
In transport	9-12
Stackcruiser 1047	
Loading	variable[1]
In transport	14-16.5
Stackliner 1010	
Loading	variable[1]
In transport	18-20

[1] Speed was influenced by field conditions, bale numbers, and windrow length, and was too variable to obtain meaningful range or average.

The machine capacity study for both systems was conducted in the same field using hay from alternate windrows. The ma-

FIG. 5. Bales are stacked for storage by same machine used to load and transport them.

TABLE 1. CAPACITY COMPARISON OF A BALE AND STACK SYSTEM FOR HANDLING HAY FROM WINDROW TO STORAGE, 1970-71 AND 1971-72

Hay handling system	Capacity	
	Per hour	Per man-hour
	Tons	*Tons*
Bale system using baler and Stackcruiser 1047	3.45	2.95[1]
Bale system with baler and Stackliner 1010	2.40	2.10[1]
Stack system with StakHand 30	3.47	3.47

[1] Requires one man each for baler and loader.

terial was cut with a mower-conditioner and raked into windrows. Average capacities of machines shown in Table 1 are for the 1970-71 and 1971-72 studies. Hay from both handling systems was transported approximately 1 mile to the storage and feeding area.

Animal Feeding Trial Comparisons

Both baled and stacked hay were stored in the open in a 14.5-acre field of fescuegrass. The baled hay was stored at a dry matter content of 79.25 percent. It was stored outside, covered with a tarpaulin, and fenced to protect it from livestock. The 10 stacks of hay harvested with the Hesston machine contained 76.11 percent dry matter at storage. Each stack was separately fenced

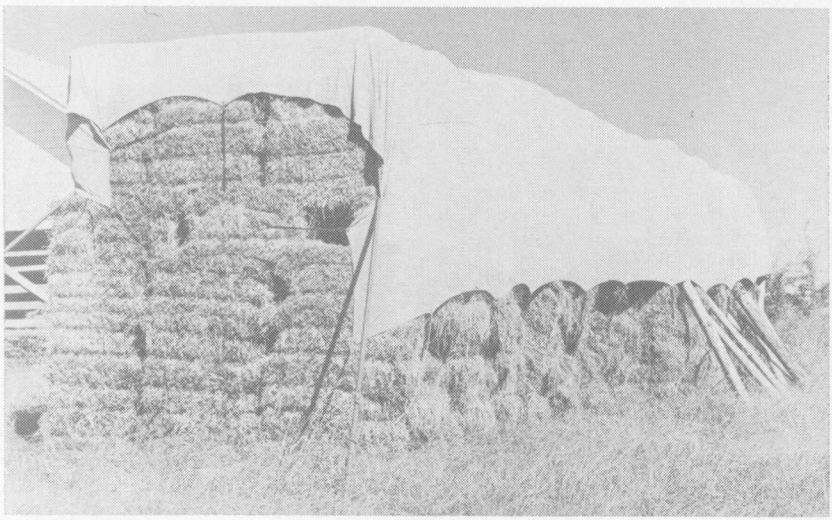


FIG. 6. Bales for the study were stored outside and protected from the weather with a cover.

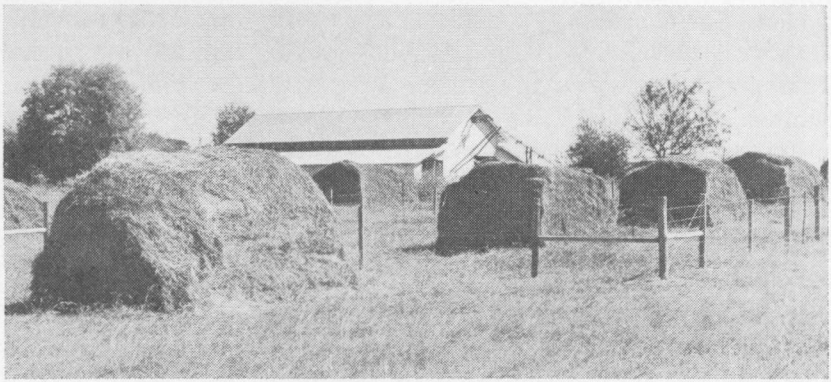


FIG. 7. Stacks were placed in a central storage area and then fed one stack at a time. Stacks were not covered.

and the enclosure fitted with a wire gap for individual stack feeding to cattle. Stacks were not covered.

The 14.5-acre field of fescue was fenced into two equal areas. Each area was supplied water. A group of 52 Angus and Angus-Hereford steers averaging 476 pounds each was divided into two comparable groups of 26 animals each. The test period was November 10, 1970, through March 10, 1971. One group of steers was offered baled hay free choice daily in hay racks while the other group had access to a stack of hay 24 hours each day. The steer groups were periodically rotated between pastures to minimize pasture differences. This was done when a stack of hay was finished and a new stack made available.

FIG. 8. Animals self feeding from a stack. Ground conditions around stack became muddy during wet weather.

Time for consuming a stack of hay by a group of 26 test animals varied from 8 to 19 days. Fescue grazing reduced hay intake early in the study but the grazing was extremely limited in midwinter. In addition to hay, all steers received daily 2 pounds of ground corn and 1.5 pounds of cottonseed meal (41 percent) per head.

Weather damage to hay in stacks did not appear to be excessive. By visual observation, weather damage to the stacks was estimated at less than 5 percent. Feeding stacked hay, however, resulted in large losses. The cattle pulled hay from the stack and trampled it in the mud. The loss was measured for 3 of the 10 stacks by picking up the trampled hay after the stack was consumed, weighing it, and determining dry matter. Based on dry matter at storage, waste amounted to 35.2 percent from stack 3, 43.5 percent from stack 7, and 46.5 percent from stack 8. Both rainfall and eating time appeared to affect stacked hay loss. It required 10, 19, and 18 days to consume stacks 3, 7, and 8, respectively. Rainfall during the feeding periods for stacks 3, 7, and 8 were 0.93, 1.52, and 1.63 inches, respectively.

Feeding baled hay in racks kept trampling loss to a minimum, with weigh-backs of damaged hay showing only 5.65 percent

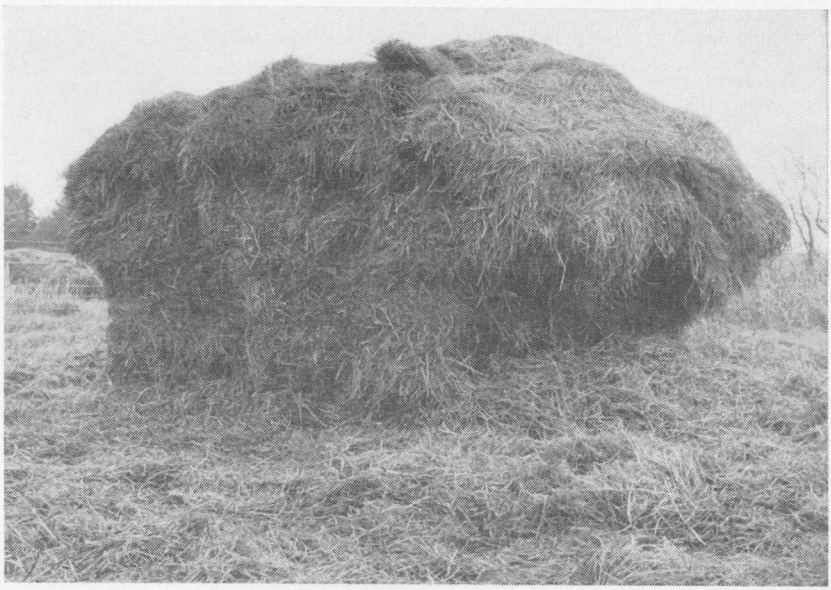


FIG. 9. Partially consumed stack of hay. Note hay on the ground.

TABLE 2. FEEDING AND PERFORMANCE DATA FOR BALED VS. STACKED JOHNSONGRASS HAY FOR WINTERING YEARLING CATTLE, 1970-71

Item	Baled hay	Stacked hay
Animals, no.	26	26
Days on test, no.	113	113
Final live weight, lb.	636	612
Initial live weight, lb.	476	477
Gain, lb.	160	135
Average daily gain, lb.	1.42	1.19
Feed fed per animal[1]		
Hay, lb.	1,540 (1,207)[2]	2,089 (1,590)
Corn, lb.	226	226
Cottonseed meal, lb.	169.5	169.5
Daily feed available per animal		
Hay, lb.	13.63 (10.68)	18.49 (14.07)
Corn, lb.	2.00	2.00
Cottonseed meal, lb.	1.50	1.50
Feed per cwt. gain		
Hay, lb.	963 (754)	1,547 (1,178)
Corn, lb.	141	167
Cottonseed meal, lb.	106	126
Feed cost per cwt. gain, dol.[3]	20.53	26.01

[1] Baled hay was fed daily in a rack; Hesston stacks (average 5,432 pounds) self-fed one at a time. Feed fed per animal was based on weight at harvest.

[2] Values in parenthesis are hay expressed as dry matter at time of storage.

[3] Feed ingredient prices used at time of the trials were, corn $3.30 per hundredweight and cottonseed meal $4.20 per hundredweight. Hay cost was calculated on the basis of an annual hay harvest and feeding of 500 tons (Table 4). Harvesting and feeding cost was estimated at $15.21 per ton for the baled system and $11.13 per ton for the stack system. In addition, hay production cost per ton was estimated to be $8.53, the same for both systems.

wasted during feeding. In addition to the feeding loss, there was an estimated 4 percent loss caused by rotting of hay lying on the ground during storage.

The yearling steers were on test for a total of 113 days. Those fed the baled hay made an average daily gain of 1.42 pounds, whereas on stacked hay the gain was only 1.19 pounds per head, Table 2.

Based on weights when stored, the cattle on baled hay had available an average of 1,540 pounds of hay per head during the test. Those on stacks had 2,089 pounds per head. The daily hay dry matter available per animal was 10.68 pounds for baled hay and 14.07 pounds for stacked. Hay dry matter required per hundredweight of gain amounted to 754 pounds for baled hay and 1,178 pounds for stacked hay. These feed efficiency data, calculated on the basis of hay dry matter at time of storage, indicate that baled hay was more efficiently utilized for animal gain than was the stacked hay, Table 2. Based on normal hay production cost and market prices of corn and cottonseed meal, feed cost

per hundredweight of animal gain was $20.53 for baled hay and $26.01 for stacked hay.

These feed efficiency data reveal considerable advantage for baled hay over stacked hay. It is important to consider, however, that there were savings in labor for the stacked hay (3.47 tons per man-hour vs. 2.95 tons per man-hour for harvesting and storing baled hay). Another saving with the stacked hay resulted because it was self-fed to the cattle whereas the baled hay had to be fed daily by man. A labor charge for feeding was included in the cost calculations. Cost of the fence used around the Hesston stack was also included.

Chemical Composition and Digestibility

Samples of hay for chemical and nutritive value study were taken with a coring tool (Pennsylvania State hay sampler) from the baled and stacked hay. Approximately 20 baled samples were cored and these samples were composited for analysis. The 10 hay stacks were cored 20 times each, with samples from each stack composited for separate chemical and nutritive value studies. In addition to the core samples, selected samples of hay taken from the top of several stacks during the feeding operation were analyzed to determine the degree of weather deterioration. Also, digestibility was determined on refused hay collected after

TABLE 3. CHEMICAL COMPOSITION AND DIGESTIBILITY OF BALED OR STACKED JOHNSONGRASS HAY, 1970-71

Item	Baled hay core sample	Stacked hay		
		Top sample (moldy)	Core sample	Refused hay
Van Soest values				
Cell wall, pct.	82.85	71.40	81.00	77.83
Non-cell wall, pct.	17.15	28.60	19.00	22.17
Crude protein, pct.	10.18	12.58	10.37	10.29
Dry matter digestibility, pct.[1]	53.87	42.37	46.27	43.17
Minerals				
Ash, pct.	7.64	9.94	8.21	9.01
Phosphorus, pct.	.50	.50	.37	.37
Calcium, pct.	.83	1.31	1.40	1.10
Magnesium, pct.	.24	.24	.21	.19
Potassium, pct.	1.08	1.08	1.30	1.04
Copper, p.p.m.	7.69	10.94	10.79	7.46
Iron, p.p.m.	115.42	186.02	174.09	180.84
Manganese, p.p.m.	17.95	27.36	22.51	29.91
Zinc, p.p.m.	25.65	32.83	30.27	24.75

[1] By nylon bag technique.

feeding several of the hay stacks. This was done by use of the nylon bag technique.

Chemical analyses for cell wall, non-cell wall, crude protein, and mineral constituents showed no important differences between core samples taken from baled and stacked hay, Table 3. In contrast, dry matter digestibility was appreciably higher for the baled hay. Hay samples from the tops of hay stacks were analyzed to determine if the noticeable deterioration would be reflected in chemical analyses. These top samples showed apparent increases in contents of cell wall, non-cell wall, crude protein, and minerals as compared with core samples from within the stacks. The increases in non-cell wall and crude protein probably resulted from action of the microflora in solubilizing the structural carbohydrates. These apparent increases in nutrients do not indicate improved nutritive value because palatability of the hay was adversely affected by the deterioration.

The data for refused hay, Table 3, represents hay that was gleaned from the feeding area of stacks after the cattle had finished eating the stack. The important fact in these data is that ash content was not appreciably elevated over that of the core samples. This is interpreted to mean that the material collected did not contain large amounts of soil as contamination but rather reflected a reasonably accurate measure of hay lost by trampling.

Economic Comparisons

Data were assembled from the time and motion studies, hay analyses, and from equipment manufacturers. For each experiment, economic budgets were prepared for each item of equipment and for other items of cost. These data were then used in analyses of the various haying systems studied during 1970-71 and 1971-72.

The 1970-71 experiments involved one bale and one stack system for feeding steers. Equipment used and associated costs are

TABLE 4. ESTIMATED TOTAL HARVESTING AND FEEDING COST PER TON HARVESTED, FOR BALED AND STACKED HAY SYSTEMS, STEER FEEDING, BLACK BELT SUBSTATION, 1970-71

Haying system	Cost per ton, when average tons harvested per year are			
	250	500	1,000	2,000
Baled hay system	$21.44	$15.21	$12.09	$10.54
Stacked hay system	$16.05	$11.13	$ 8.68	$ 7.45

TABLE 5. ESTIMATED TOTAL FEED COST PER HUNDREDWEIGHT GAIN, FOR BALED AND STACKED HAY SYSTEMS, STEER FEEDING, BLACK BELT SUBSTATION, 1970-71

Item of cost	Cost per unit, when average tons harvested per year are			
	250	500	1,000	2,000
Baled hay system				
Total hay cost per cwt. gain[1]	$14.43	$11.42	$ 9.92	$ 9.18
Other feed cost per cwt. gain	9.10	9.10	9.10	9.10
Total feed cost per cwt. gain	$23.53	$20.52	$19.02	$18.28
Stacked hay system				
Total hay cost per cwt. gain[1]	$19.02	$15.21	$13.31	$12.37
Other feed cost per cwt. gain	10.80	10.80	10.80	10.80
Total feed cost per cwt. gain	$29.82	$26.01	$24.11	$23.17

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

listed in Appendix Table 1. Economic analysis indicated that harvesting and feeding costs per ton per year were less for the stack system than for the bale system, Table 4. When total feed costs per hundredweight gain were computed, however, the results were reversed and the bale system was least costly per ton per year, Table 5. This shift was mainly a reflection of feed efficiency differences. The stack system required an average of 1,547 pounds of hay per hundredweight gain as compared with 963 pounds for the bale system. The stack system also required more supplemental corn and cottonseed meal per hundredweight gain. The apparent reason for the higher hay requirement of the stack system was the high losses from trampling and spoilage when steers were allowed access to open stacks. Measures of such losses indicated an average loss of 41.7 percent for the stack system and 9.5 percent for the bale system. From the standpoint of tons per hour, the two systems were approximately equal.

CONDITIONS AND RESULTS, 1971-72

Machine Use and Time Requirements

Machinery use conditions for 1971-72 were somewhat different from the previous year, mainly because different machines were used for handling hay during the feeding trials.

Field practices used to cut, condition, and windrow hay were the same as for 1970-71. The stack system again included the StakHand 30 to handle hay from the windrow to the storage area. The bale system was the same as for 1970-71 except that the Stackcruiser 1047 was used to pick up and transport only part of

the hay and the Stackliner 1010 was used for the remainder. For machine capacities see Table 1.

Some changes were made in 1971-72 in handling hay for the feeding trials and in type of cattle fed. Both yearling steers and cow-calf units were used in tests with both bales and stacks. Line diagrams showing the machinery and feeding systems used are shown in Figure 4.

One bale method used for feeding steers utilized the Stackliner 1010 to retrieve bales from the storage site, transport to the feeding area, and deposit on the ground. Some difficulty was experienced in operating the machine while unloading bales into the storage stack pile. Bottom bales in the stack tended to pull out while unloading, so the bales in the stack were not well aligned vertically. This poor alignment interfered with normal machine operation when bales were retrieved for feeding. The Stackliner 1010 handles 55 bales per load, and for the test conditions 21 minutes were needed to retrieve and feed a ton of dry matter.

Another steer feeding trial used stacks and the StakFeeder 60 for comparisons with the bale method described. The machine was used to pick up a stack in the storage area, transport it to the feeding area daily, slice off part of the load, and deposit it on the ground for the steers. This method required 20 minutes to handle a ton of dry matter from storage stack through feeding.

The remaining two feeding trials compared conventional and mechanized feeding of cow-calf herds.

One of these was a bale haying method using a pickup truck and two men. Hay was loaded at the storage area, transported to the feeding area, and placed intact on the ground for animal consumption. Hauling distance was 0.9 mile. Approximately 550 pounds of dry matter were used at each feeding, thus requiring four feeding trips per ton. This bale method required 35 minutes to transport and feed 1 ton of dry matter.

The other method involved stack feeding using a StakMover 30 for a cow-calf herd. The StakMover 30 was used to pick up a stack at the storage area, transport to the feeding area, and unload the stack intact. Animals had free access to the stack after it was unloaded. Transport distance was 0.9 mile. Time to handle a ton of dry matter was 10 minutes.

Animal Feeding Trial Comparisons

Both baled and stacked hay were used in steer and cow-calf feeding trials.

Steer Feeding Trial. Two groups of yearling steers, one with 27 animals and the other with 28, were allotted to test in late fall. The feeding area and rotation of cattle on the area was the same as for the 1970-71 test. One group was fed stacked hay and the other got baled hay.

Hesston stacked hay was moved from a central storage area to the feeding area using a Hesston StakMover. The StakMover was equipped with a slicer which sliced the hay and dropped it to the ground as the equipment was pulled through the paddock area. In addition to the hay, which was offered to appetite, the steers received 1.5 pounds of cottonseed meal (41 percent) and 2 pounds of ground shelled corn daily per head.

The other group of steers was fed baled hay that had been stored in the open and covered with a tarpaulin. Bales with unbroken twine were placed in the sod area where the animals were confined. The hay was transported to the cattle using a New Holland 1010 bale wagon. In addition to hay fed to appetite, the steers were fed 1.5 pounds of cottonseed meal (41 percent) and 2 pounds of ground shelled corn daily per head.

Differences in nutritive value between the two kinds of hay were evaluated according to weight changes of the steers, hay intake, hay required per pound of gain, and chemical composition of the hay.

FIG. 10. Feeding bales with a bale wagon. Bales are discharged from the machine one at a time. Bale twine was not removed for feeding.

TABLE 6. FEEDING AND PERFORMANCE DATA FOR BALED VS. STACKED JOHNSONGRASS HAY FOR WINTERING YEARLING CATTLE, 1971-72

Item	Baled hay	Stacked hay
Animals, no.	28	27
Days on test, no.	120	120
Final live weight, lb.	567	566
Initial live weight, lb.	461	460
Gain, lb.	106	106
Average daily gain, lb.	0.88	0.88
Feed per animal[1]		
Hay, lb.	1,094 (939)[2]	1,560 (1,339)
Corn, lb.	240	240
Cottonseed meal, lb.	180	180
Daily feed offered per animal		
Hay, lb.	9.11 (7.82)	13.00 (11.15)
Corn, lb.	2.00	2.00
Cottonseed meal, lb.	1.50	1.50
Feed per cwt. gain		
Hay, lb.	1,032 (886)	1,471 (1,263)
Corn, lb.	226.4	226.4
Cottonseed meal, lb.	169.8	169.8
Feed cost per cwt. gain, dol.[3]	25.42	30.12

[1] Unbroken bales fed *ad lib.* on sod daily with New Holland 1010 bale wagon; Hesston stacks moved daily to the feeding area with StakFeeder 60 and sliced and distributed on the sod.

[2] Values in parenthesis are hay expressed as dry matter.

[3] Feed ingredient prices were, corn, $2.64 per hundredweight and cottonseed meal, $4.10 per hundredweight. Hay cost was calculated on the basis of an annual hay harvest and feeding of 500 tons (Appendix Table 4). Harvesting and feeding cost was $15.67 per ton for the bale system and $14.80 per ton for the stack system. In addition, hay production cost per ton was $8.53, the same for both systems.

Average daily gain per steer during the 120-day test was exactly the same for the two groups, 0.88 pound, Table 6. Animals fed baled hay consumed an average of 1,094 pounds, while those fed stacked hay consumed 1,560 pounds per animal. It required 1,032 pounds of baled hay and 1,471 pounds of stacked hay to produce 100 pounds of gain. Therefore, feed cost was higher for animals fed stacked hay than for those fed baled hay, Table 6.

Storage losses were estimated to be 15.03 percent for baled and 13.64 percent for stacked hay, Table 7. No important differences in chemical composition were found between the two kinds of stored hay, although dry matter digestibility was lowest for the Hesston stacks, Table 8.

Second-year test data showed no differences in steer gain for animals fed baled and stacked hay. This was in contrast to results from the previous year when animals fed baled hay gained 1.42 pounds per head daily while those fed stacked hay gained 1.19

TABLE 7. STORAGE LOSSES OF HAY FOR STEER FEEDING TRIAL, 1971-72

Item	Baled hay	Stacked hay
Stored		
Hay, air dry, lb.	39,507	52,935
Hay, dry matter, lb.	32,356	42,902
Moisture, pct.	18.10	18.95
Removed from storage		
Fed, air dry, lb.	32,023	43,150
Fed, dry matter, lb.	27,495	37,049
Moisture, pct.	14.14	14.14
Rotted hay dry matter, lb.	2,733	[1]
Total hay dry matter out of storage, lb.	30,228	37,049
Unaccountable hay dry matter, lb.	2,128	5,853
Losses		
Unaccountable hay dry matter, pct.	6.58	13.64
Rotted, pct.	8.45	[1]
Total loss, pct.	15.03	13.64

[1] Included with unaccountable dry matter loss.

pounds. This change between years is partly explained by differences in bale feeding methods. In the first year animals were fed baled hay in a rack, whereas in the second year the bales were fed on sod without the twine being broken. Daily feed consumption of baled hay was 13.6 pounds per steer the first year but only 9.11 pounds per head the second year.

Results from both years showed much higher hay requirement on stacked hay than for steers fed baled hay. Since storage losses were reasonably similar for the two kinds of hay, Table 7, the

TABLE 8. CHEMICAL COMPOSITION AND DIGESTIBILITY OF STEER HAYS AT INITIAL HARVEST AND AT TIME OF FEEDING, 1971-72

Item	Baled hay		Stacked hay	
	At harvest	At feeding	At harvest	At feeding
Crude protein, pct.	11.11	11.76	12.14	11.13
Van Soest values				
Cell wall constituents, pct.	85.81	86.06	83.47	79.91
Non-cell wall constituents, pct.	14.19	13.94	16.53	20.09
Ash, pct.	7.13	8.57	7.12	7.74
Calcium, pct.	0.55	1.14	0.49	0.99
Phosphorus, pct.	0.29	0.25	0.33	0.25
Potassium, pct.	0.81	0.72	0.87	0.76
Magnesium, pct.	0.13	0.15	0.15	0.17
Iron, p.p.m.	85.70	131.18	90.53	94.14
Manganese, p.p.m.	23.54	27.53	29.22	30.33
Zinc, p.p.m.	35.11	21.97	29.45	40.53
Copper, p.p.m.	19.55	15.35	6.59	17.00
Dry matter digestibility,[1] pct.	54.92	56.33	56.55	50.70

[1] By nylon bag technique.

major reason that more stacked hay was needed apparently was that more hay was trampled by the cattle than when baled hay was fed.

Brood Cow and Calf Wintering Test. Thirty-eight beef cows nursing fall and winter born calves were used in this study. These animals were allotted to two groups of 19 each, selected to minimize differences in age and date of calving. Average age of the calves was 26 days at the start of the test and 100 days when the experiment ended. The experimental design was a switchback whereby one group started on baled hay and the other group started on stacked hay. After 32 days the groups were switched. The feeding areas were dallisgrass sod pastures and the stocking rate was 1 cow and calf per 2 acres. The warm season sod pasture provided little, if any, food during the late fall and winter test season.

Data were collected on weight change in the animals, hay fed, storage losses for each of the two kinds of hay, wintering feed cost per cow, creep feed consumption by the calves, and chemical composition and digestibility of the hays.

Cows fed stacked hay lost less body weight than the cows fed baled hay, Table 9. Also, calves nursing cows on stacked hay gained slightly more than calves of the baled hay group. How-

TABLE 9. COW AND CALF WEIGHT CHANGE ON BALED OR STACKED HAY, 1971-72[1]

Item	Baled hay		Stacked hay	
	Trial 1	Trial 2	Trial 1	Trial 2
Cows, no.	19	19	19	19
Days, no.	32	32	32	32
Initial weight, lb.	945	941	979	908
Final weight, lb.	896	930	958	907
Gain or loss, lb.	—49	—11	—21	—1
Av. daily gain or loss, lb.	—1.53	—0.34	—0.66	—0.03
Average 2 trials				
Gain or loss, lb.	—30		—11	
Av. daily gain or loss, lb.	—0.94		—0.35	
Calves, no.	19	19	19	19
Days, no.	32	32	32	32
Initial weight, lb.	120	162	115	172
Final weight, lb.	157	211	149	235
Gain or loss, lb.	37	49	34	63
Av. daily gain or loss, lb.	1.15	1.53	1.06	1.96
Average 2 trials				
Gain or loss, lb.	43		48	
Av. daily gain or loss, lb.	1.34		1.51	

[1] Differences were significant and favored cows and calves fed stacked hay (for calves $P<0.05$, for cows $P<0.005$).

TABLE 10. COW EFFICIENCY FOR USE OF DRY MATTER FROM BALED AND STACKED HAY, 1971-72

Daily feed/animal	First trial[1]		Second trial[1]	
	Baled	Stacked	Baled	Stacked
Hay dry matter, lb.	23.17	35.28	19.26	27.80
Cottonseed meal, lb.	2.00	2.00	2.00	2.00
Hay ration dry matter as percent of live weight	2.52	3.64	2.06	3.06

[1] In the first trial stacks were fed without protection from trampling by the cows; in the second trial, panels were placed around the stacks.

ever, the major difference in calf gain was during the second trial when the calves fed baled hay gained 1.53 pounds per head per day and those on stacked hay gained 1.96 pounds.

In the first 32-day phase of the feeding trial the Hesston stacks were fed without protection from trampling, while in the second 32-day trial panels were placed around the stacks. Cows fed baled hay used less hay than those offered stacked hay, Table 10, mainly because the stacked hay suffered greater trampling loss. The use of panels appeared to reduce hay waste by trampling, but experimental data were insufficient to measure value of the panels. Cows consumed less hay during the second 32-day trial than in the first 32 days, but this was true for both baled and stacked hay. Consumption of hay ration dry matter in proportion to animal live weight averaged 2.29 percent for baled hay and 3.35 percent for stacked hay.

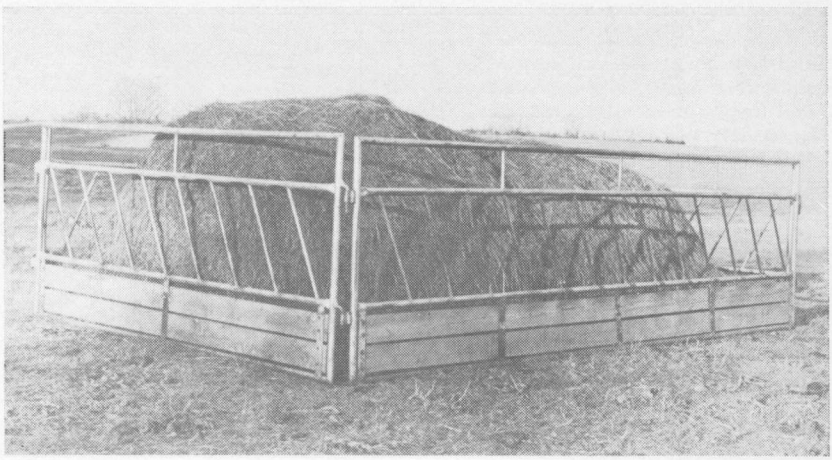


FIG. 11. Feeding panels were used in some feeding trials to help reduce hay waste. Panels are pushed in toward the stack by the animals as they eat.

Losses during storage were somewhat greater for stacked hay than for baled hay, Table 11. The difference was not very large, however, and results indicate that hay is reasonably well preserved either in conventional bales or in loose stacks. Hay needs per animal and winter feed cost per cow were greater for stacked hay than for baled hay, Tables 10 and 12.

Creep feed consumption was higher by calves nursing cows fed stacked hay than by those whose dams were on baled hay, Table 13. Since the cows and the calves remained in close vicinity of the stacks, the calves were always near the grain creep. In

TABLE 11. STORAGE LOSSES OF HAY FOR COW FEEDING TRIAL, 1971-72

Item	Baled hay	Stacked hay
Stored		
Hay, air dry, lb.	73,530	84,680
Hay, dry matter, lb.	58,818	68,612
Moisture, pct.	20.01	18.97
Removed from storage		
Fed, air dry, lb.	61,604	72,710
Fed, dry matter, lb.	52,815	58,540
Moisture as fed, pct.	14.27	19.49
Rotted hay dry matter, lb.	5,436	[1]
Total hay dry matter out of storage, lb.	58,251	58,540
Unaccountable hay dry matter, lb.	567	10,072
Losses		
Unaccountable hay dry matter, pct.	0.96	14.68
Rotted, pct.	9.24	[1]
Total losses, pct.	10.20	14.68

[1] Included with unaccountable hay dry matter losses.

TABLE 12. WINTERING FEED COST PER COW AND CALF, 1971-72

Item	Baled hay	Stacked hay
Hay cost as fed	$21.83	$25.68
Creep feed cost[1]	1.57	3.13
Cottonseed meal cost for cows[1]	5.50	5.50
TOTAL	$28.90	$34.31

[1] Cottonseed meal pellets @ $86 per ton; calf creep feed @ $78 per ton.

TABLE 13. CALF CREEP FEED CONSUMPTION WHEN DAMS WERE FED BALED OR STACKED HAY, 1971-72[1]

Item	Baled hay	Stacked hay
First trial, feed per calf, lb.	6.00	2.68
Second trial, feed per calf, lb.	34.26	77.70
Total per calf, lb.	40.26	80.38

[1] Creep feed formula: cottonseed meal 21 percent, ground corn 39 percent, dehydrated alfalfa 40 percent.

TABLE 14. CHEMICAL COMPOSITION AND DIGESTIBILITY OF COW HAYS AT INITIAL HARVEST AND AT TIME OF FEEDING, 1971-72[1]

Item	Baled hay		Stacked hay	
	At harvest	At feeding	At harvest	At feeding
Crude protein, pct.	8.87	9.35	8.19	8.89
Van Soest values				
Cell wall constituents, pct.	83.97	85.80	86.40	85.19
Non-cell wall constituents, pct.	16.03	14.20	13.59	14.81
Ash, pct.	7.29	7.94	6.49	7.96
Calcium, pct.	0.49	0.81	0.63	0.86
Phosphorus, pct.	0.25	0.23	0.26	0.26
Potassium, pct.	0.91	0.85	0.85	0.90
Magnesium, pct.	0.14	0.15	0.18	0.16
Iron, p.p.m.	94	92	81	74
Manganese, p.p.m.	29	34	23	30
Zinc, p.p.m.	37	41	13	18
Copper, p.p.m.	29	16	7	8
Dry matter digestibility,[2] pct.	52.74	49.80	54.15	47.97

[1] Analyses made on composites of two sampling periods.
[2] By nylon bag technique.

contrast, cows fed baled hay moved away from the feeding area so their calves did not continually stay near the grain creep. Consequently, calves nursing cows fed stacked hay were encouraged to consume more creep feed than were those in the baled hay feeding group.

Chemical composition data showed only small and unimportant differences between baled hay and stacked hay, Table 14. Dry matter digestibility was slightly lower in stacked hay. As shown by results of the cow feeding trial, the major difference between baled and stacked hay was that feeding losses were greater for the stacked hay.

Economic Comparisons

Based on the 1970-71 findings, seven systems were tested or synthesized for the 1971-72 season. Some of the seven were new systems, while others were variations of the two systems tested in 1970-71. One modification involved adding cow and calf wintering operations to accompany steer feeding. Another involved use of collapsible panels around stacks to reduce trampling. Others involved different items of equipment for moving and feeding bales and stacks. System 4 was synthesized. It assumed use of the StakFeeder 30 instead of the StakFeeder 60, but with the same time requirements. Items of equipment and costs for the different systems are listed in Appendix Table 3.

TABLE 15. ESTIMATED TOTAL HARVESTING AND FEEDING COST PER TON HARVESTED, FOR DIFFERENT FORAGE HARVESTING SYSTEMS, BLACK BELT SUBSTATION, ALABAMA, 1971-72

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

Harvesting and feeding costs per ton were generally lower for the stack systems than for the bale systems in 1971-72, except at low volumes of hay harvested per year for steer feeding using systems 1 and 2, Figure 4 and Table 15. When total costs per hundredweight gain and per cow and calf wintered were considered, however, results again favored the bale systems as in 1970-71. Reasons were the same—trampling and wastage resulted in more hay being required per hundredweight gain and per cow and calf wintered with the stack systems, Table 16 and Appendix Table 4.

It appears from the experiments over the 2 years that, if trampling and wastage of stacked hay could be reduced sufficiently, the stack systems tested would be the least costly methods of haymaking and feeding. Otherwise, losses from hay trampling and spoilage on heavy Black Belt soils can easily outweigh the cost economies of the stack systems. The collapsible panels used in one cow and calf wintering operation (System 7) reduced wastage considerably over the stack system without panels (System 6) and might provide a solution to the trampling and wastage prob-

lem. Trampling and wastage on lighter or sandy soil conditions would probably not be as serious as found in this experiment.

Relation of volume of hay handled to economics is an important consideration regardless of the system under consideration. For both steer feeding and wintering cows and calves, a certain minimum average amount of hay must be harvested per year to justify

TABLE 16. ESTIMATED TOTAL HAY AND OTHER FEED COST PER HUNDREDWEIGHT GAIN AND PER COW AND CALF WINTERED, FOR DIFFERENT SYSTEMS OF HAY HARVESTING AND FEEDING, 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[1]	$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	$12.28	$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	12.94	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 cow 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	$21.02	$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.

the investment required, Appendix Table 5. Unless a farmer can count on harvesting a high enough tonnage to make the mechanized systems economical, the investment probably could not be justified for any of the systems tested.

SUMMARY AND CONCLUSIONS

This project involved a 2-year comparison of a bale and stack system for handling and feeding hay. The study at the Black Belt Substation, using johnsongrass hay, involved four separate phases: (1) a time study to determine labor needs and machine capacity, (2) a chemical composition and nutritive value comparison of the hay, (3) feeding trials with steers and a cow-calf herd, and (4) a cost analysis.

The following general conclusions can be drawn:

1. Stacks stored outside and not covered had little weather damage (estimated at less than 5 percent).

2. Under the hauling and field conditions of this study, the two haying systems had about equal tons-per-hour capacity. Bale system capacity is greatly influenced by method of hauling bales to the storage area.

3. Handling hay from windrow to storage with the stack system has lower labor needs than the bale system.

4. No significant differences were found in the mineral content, crude protein, and cell wall and non-cell wall percentage of the hay after having been stored in bales or stacks.

5. Dry matter digestibility for the baled hay was higher than for stacked hay at time of feeding.

6. Hay wasted by animals was greater for stacked hay than for baled.

7. Hay waste from stacks fed free choice was reduced by using feeding panels around the stack.

8. Feed efficiency and cost per pound of gain favored the bale system in both steer feeding trials, even though cost per ton of hay harvested and fed was generally less for the stack systems.

9. In the tests with brood cows and calves, more hay was required and cow wintering cost was greater on the stacked hay. However, cow and calf performance was better on stacked hay than on baled hay.

APPENDIX

APPENDIX TABLE 1. ESTIMATED HARVESTING AND FEEDING COST PER TON HARVESTED, FOR BALED AND STACKED HAY SYSTEMS, STEER FEEDING, BLACK BELT SUBSTATION, 1970-71

Machine or item of cost	Cost per ton, when average tons harvested per year are			
	250	500	1,000	2,000
Baled hay system				
New Holland 1469 Haybine	$ 4.12	$ 2.56	$ 1.79	$ 1.40
Massey Ferguson rake	1.94	1.45	1.21	1.09
New Holland 277 baler	3.86	2.68	2.08	1.79
New Holland 1047 Stackcruiser	7.15	4.15	2.64	1.89
Tarpaulins and tiedowns	.73	.73	.73	.73
Hay racks for feeding	.53	.53	.53	.53
Fencing	.04	.04	.04	.04
Feeding labor	2.34	2.34	2.34	2.34
Pickup truck	.73	.73	.73	.73
Total harvesting and feeding cost	$21.44	$15.21	$12.09	$10.54
Stacked hay system				
Hesston 310 Windrower	$ 4.04	$ 2.56	$ 1.83	$ 1.46
Massey Ferguson rake	1.94	1.45	1.21	1.09
Hesston StakHand 30	7.92	4.97	3.49	2.75
Fencing (including labor)	2.15	2.15	2.15	2.15
Total harvesting and feeding cost	$16.05	$11.13	$ 8.68	$ 7.45

APPENDIX TABLE 2. ESTIMATED TOTAL HAY COST PER TON HARVESTED AND TOTAL FEED COST PER HUNDREDWEIGHT GAIN, FOR BALED AND STACKED HAY SYSTEMS, STEER FEEDING, BLACK BELT SUBSTATION, 1970-71

Item of cost	Cost per unit, when average tons harvested per year are			
	250	500	1,000	2,000
Baled hay system				
Total hay cost per ton harvested[1]	$29.97	$23.74	$20.62	$19.07
Total hay cost per ton dry matter harvested	38.26	30.30	26.32	24.34
Total hay cost per cwt. gain	$14.43	11.42	9.92	9.18
Other feed cost per cwt. gain	9.10	9.10	9.10	9.10
Total feed cost per cwt. gain	$23.53	20.52	19.02	18.28
Stacked hay system				
Total hay cost per ton harvested	$24.58	$19.66	$17.21	$15.98
Total hay cost per ton dry matter harvested	32.30	25.83	22.61	21.00
Total hay cost per cwt. gain	$19.02	15.21	13.31	12.37
Other feed cost per cwt. gain	10.80	10.80	10.80	10.80
Total feed cost per cwt. gain	$29.82	26.01	24.11	23.17

[1] Includes $8.53 per ton cost of producing hay as estimated at Black Belt Substation, as well as harvesting and feeding cost from Appendix Table 1.

APPENDIX TABLE 3. ESTIMATED HARVESTING AND FEEDING COST PER TON HARVESTED, FOR DIFFERENT FORAGE HARVESTING SYSTEMS, BLACK BELT SUBSTATION, ALABAMA, 1971-72

Machine or item of cost	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				
New Holland 1469 Haybine	$ 4.12	$ 2.56	$ 1.79	$ 1.40
Massey Ferguson rake	1.94	1.45	1.21	1.09
New Holland 277 baler	3.86	2.68	2.08	1.79
New Holland 1010 Stackliner (to storage and feeding)	5.41	3.63	2.74	2.30
Tarpaulins and tiedowns	.73	.73	.73	.73
Fencing	.04	.04	.04	.04
Total harvesting and feeding cost	$16.10	$11.09	$ 8.59	$ 7.35
System 2—steer feeding with New Holland 277 baler, 1010 Stackliner, and pickup truck				
New Holland 1469 Haybine	$ 4.12	$ 2.56	$ 1.79	$ 1.40
Massey Ferguson rake	1.94	1.45	1.21	1.09
New Holland 277 baler	3.86	2.68	2.08	1.79
New Holland 1010 Stackliner (to storage)	4.10	2.60	1.85	1.47
Pickup truck with 2 men (feeding)	.73	.73	.73	.73
Tarpaulins and tiedowns	.73	.73	.73	.73
Fencing	.04	.04	.04	.04
Feeding labor	2.34	2.34	2.34	2.34
Total harvesting and feeding cost	$17.86	$13.13	$10.77	$ 9.59
System 3—steer feeding with Hesston Model 30 StakHand and Model 60 Stak-Feeder				
New Holland 1469 Haybine	$ 4.12	$ 2.56	$ 1.79	$ 1.40
Massey Ferguson rake	1.94	1.45	1.21	1.09
Hesston Model 30 StakHand (to storage)	7.92	4.97	3.49	2.75
Hesston Model 60 StakFeeder (feeding)	5.64	3.31	2.14	1.55
Fencing	.06	.06	.06	.06
Total harvesting and feeding cost	$19.68	$12.35	$ 8.69	$ 6.85
System 4—steer feeding with Hesston Model 30 StakHand and Model 30 Stak-Feeder				
New Holland 1469 Haybine	$ 4.12	$ 2.56	$ 1.79	$ 1.40
Massey Ferguson rake	1.94	1.45	1.21	1.09
Hesston Model 30 StakHand (to storage)	7.92	4.97	3.49	2.75
Hesston Model 30 StakFeeder (feeding)	3.73	2.25	1.52	1.15
Fencing	.06	.06	.06	.06
Total harvesting and feeding cost	$17.77	$11.29	$ 8.07	$ 6.45
System 5—brood cows with calves with New Holland 277 Baler, 1047 Stackcruiser, and pickup truck				
New Holland 1469 Haybine	$ 4.12	$ 2.56	$ 1.79	$ 1.40
Massey Ferguson rake	1.94	1.45	1.21	1.09
New Holland 277 baler	3.86	2.68	2.08	1.79
New Holland 1047 Stackcruiser (to storage)	7.15	4.15	2.64	1.89
Pickup truck	.73	.73	.73	.73
Fencing	.04	.04	.04	.04
Tarpaulins and tiedowns	.73	.73	.73	.73
Feeding labor (2 men)	2.34	2.34	2.34	2.34
Total harvesting and feeding cost	$20.91	$14.68	$11.56	$10.01

(Continued)

APPENDIX TABLE 3 *(cont.)*. ESTIMATED HARVESTING AND FEEDING COST PER TON HARVESTED, FOR DIFFERENT FORAGE HARVESTING SYSTEMS, BLACK BELT SUBSTATION, ALABAMA, 1971-72

Machine or item of cost	Cost per ton, when average tons harvested per year are			
	250	500	1,000	2,000
System 6—brood cows with calves with Hesston Model 30 StakHand and Model 30 StakMover—open stacks				
New Holland 1469 Haybine	$ 4.12	$ 2.56	$ 1.79	$ 1.40
Massey Ferguson rake	1.94	1.45	1.21	1.09
Hesston Model 30 StakHand (to storage)	7.92	4.97	3.49	2.75
Hesston Model 30 StakMover (placed in area)	1.27	.73	.47	.33
Fencing	.06	.06	.06	.06
Total harvesting and feeding cost	$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				
New Holland 1469 Haybine	$ 4.12	$ 2.56	$ 1.79	$ 1.40
Massey Ferguson rake	1.94	1.45	1.21	1.09
Hesston Model 30 StakHand	7.92	4.97	3.49	2.75
Hesston Model 30 StakMover	1.27	.73	.47	.33
Collapsible panels for feeding	.42	.42	.42	.42
Fencing	.06	.06	.06	.06
Labor for handling panels	.23	.23	.23	.23
Total harvesting and feeding cost	$15.96	$10.42	$ 7.67	$ 6.28

APPENDIX TABLE 4. ESTIMATED TOTAL HAY COST PER TON HARVESTED AND PER TON FED AND TOTAL FEED COST PER HUNDREDWEIGHT GAIN AND PER COW AND CALF WINTERED, FOR DIFFERENT SYSTEMS OF HAY HARVESTING AND FEEDING, 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 ton harvested[1]	$24.63	$19.62	$17.12	$15.88
Total hay cost per ton dry matter harvested[1]	30.07	23.96	20.90	19.39
Total hay cost per ton fed[2]	30.38	24.20	21.11	19.59
Total hay cost per ton dry matter fed[2]	35.39	28.19	24.60	22.82
Total hay cost per cwt. gain	$15.57	$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 ton harvested	$26.39	$21.66	$19.30	$18.12
Total hay cost per ton dry matter harvested	32.22	26.45	23.57	22.12
Total hay cost per ton fed	32.55	26.71	23.80	22.35
Total hay cost per ton dry matter fed	37.92	31.12	27.73	26.03
Total hay cost per cwt. gain	$16.79	$13.78	$12.28	$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 ton harvested	$28.21	$20.88	$17.22	$15.38
Total hay cost per ton dry matter harvested	34.71	25.69	21.19	18.92
Total hay cost per ton fed	31.54	23.35	19.26	17.20
Total hay cost per ton dry matter fed	36.76	27.21	22.44	20.04
Total hay cost per cwt. gain	$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 ton harvested	$26.30	$19.82	$16.60	$14.98
Total hay cost per ton dry matter harvested	32.36	24.38	20.42	18.43
Total hay cost per ton fed	29.41	22.16	18.56	16.75
Total hay cost per ton dry matter fed	34.27	25.82	21.63	19.52
Total hay cost per cwt. gain	$21.64	$16.30	$13.66	$12.32
Other feed cost per cwt. gain	12.94	12.94	12.94	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 ton harvested	$29.44	$23.21	$20.09	$18.54
Total hay cost per ton dry matter harvested	36.69	28.92	25.03	23.10
Total hay cost per ton fed	35.14	27.70	23.98	22.13
Total hay cost per ton dry matter fed	40.85	32.21	27.88	25.73
Total hay cost per cow wintered	$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

(Continued)

APPENDIX TABLE 4 *(Cont.)*. ESTIMATED TOTAL HAY COST PER TON HARVESTED AND PER TON FED AND TOTAL FEED COST PER HUNDREDWEIGHT GAIN AND PER COW AND CALF WINTERED, FOR DIFFERENT SYSTEMS OF HAY HARVESTING AND FEEDING, 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 6—wintering brood cows with calves with Hesston Model 30 StakHand and Model 30 StakMover—open stacks				
Total hay cost per ton harvested	$23.84	$18.30	$15.55	$14.16
Total hay cost per ton dry matter harvested	29.00	22.26	18.92	17.23
Total hay cost per ton fed	26.69	20.49	17.41	15.85
Total hay cost per ton dry matter fed	34.26	26.30	22.35	20.35
Total hay cost per cow wintered	$38.67	$26.69	$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 cow 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 ton harvested	$24.49	$18.95	$16.20	$14.81
Total hay cost per ton dry matter harvested	30.79	23.82	20.37	18.62
Total hay cost per ton fed	30.03	23.23	19.86	18.16
Total hay cost per ton dry matter fed	35.72	27.64	23.63	21.60
Total hay cost per cow wintered	$31.78	$24.58	$21.02	$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.

[2] There was some loss of hay and dry matter between the time of storage and the time of feeding, which these figures reflect.

APPENDIX TABLE 5. ESTIMATED INVESTMENT REQUIRED FOR MAJOR HAY HARVESTING EQUIPMENT, DIFFERENT SYSTEMS OF HAY HARVESTING AND FEEDING, BLACK BELT SUBSTATION, 1971-72

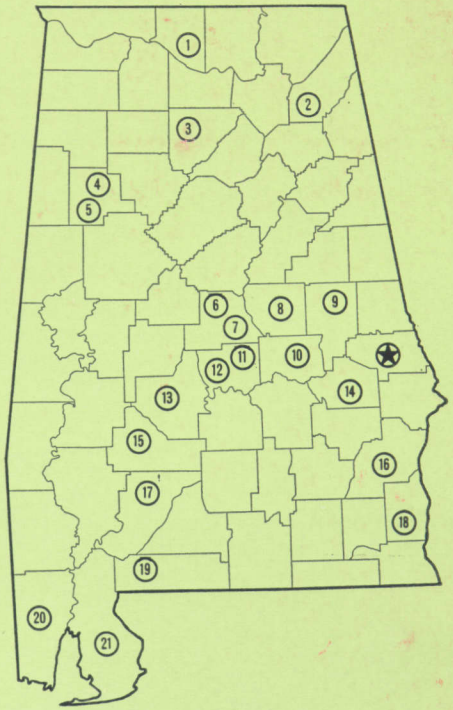
Equipment[1]	Initial new investment[2]
System 1	
New Holland 1469 Haybine	$ 5,572.30
Massey Ferguson rake	604.00
New Holland 277 baler	3,293.10
New Holland 1010 Stackliner	4,540.00
TOTAL	$14,009.40
System 2	
New Holland 1469 Haybine	$ 5,572.30
Massey Ferguson rake	604.00
New Holland 277 baler	3,293.10
New Holland 1010 Stackliner	4,540.00
TOTAL	$14,009.40
System 3	
New Holland 1469 Haybine	$ 5,572.30
Massey Ferguson rake	604.00
Hesston Model 30 StakHand	7,750.00
Hesston Model 60 StakFeeder	8,162.94
TOTAL	$22,089.24
System 4	
New Holland 1469 Haybine	$ 5,572.30
Massey Ferguson rake	604.00
Hesston Model 30 StakHand	7,750.00
Hesston Model 30 StakFeeder	4,845.00
TOTAL	$18,771.30
System 5	
New Holland 1469 Haybine	$ 5,572.30
Massey Ferguson rake	604.00
New Holland 277 baler	3,293.10
New Holland 1047 Stackcruiser	12.078.00
TOTAL	$21,547.40
System 6	
New Holland 1469 Haybine	$ 5,572.30
Massey Ferguson rake	604.00
Hesston Model 30 StakHand	7,750.00
Hesston Model 30 StakMover	1,995.00
TOTAL	$15,921.30
System 7	
New Holland 1469 Haybine	$ 5,572.30
Massey Ferguson rake	604.00
Hesston Model 30 StakHand	7,750.00
Hesston Model 30 StakMover	1,995.00
Collapsible panels (per 500 tons/year)	1,900.00
TOTAL	$17,821.30

[1] Does not include equipment such as tractors or pickup trucks, which an average farm might already have.

[2] Manufacturers suggested price plus transportation.

AGRICULTURAL EXPERIMENT STATION SYSTEM OF ALABAMA'S LAND-GRANT UNIVERSITY

With an agricultural research unit in every major soil area, Auburn University serves the needs of field crop, livestock, forestry, and horticultural producers in each region in Alabama. Every citizen of the State has a stake in this research program, since any advantage from new and more economical ways of producing and handling farm products directly benefits the consuming public.



Research Unit Identification

★ Main Agricultural Experiment Station, Auburn.

1. Tennessee Valley Substation, Belle Mina.
2. Sand Mountain Substation, Crossville.
3. North Alabama Horticulture Substation, Cullman.
4. Upper Coastal Plain Substation, Winfield.
5. Forestry Unit, Fayette County.
6. Thorsby Foundation Seed Stocks Farm, Thorsby.
7. Chilton Area Horticulture Substation, Clanton.
8. Forestry Unit, Coosa County.
9. Piedmont Substation, Camp Hill.
10. Plant Breeding Unit, Tallassee.
11. Forestry Unit, Autauga County.
12. Prattville Experiment Field, Prattville.
13. Black Belt Substation, Marion Junction.
14. Tuskegee Experiment Field, Tuskegee.
15. Lower Coastal Plain Substation, Camden.
16. Forestry Unit, Barbour County.
17. Monroeville Experiment Field, Monroeville.
18. Wiregrass Substation, Headland.
19. Brewton Experiment Field, Brewton.
20. Ornamental Horticulture Field Station, Spring Hill.
21. Gulf Coast Substation, Fairhope.