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R. Dennis Rouse, Director
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Hay in Round and Conventional Bale Systems

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HAY in ROUND and CONVENTIONAL BALE SYSTEMS

L. A. SMITH, W. B. ANTHONY, E. S. RENOLL, and J. L. STALLINGS[1]

HAY CONTINUES to be of major importance in most cattle operations in Alabama and many other southeastern states.

Increasing labor costs and difficulty in obtaining labor have kindled interest in the mechanization of baling, handling, storing, and feeding of hay. The Black Belt Substation has compared several systems of handling and feeding hay. One of these was a comparison of stack and bale systems. Results from this study are available in Auburn University Agricultural Experiment Station Bulletin 455 published in 1974. In a later study tests were carried out with large round and conventional bale handling and feeding systems. Results from this study are presented in this publication.

CONDITIONS OF THE TEST

This was a cooperative experiment among units of the Agricultural Experiment Station System of Auburn University including Departments of Agricultural Engineering, Animal and Dairy Sciences, Agricultural Economics and Rural Sociology, and the Black Belt Substation. Hay machines used in the study were manufactured by New Holland Division of Sperry Rand Corporation and Vermeer Manufacturing Company.

The study involved four separate phases; namely, a time study of the machines, a feeding trial, a chemical composition and nutritive value comparison, and a cost analysis.

Johnsongrass was cut with a self-propelled hay conditioner and raked into windrows after field curing. Hay yields in the test field

[1] Superintendent, Black Belt Substation; Professor, Department of Animal and Dairy Sciences; Professor, Department of Agricultural Engineering; and Associate Professor, Department of Agricultural Economics and Rural Sociology, respectively.

averaged 3,614 pounds of air-dry hay per acre. Alternate windrows were baled with a conventional baler and the large round baler.

Round bales were transported from the field to the storage area one at a time using a front-end tractor loader and a pickup truck. Round bales were stored outside and were not covered. The conventional bales were hauled to the storage area and covered with a tarpaulin.

A feeding trial was conducted using three groups of steers. One group was fed conventional bales and two groups were fed round bales, one using feeding panels, and one without.

The study was conducted on heavy clay soil in the "Prairie" soil area of Alabama.

MACHINERY COMPARISON

Hay in the conventional system was baled with a New Holland 277 baler and hauled with a New Holland 1047 Stackcruiser.[2] The Stackcruiser is an automatic self-propelled bale wagon that loads, hauls, and unloads 119 bales (14″ × 18″ × 36″). The hay was stacked outside on a dallisgrass sod and covered with a tarpaulin. Hauling distance was 1.4 miles from field to storage area.

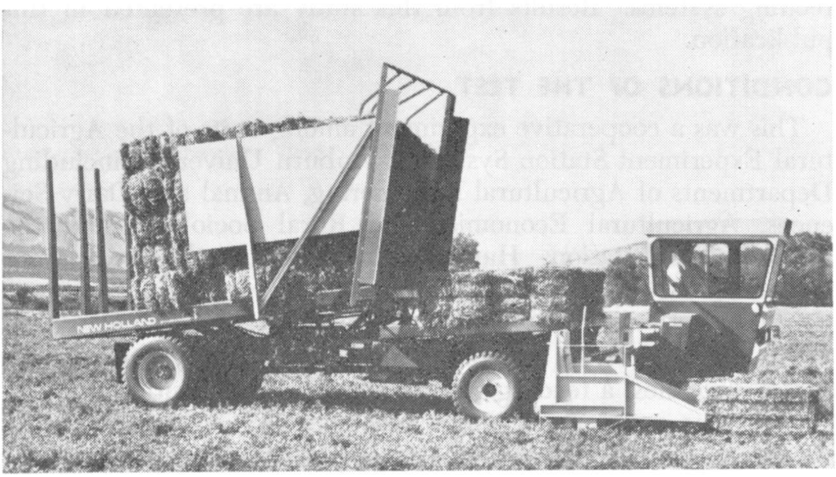


FIG. 1. The automatic bale wagon is one efficient system for handling conventional bales by reducing hand labor and increasing capacity.

[2] The use of commercial names is to help identify machine and does not imply endorsement of these machines over those of other manufacturers.

TABLE 1. BALE DIMENSION, WEIGHT, AND DENSITY

Item	Conventional	Round
Dimensions, in.	14 × 18 × 36.5	72.5 × 60
Average weight, lb.	46.5	930.7
Density, lb./cu. ft.	8.6	6.5

The large round bales were baled with a Model 605 Vermeer baler. This machine was operated from the PTO of a John Deere 4020 tractor (approximately 90 hp). This baler produces a cylindrical shaped bale approximately 6 feet in diameter and 5 feet wide. Twine is wrapped around the bale in a spiral pattern before the bale is discharged from the rear of the machine. Average weight of the johnsongrass hay bales was 930.7 pounds with the heaviest bale weighing 1,150 pounds, Table 1.

The round bales were loaded on a pickup truck with a tractor-mounted front end loader and hauled 1.4 miles to a central storage area. The round bales were stored about 1 foot apart on dallisgrass sod. They were not covered.

Machine capacity and man hours required for the two baling and handling systems are shown in Table 2. These data include total handling time from harvest to storage.

For the conventional bale system the baling rate was 5.2 tons per hour. Loading and hauling capacity was 4.9 tons per hour. Overall capacity for the conventional baling system was 4.5 tons per hour. A word of explanation about how the values were determined might be helpful.

Since loading and hauling cannot be completed until some time after baling is finished, the total accumulated clock time for baling, loading, and hauling is equal to the baling time plus sub-

TABLE 2. CAPACITY COMPARISON OF CONVENTIONAL AND LARGE ROUND BALE HANDLING SYSTEMS

Item	Conventional		Round	
	Tons/hr.	*Tons/man hr.*	*Tons/hr.*	*Tons/man hr.*
Baling capacity	5.2	----	5.9	----
Loading, hauling NH 1047[1]	4.9	----	----	----
Loading, hauling, pickup truck[1]	----	----	2.4	----
Baling, loading, hauling[2]	4.5	2.5	2.2	1.7

[1] Hauling distance is 1.4 miles.

[2] Required two men part of the time.

sequent loading and hauling time. For this reason the capacity of the total system is less than for either baling or loading and hauling.

In this conventional-bale haying system, one man operated the baler and one the loader. During part of the operation only one man worked and during the remainder the two men worked simultaneously. This system had a capacity of 2.5 tons per man hour.

The round baler baling rate was 5.9 tons per hour and the loading and hauling rate was 2.4 tons per hour. Production by the total round bale system was 2.2 tons per hour and 1.7 tons per man hour. The overall system baling rate was less than for baling or for loading and baling for the same reason as in the conventional-bale system. Two men were also used part of the time in this system.

Hay production for the total round bale system of 2.2 tons per hour in this study was rather low. The limiting factor being the pickup truck. This was not a very efficient way to transport round bales to storage, but was one fairly common method in use at the time. Capacity of the round bale system can be materially increased by using a larger truck or trailer where multiple bales could be hauled in one trip. In some instances it would be possible to store hay adjacent to the area being harvested, and bales could be hauled directly to the storage area with the tractor and front end loader.

For both of the haying systems under study, actual baling of hay and the loading and hauling were conducted simultaneously as much as possible.

CHEMICAL COMPOSITION AND DIGESTIBILITY

Hay samples were taken at time of baling and at time of feeding for chemical and nutritive value determination. Samples at feeding were obtained from conventional and round bales with a Pennsylvania State Hay Sampler. Each Vermeer bale was sampled at feeding and random samples were taken from the conventional bales. The hay was baled in early August, 1972, and was fed from November 8, 1972, to January 24, 1973. The digestibility of the samples was determined through the use of the nylon bag technique.

There were no major differences between conventional bales and round bales in crude protein, ash, or dry matter digestibility at time of baling, Table 3. By feeding time the percentages of

FIG. 2. Large round bales can be loaded on a truck or trailer for transport using a tractor equipped with a front-end loader or a rear-mounted loader. Capacity for the round baler system is greatly influenced by the bale transport system.

TABLE 3. CHEMICAL COMPOSITION AND DIGESTIBILITY OF JOHNSONGRASS HAY FOR TWO METHODS OF BALING

Item	Conventional bales		Round bales	
	At baling	At feeding	At baling	At feeding
	Pct.	*Pct.*	*Pct.*	*Pct.*
Crude protein	11.20	11.97	12.83	11.94
Ash	6.73	9.53	6.71	9.54
Dry matter digestibility	70.52	63.43	70.03	64.82

these three items had changed somewhat but again there were no major differences. Visually there appeared to be very little weather damage to the hay. Most damage appeared to occur where round bales were resting on the ground during storage.

FIG. 3. Hay quality can be maintained in round bales stored outside without cover. They should be stored at least a foot apart so each bale can shed water.

ANIMAL FEEDING TRIALS

Feeding trials using the hay from the two systems were conducted for a 79-day period during the winter of 1972-73. A group of 51 Angus-Hereford steers having an average weight of 537 pounds was divided into three lots of 17 animals each. Each lot was placed in a 7-acre pasture of fescue-dallisgrass. There was a minimum of grazing from these pastures, but the lots were rotated among the three pastures in order to minimize any pasture differences. A feeding panel or wood frame was used in one of the feeding trials to help control hay waste when feeding free choice. The three feeding trial treatment groups were:

1. Conventional bales fed daily on the sod without panels with bale ties intact.

2. Large round bales fed on the sod with no panels.

3. Large round bales fed on the sod with panels.

In all cases hay was fed free choice and weighed just prior to feeding.

In Treatment 2, round bales were fed one bale at a time. Time of consuming a bale varied from 2 to 5 days with the average time of consumption being 2.5 days per bale.

In Treatment 3, two bales were placed in panels except for a few instances when only one was added to facilitate steer rotation. Hay was fed for about 2 weeks on the same area before panels were moved to a new location. Time of consuming a bale varied from 3 to 8 days with the average time of consumption being 4.0

TABLE 4. DAILY FEED AVAILABLE FOR THREE HAY FEEDING SYSTEMS

Item	Daily feed per animal		
	Conventional bales on sod	Round bales on sod	Round bales with panels
	Lb.	*Lb.*	*Lb.*
Hay (as fed)	10.87	21.47	13.80
Hay (dm basis)*	9.11	19.13	12.29
Corn	2.00	2.00	2.00
CSM, 41%	1.50	1.50	1.50

* Dry matter basis.

days per bale. The tests were conducted on heavy clay soil, and, in times of high rainfall, muddy conditions existed where steers congregated.

In addition to hay, each treatment group of steers received 2 pounds of ground shelled corn and 1.5 pounds of cottonseed meal (41 percent) per head daily. Daily feed intake is presented in Table 4.

Steers receiving round baled hay in panels made better gains than the other two groups, Table 5. Those receiving round bales on the sod without protection were intermediate in gain and those on conventional bales gained least.

TABLE 5. STEER PERFORMANCE FOR THREE HAY FEEDING SYSTEMS

Item	Conventional bales on sod	Round bales on sod	Round bales with panels
Animals, No.	17	17	17
Days on test, No.	79	79	79
Initial average wt., lb.	535	538	538
Final average wt., lb.	615	635	646
Gain, lb.	80	97	108
Av. daily gain, lb.	1.01	1.23	1.37

Data in Table 6 clearly indicate that the use of panels with round bales under conditions of this test improved efficiency of hay utilization. Hay needed per 100 pounds gain was reduced 42 percent by using panels. Utilization of conventional bales on sod and round bales in panels was essentially the same.

TABLE 6. FEED EFFICIENCY FOR THREE HAY FEEDING SYSTEMS

Item	Feed required for pound of gain		
	Conventional bales on sod	Round bales on sod	Round bales with panels
	Lb.	*Lb.*	*Lb.*
Hay (as fed)	10.74	17.48	10.09
Hay (dm basis)	9.00	15.58	8.99
Corn	1.97	1.63	1.46
CSM, 41%	1.48	1.22	1.10

ECONOMIC COMPARISONS

Results from time and motion studies made by the Agricultural Engineering Department determined physical performance. Cost information on equipment was obtained from manufacturers and machinery dealers. Feeding trials and analysis were done by the Department of Animal and Dairy Sciences and the Black Belt Substation. Budgets were then prepared by the Department of Agricultural Economics and Rural Sociology for the following three harvest and feeding systems.

System I – New Holland 277 baler producing conventional bales; New Holland 1047 Stackcruiser for hauling conventional bales to storage; pickup truck used for feeding once a day; no panels.

System II – Vermeer 605 baler producing large-round bales; front-end loader and pickup truck for hauling round bales to storage; front-end loader and pickup truck for feeding free choice; no panels.

System III – Same as System II but using panels around bales to help control hay waste.

In Table 7, total costs per ton harvested and fed are computed for assumed average amounts of hay harvested per year ranging from 250 tons to 2,000 tons. These costs are based on budgets for the Black Belt Substation which harvests approximately 500 tons of hay per year and modified for various assumed tons per year. The total hay cost includes all costs of machinery, labor, and other costs in producing, harvesting, storing, and feeding the hay. It *does not* consider losses from feeding or by spoilage. These data show that total hay costs per ton harvested and fed were cheaper for System II, the large-round bale system without panels, than for the other two systems. The conventional bale system had the highest costs per ton in this test. However, cost data from Table 7 do not include hay utilization – only the costs involved in getting hay to the animal.

The total feed costs per hundredweight gain are presented in Table 8. These data include hay costs and other feed costs such as corn and cottonseed meal and *do* consider losses from feeding and by spoilage.

The data in Table 8 indicate a distinct advantage in total costs per hundredweight gain for System III, the large-round bale system with panels. System I, the conventional bale system, was second in cost and System II, the round bale system without panels, had the highest cost. The relative costs per hundredweight of gain occur in the same order as efficiency of feeding. Excessive hay wastage in System II resulted in poorer utilization and the highest cost per hundredweight gain in spite of the fact that it was the lowest cost system in terms of only costs of harvesting and feeding.

TABLE 7. ESTIMATED HARVESTING AND FEEDING COSTS PER TON HARVESTED FOR THREE SYSTEMS OF HANDLING HAY

Item	Cost per unit when average tons harvested/yr. are			
	250	500	1,000	2,000
	Dol.	*Dol.*	*Dol.*	*Dol.*
System I. NH 277 baler; NH 1047 Stackcruiser to Storage; Pickup for Feeding on Sod				
NH 1469 Haybine	$ 4.12	$ 2.56	$ 1.79	$ 1.40
Massey Ferguson rake	1.94	1.45	1.21	1.09
NH 277 Baler	3.86	2.68	2.08	1.79
NH 1047 Stackcruiser	7.15	4.15	2.64	1.89
Fencing	.04	.04	.04	.04
Tarps and tie-downs	.73	.73	.73	.73
Pickup truck	.73	.73	.73	.73
Hauling and feeding labor	2.34	2.34	2.34	2.34
Total harvesting and feeding costs	$20.91	$14.68	$11.56	$10.01
Growing costs	9.00	9.00	9.00	9.00
Total hay costs	$29.91	$23.68	$20.56	$19.01
System II. 605 Vermeer Baler; Front-end Loader; Pickup for Feeding; No Panels				
MH 1469 Haybine	$ 4.12	$ 2.56	$ 1.79	$ 1.40
Massey Ferguson rake	1.94	1.45	1.21	1.09
Vermeer 605 Baler	4.18	2.84	2.16	1.83
Tractor w/front-end loader	1.77	1.77	1.77	1.77
Pickup truck	.58	.58	.58	.58
Hauling and feeding labor	1.97	1.97	1.97	1.97
Total harvesting and feeding costs	$14.56	$11.17	$ 9.48	$ 8.64
Growing costs	9.00	9.00	9.00	9.00
Total hay costs	$23.56	$20.17	$18.48	$17.64
System III. 605 Vermeer Baler; Front-end Loader; Pickup for Feeding; Panels				
MH 1469 Haybine	$ 4.12	$ 2.56	$ 1.79	$ 1.50
Massey Ferguson rake	1.94	1.45	1.21	1.09
Vermeer 605 Baler	4.18	2.84	2.16	1.83
Tractor w/front-end loader	2.40	2.40	2.40	2.40
Pickup truck	.70	.70	.70	.70
Panels	.42	.42	.42	.42
Hauling and feeding labor	2.77	2.77	2.77	2.77
Total harvesting and feeding costs	$16.53	$13.14	$11.45	$10.61
Growing costs	9.00	9.00	9.00	9.00
Total hay costs	$25.53	$22.14	$20.45	$19.61

FIG. 4. Feeding round bales free choice requires some type of feeding frame or panel to prevent excess hay waste. These metal panels (top) are hinged in the middle and encircle the bale. Wooden frames (bottom) are pinned at the corners and one side is removed and the bale rolled in.

TABLE 8. TOTAL FEED COST PER HUNDREDWEIGHT GAIN FOR THREE SYSTEMS OF HANDLING HAY

Item	Cost per unit when average tons harvested/yr. are			
	250	500	1,000	2,000
	Dol.	*Dol.*	*Dol.*	*Dol.*
System I. NH 277 Baler; NH 1047 Stackcruiser; Pickup for Feeding on Sod				
Hay cost per cwt. gain	$16.14	$12.78	$11.09	$10.26
Other feed cost per cwt. gain	14.09	14.09	14.09	14.09
Total cost per cwt. gain	$30.23	$26.87	$25.18	$24.35
System II. 605 Vermeer Baler; Front-end Loader; Pickup for Feeding; No Panels				
Hay cost per cwt. gain	$20.70	$17.72	$16.24	$15.50
Other feed cost per cwt. gain	11.56	11.56	11.56	11.56
Total cost per cwt. gain	$32.26	$29.28	$27.80	$27.06
System III. Vermeer 605 Baler; Front-end Loader; Pickup for Feeding; Panels				
Hay cost per cwt. gain	$12.93	$11.21	$10.36	$ 9.93
Other feed cost per cwt. gain	10.37	10.37	10.37	10.37
Total cost per cwt. gain	$23.30	$21.58	$20.73	$20.30

CONCLUSIONS

Results from this test suggest the following conclusions:

1. Baling capacity with the large round baler was slightly higher than the capacity of the conventional rectangular baler, 5.9 tons per hour compared to 5.2 tons.

2. Conventional bales had higher density than large round bales, 8.6 pounds per cubic foot compared to 6.5 pounds per cubic foot.

3. There were no important differences in crude protein and dry matter digestibility of conventional and round bales at storage nor at time of feeding.

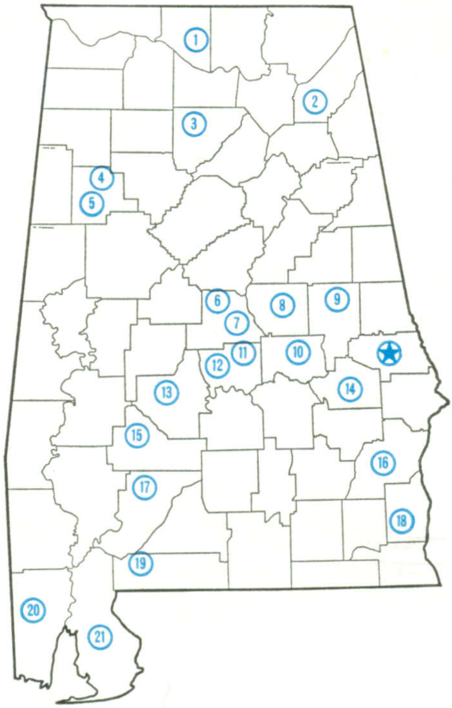
4. Hay dry matter per pound of gain was about the same with conventional bales on sod and round bales fed in panels, 9.00 pounds compared to 8.99 pounds. However, large round bales fed on sod without panels required 15.58 pounds dry matter per pound of gain. The amount of hay dry matter required per pound of gain was reduced by 42 percent by using panels with round bales.

5. The total cost of producing, harvesting, storing, and feeding hay favored the large round bale system.

6. The cost per pound of gain favored the large round bale system with panels.

Alabama's Agricultural Experiment Station System
AUBURN 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.