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Machine Systems for Transporting and Handling Large Round Bales

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Machine Systems for Transporting and Handling Large Round Bales

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INTEREST in large hay packages continues to grow among Alabama farmers. In an attempt to answer the many questions raised about these new haying systems, Auburn University Agricultural Experiment Station scientists and engineers have conducted a number of studies.

Results from a study involving loose stacks and conventional rectangular bales are available in Auburn University Agricultural Experiment Station Bulletin 455. A comparison of hay packaging systems using large round bales and conventional rectangular bales was conducted and results presented in Auburn University Agricultural Experiment Station Circular 216. The results of a study to examine some feeding procedures, machines used, and hay wasted were published in Agricultural Experiment Station Circular 238.

The large round bale system has many attractive features such as reduced labor needs. However, it also presents some problems since these bales weigh as much as 1,500 pounds.

The problem of transporting and handling bales includes such things as costs, labor needs, source of power, efficiency of operation, and size of machine. To help answer some of these problems, Auburn researchers conducted a series of studies; results are presented in this publication.

OBJECTIVES

The basic concern of the study was to examine large round bale transport systems and their associated problems. The specific objectives were as follows:

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1. To analyze capacity, speed of operation, labor needs, and economics of various machines or machine systems for handling round bales.
2. To better understand factors such as operator convenience, fatigue, ease of handling, and skill required to operate machines for handling round bales.

GENERAL TEST CONDITIONS

This was a cooperative experiment by several units of the Agricultural Experiment Station System of Auburn University including Departments of Agricultural Engineering, Agricultural Economics and Rural Sociology, and the Black Belt Substation. Farm machinery manufacturers, their technical representatives, and dealers also assisted with the project.

The machines were used to handle and to transport newly formed round bales from field to central storage. Data relating to machine performance with new bales on firm ground conditions were obtained. The machines were later used to handle and transport bales from the storage area to the feeding area. Data relating to machine performance with stored, weathered, and partially flattened bales under winter feeding conditions were also obtained.

Twine wrapped bales of johnsongrass hay, about 66 inches in diameter and 66 inches long, weighing 723 to 1,230 pounds were used in the study.

Input data such as capacity, labor needs, transport speeds in the field and on the road, bale loading and unloading time, bale alignment problems, machine function evaluation, and information necessary for an economic analysis were obtained. In addition, the machine operator was carefully observed to determine such things as ease of machine operation, operator convenience, line of sight problems, and amount of external aid or guidance needed during operation. The operator was asked to make his own observations relating to the machines.

MACHINES AND SYSTEMS USED

Ten machines capable of handling from one to four bales each were used in the study. They included four machines for handling single bales, three machines for handling two bales each, one machine for handling three bales, and two machines for handling four

TABLE 1. PURCHASE PRICE AND POWER SOURCES FOR TEN ROUND BALE TRANSPORT SYSTEMS

Machine system	Bales per load	Estimated average purchase price[1]	Power source
3-point hitch unroller	1	$ 600	Tractor
3-point hitch fork	1	275	Tractor
2-wheel self-loading trailer	1	600	Pickup truck
Front-end tractor loader	1	2,000	Tractor
Front and rear tractor loader	2	2,275	Tractor
Bale self-loader on pickup truck	2	1,850	Pickup truck
Dump bed on pickup truck	2	1,350	Pickup truck
Multi-bale hauler	3	3,700	Tractor
Multi-bale hauler	4	4,600	Tractor
Multi-bale hauler	4[2]	5,000	Tractor

[1]Actual cost for a specific machine of the same type might be more or less.
[2]Machine is listed as a 5-bale hauler by the manufacturer when hauling 60-inch bales. In this study 66-inch bales were used, thus the 4 bales per load.

bales each. Table 1 lists the machines with their power source, bales per load, and approximate purchase price.

RESULTS

Results from the study are presented under three general categories. These include machine capacity and performance, economic evaluation and comparison, and machine or system problems.

Capacity and Performance

Table 2 shows machine performance as measured in bales per hour and tons per hour for 1,000-pound bales. This table also shows labor needs. Data for table 2 were obtained for newly formed bales. This included picking up the bales where the baler had dropped them in the field, transporting them to a central storage area, and unloading them. Values in the table are for a 1-mile transport distance and a machine efficiency of 85 percent.

Transport capacity when hauling these new bales ranged from 3.9 to 14.8 bales per hour. As might be expected, the 4-bale haulers had greatest capacity and single-bale machines the least. In general, the 2-bale haulers had about twice the capacity of 1-bale haulers.

Some of the machines were also used to handle bales at a field storage area to evaluate machine performance when handling weathered bales in wet field conditions. Several problems were

TABLE 2. CAPACITY OF TEN ROUND BALE TRANSPORT SYSTEMS HANDLING NEWLY FORMED BALES[1]

Machine system	Bales per trip	Bales per hour (85% efficiency)[2]	Tons per hour Using 1,000 lb. bales (85% efficiency)	Manpower needs
3-point hitch unroller	1	4.3	2.15	1
3-point hitch fork	1	4.8	2.4	1
2-wheel self-loading trailer	1	3.9	1.95	1
Front-end tractor loader	1	4.8	2.4	1
Front and rear tractor loader	2	8.2	4.1	1
Bale self-loader on pickup truck	2	10.6	5.3	1
Dump bed on pickup truck[3]	2	10.0	5.0	1
Multi-bale hauler	3	12.0	6.0	1
Multi-bale hauler	4	14.8	7.4	1
Multi-bale hauler	4	14.8	7.4	1

[1]New bales picked up in the field.
[2]Assuming an operation efficiency of 85 percent and a haul distance of 1 mile.
[3]Bales loaded onto the truck with front tractor loader.

encountered. Field stored bales are frequently wet on the bottom and generally are also flat-bottomed. Both of these conditions tend to make weathered bales more difficult to pick up than new bales.

Wet and muddy ground conditions sometimes caused traction problems making it difficult to maneuver the machines into cor-

FIG. 1. Rear-mounted 1-bale hauler on a farm tractor. Additional front-end weight should be used to counterbalance the bale.

FIG. 2. Low-cost single-bale hauler. Trailer requires some hand labor for loading and can be pulled by a truck or tractor.

rect position to pick up the bale. This was true for both the tractors and trucks.

Table 3 shows ground speed for empty and loaded machines for both road and field transport conditions. Also shown are loading and unloading time.

In these studies, ground speeds ranged from 5.0 mph to 22.5 mph for loaded machines and from 6.0 mph to 23.5 mph when empty. Road speeds were faster than field speeds. In general the

TABLE 3. GROUND SPEEDS AND LOADING TIMES FOR TEN ROUND BALE TRANSPORT SYSTEMS

Machine system	Bales per load	Machine ground speed				Machine time	
		Empty		Loaded		Loading	Unloading
		Field	Road	Field	Road		
		(mph)	(mph)	(mph)	(mph)	(min)	(min)
3-point hitch unroller	1	7.5	13.5	6.5	13.5	0.4	0.6
3-point hitch fork	1	7.5	13.5	7.0	13.5	0.3	0.2
2-wheel self-loading trailer	1	9.5	19.0	9.0	19.0	3.3	2.0
Front-end tractor loader	1	9.0	14.0	7.0	10.5	0.4	0.3
Front and rear tractor loader	2	8.5	14.5	7.0	12.5	1.1	1.0
Bale self-loader on pickup truck	2	17.0	23.5	15.0	22.5	1.9	2.0
Dump bed on pickup truck	2	9.5	19.5	9.5	19.5	1.8	1.0
Multi-bale hauler	3	7.0	18.5	7.0	13.5	2.6	1.7
Multi-bale hauler	4	6.0	19.5	5.0	11.0	1.6	1.4
Multi-bale hauler	4	8.0	12.5	7.5	12.0	2.0	0.6

machines used with a pickup truck traveled at faster ground speeds than those propelled with a tractor. In a few instances, travel speed for the machine was the same when loaded as when empty.

Economic Comparisons

Estimated costs per ton for transporting round bales for the ten systems studied are found in table 4. Costs were determined for six different yearly volumes ranging from 25 to 1,000 tons.

The 1-bale systems are generally cheaper for small operations. They utilize low-cost equipment on a truck or tractor that many farmers already have. The exception is the front-end loader and even this cost could be reduced by spreading its use over non-hay operations. In this economic analysis, all fixed costs for special equipment were charged only for the hay operation. The lowest cost system, the 2-wheel self-loading trailer and pickup truck, had a cost of $4.78 per ton for 25 tons per year and $2.52 for 100 tons per year. Corresponding costs for the most expensive system, the front tractor loader, were $14.16 and $5.99, respectively. As indicated, using a pickup truck tended to reduce the cost. This is

FIG. 3. Pickup truck equipped with mechanism to self load and unload round bales. Operator controls are located in the cab.

TABLE 4. ESTIMATED COST PER TON FOR TEN ROUND BALE TRANSPORT SYSTEMS HANDLING VARIOUS AMOUNTS OF HAY PER YEAR[1]

Machine system	Bales per trip	Tons per year[2]					
		25	50	100	250	500	1,000
3-point hitch unroller	1	$ 7.30	$ 5.79	$5.04			
3-point hitch fork	1	5.25	4.59	4.25			
2-wheel, self-loading trailer	1	4.78	3.27	2.52			
Front-end tractor loader	1	14.16	8.71	5.99			
Front and rear tractor loader	2	14.11	7.90	4.94	3.11		
Bale self-loader on pickup truck	2	10.72	5.73	3.24	1.74		
Dump bed on pickup truck	2	19.84	10.76	6.22	3.51		
Multi-bale hauler	3	21.85	11.71	6.65	3.61	2.59	2.09
Multi-bale hauler	4	27.04	14.19	7.76	3.90	2.62	1.97
Multi-bale hauler	4	29.07	15.20	8.26	4.10	2.72	2.02

[1]Cost determined using recommendations from ASAE Agricultural Machinery Management Data D 230.2 and the following assumptions: Labor $3.00 per hour, diesel 45 cents per gallon, gasoline 50 cents per gallon, tractor annual use of 600 or 700 hours depending on size, and pickup truck annual use of 15,000 miles and haul distance of 1 mile from field to storage area.

[2]1-bale systems not feasible for handling above 100-125 tons per year due to time required. Top limit for 2-bale system is about 250 tons per year for same reason.

because truck fixed costs are spread over many miles of use for many purposes compared with tractors. The pickup truck also involves less labor.

In the 2-bale operations, the self-loading system on a pickup truck shows a sizable cost advantage over the other two 2-bale systems. The self-loading pickup truck system had a cost of $5.73 per ton when handling 50 tons per year and $1.74 when handling 250 tons. The lower cost per ton results from its lower initial purchase price and higher capacity when compared to the other 2-bale systems. For the highest cost system, the dump bed on a pickup truck, the costs were $10.76 and $3.51 per ton. Here again, the special equipment fixed costs in the 2-bale operations were all charged to the hay enterprise. If these items of equipment are on a farm where they could be used for non-hay operations, costs for these operations would be reduced.

The 3- and 4-bale systems are definitely for larger operators. Costs per ton generally do not start to compete with the 1-bale system until the volume exceeds 100 tons per year. Potential for cost savings increases as volume per year gets larger. For hay production of 250 tons per year and over, the costs are not significantly different for the 3- and 4-bale systems. Factors other than cost would determine the choice between these systems.

Machine Operation Comments

The following comments relating to field operation of the machines during the studies were derived from field results and observations and from operator comment.

When using a 3-point hitch unroller for bale transport it is important that the cone-pointed squeeze bars clamp the bale slightly above the middle. If this is not done some bales tend to rotate after being picked up, allowing the bales to drag on the ground causing the twine to come off and hay to be lost.

The hand operated 2-wheel self-loading trailer required the greatest amount of loading time and a considerable amount of physical labor.

Transporting bales with a front-end loader should be done with care. The tractor can become very unstable and bales can fall off the loader arms. Operator line of sight may also be obstructed.

When unloading bales with the self-loading pickup truck at the storage area it was somewhat difficult to get bale spacing and alignment correct without jockeying for correct position.

Bale spacing and correct row alignment were difficult when unloading bales from a pickup truck dump bed. When unloading

FIG. 4. Bale transporter hauling four bales. Machine loads and unloads bales one at a time.

bales to the rear from the trailer multi-bale loaders it was difficult for the operator to see over the bales and determine where the first bale would be discharged.

With the 3- and 4-bale machines, accidental breaking or partial removal of the twine occurred during loading and unloading. This resulted in some hay loss.

When retrieving bales from the storage area during wet winter ground conditions it was sometimes difficult to maneuver the machine into the correct position to pick up the bale.

When transporting field stored bales some hay fell from the bales and was lost enroute to the feeding area. This was especially true for bales handled by machines that rotate them 90 degrees during loading and transport them on end.

Safety and Bale Handling

Handling and transporting round bales should always be done with care. A number of accidents have occurred as a result of 1,000- to 1,500-pound round bales falling from the loading mechanism and striking or rolling over someone. Handling round bales with a front-mounted loader can be dangerous. If a front-mounted loader is used, add weight to the rear of the tractor to improve stability and traction. Keep the bale low and the tractor speed slow. If possible, use a tractor with wide front wheel spacing. Avoid use of front-end loaders on steep field slopes.

For front bale hauling, use a tractor equipped with an operator protective frame or safety cab to protect the operator from bales that might accidentally fall from the loader arms. Pay extra attention to front tire condition and inflation. These big bales place additional weight on the front tires which can cause tire failure and may result in an accident.

Many large farm operators handle bales with a self-loading wagon or hauler pulled behind the tractor. Slow transport speeds are also important here. A tractor with enough weight and braking power to safely handle the heavy load should be used.

CONCLUSIONS

The following conclusions can be drawn from these studies:

1. The 1-bale transport machines had an average capacity of 2.2 tons per hour when transporting bales 1 mile. These 1-bale systems

appear to be reasonable for the operator handling 100 to 125 tons per year or less.

2. The 2-bale systems had an average capacity of 4.7 tons per hour and were powered by either a tractor or pickup truck. The pickup truck is better adapted to longer transport distances. A 2-bale system can be efficiently used for handling 50 to 250 tons per year.

3. The 3-bale and 4-bale transport systems had an average capacity of 7.0 tons per hour. All of these systems were powered by the tractor. These multi-bale systems are best suited for 250 tons per year and up. The cost per ton for these machines is about $2.00 for an annual production of 1,000 tons.

4. The pickup truck is more comfortable than a tractor for transporting bales during wet, cold winter conditions. Under wet, muddy ground conditions or heavy snow, traction can be a problem with the truck even with 4-wheel drive.

5. Maneuvering the transport machines to pick up round bales under the wet and muddy ground conditions in the field storage area presented problems.

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Machines illustrated are examples of some used to handle round bales. Such illustration does not constitute endorsement by the Alabama Agricultural Experiment Station.