August 2017

Harvesting alfalfa with a windrow pick-up bale

J. Brownlee Davidson  
Iowa State College

William H. Carter  
Iowa State College

Follow this and additional works at: http://lib.dr.iastate.edu/bulletin
Part of the Agriculture Commons, and the Bioresource and Agricultural Engineering Commons

Recommended Citation
Available at: http://lib.dr.iastate.edu/bulletin/vol28/iss322/1

This Article is brought to you for free and open access by the Extension and Experiment Station Publications at Iowa State University Digital Repository. It has been accepted for inclusion in Bulletin by an authorized editor of Iowa State University Digital Repository. For more information, please contact digirep@iastate.edu.
Harvesting Alfalfa with a Windrow Pick-up Baler

By J. BROWNLEE DAVIDSON and WILLIAM H. CARTER

Agricultural Experiment Station
Iowa State College of Agriculture
and Mechanic Arts

R. E. BUCHANAN, Director
Agricultural Engineering Section
AMES, IOWA

Windrow Pick-up Baler in Field
SUMMARY

EXCELLENT quality hay may be made with the windrow pick-up baler.

A windrow pick-up baler, operated at Iowa State College during the haymaking season of 1933, showed an average capacity of 1.59 tons of alfalfa per hour and a labor requirement of 2.52 man hours per ton. After the operators had developed some skill, the capacity of the machine in baling one crop from a field was increased to 3 tons per hour, and the labor expenditure lowered to 1.35 man hours per ton.

It was found in the tests that efficiency in the operation of the baler is largely dependent upon two factors: (1) a windrow of sufficient size to furnish hay at a rate near the capacity of the machine but not so fast as to necessitate stops, and (2) the skill of the operators, particularly of the feeder and the bale tier.

Owners of three machines of a similar size to the one used in these tests reported an average capacity of 2.75 tons of alfalfa and 2.3 tons of straw per hour.

An estimate of the cost of baling when 1.59 tons per hour were baled was $2.17 per ton. Increasing the capacity to 2.75 tons per hour lowered the estimated cost to $1.42 per ton.

An average of 4.5 horsepower was required from the power take-off of the tractor to operate the baler. A draw-bar pull of 850 pounds was required to draw the baler on level ground.

In operating the baler an independent clutch for the power take-off would be very convenient. An auxiliary engine to operate the baler would furnish the same advantages.

Hay baled directly from the windrow will store satisfactorily if the water content is sufficiently low. Hay containing as much as 23 percent moisture can be baled with reasonable safety, although under some conditions there might be sufficient heat developed to result in a loss of color and a lowering of the grade. The windrow pick-up baler presents a good opportunity for saving a large proportion of the leaves of the alfalfa plant.
Harvesting Alfalfa With a Windrow Pick-up Baler

By J. Brownlee Davidson and William H. Carter

The windrow pick-up baler, also called the hay press combine, is a new machine recently offered to alfalfa growers by farm equipment manufacturers. As it is drawn through the field by a tractor, the cured alfalfa is gathered direct from the windrow and baled.

This bulletin reports the data and experience obtained by operating one of these machines in harvesting three cuttings of alfalfa during 1933.

EARLY MACHINES OF THIS KIND

The windrow pick-up baler should perhaps not be termed a new machine, for similar homemade combine outfits have been in use for several years.

From 1926 to 1929 the Iowa Agricultural Experiment Station conducted investigations into economical methods of harvesting cornstalks for industrial purposes. To aid in this study, combinations of several machines were made. They included a mower for cutting the stalks loose, a hayloader for raking the stalks and delivering them to the baler, and a baler driven by a power take-off shaft from the tractor which pulled the entire combination through the field. Several forms of this combination were also tried, including a self-propelled baler equipped with a power-driven motor attachment.

Other combined outfits were subsequently developed and used for harvesting alfalfa from the swath and windrow and for the baling of straw left in the field after a harvester-thresher, combine. And they have been found very successful in reducing the hours and the difficulty of the labor required. Alfalfa growers who have made such combinations report them to be economical and satisfactory.

1 Project No. 344 of the Iowa Agricultural Experiment Station.
2 The authors acknowledge the valuable assistance received from E. R. Henson and J. C. Eldredge, of the Farm Crops Subsection of the Iowa Agricultural Experiment Station, under whose direction the alfalfa was harvested. The authors also acknowledge assistance received from the J. I. Case Company, of Des Moines, Iowa, and the Ann Arbor Machine Company, of Shelbyville, Ill.
3 The windrow pick-up baler used in the tests reported in this bulletin was obtained from the J. I. Case Company, of Des Moines.
The "new" windrow pick-up baler shows many improvements over the old combinations. It has the advantage of coordinated design and special development in the drive and feeding arrangements. Other important changes include the use of a pick-up attachment similar to those used with combined harvester-threshers for picking up windrowed grain. At least two manufacturers are making windrow pick-up balers at the present time.

INVESTIGATING THE WINDROW PICK-UP BALER

The information and data reported in this bulletin were obtained from the operation of a windrow pick-up baler in harvesting the three cuttings of two fields of alfalfa during 1933. These fields—one 23 acres and the other 52—were located near Ames, Iowa, and represented normal field conditions. The 52-acre field had been seeded in the spring of 1932 and the 23-acre field in 1930. In the latter field the presence of much bluegrass not only lowered the quality of the hay but also made the mowing of the first cutting difficult. The topography of the fields was gently rolling, with no steep grades. The soil was a black silt loam, largely of the type known as Webster silt loam.

In addition to the data obtained in the study, information concerning the operation of an assembled outfit which has been in use for several years was supplied by the owner. A number of owners of windrow pick-up balers in Iowa and other states also gave results with their machines.

Before using the windrow pick-up baler, mowers and rakes were used to mow the alfalfa and rake it into windrows. The operation of these machines, however, will not receive detailed consideration here.

THE EQUIPMENT USED

The machine used in the field tests was a 14x18 baler of the plunger type mounted on a two-wheel truck. A windrow pick-up attachment was mounted on the right side of the machine and driven by power received from one of the truck wheels. The pick-up attachment delivered the hay to a hopper equipped with a conveyor bottom for carrying the hay over the receiving chamber of the baler proper. The conveyor was controlled...
by a clutch for stopping the feed while division blocks, for separating the bales, were placed in the machine.

Power for the operation of the baler was delivered to the baler from the tractor by a power take-off of the standard speed and design. The baler complete weighed 5,395 pounds.

The tractor which furnished the power for the tests was a general purpose type of 27 horsepower, weighing 4,240 pounds and having field speeds of 2.63, 3.75 and 5.14 miles per hour.

Equipment for handling the baled hay will be described later.

**ORGANIZATION OF THE LABOR**

Three men are normally required to operate the windrow pick-up baler in addition to the tractor operator—one man to feed the hay to the baler, one man to thread and tie the bale ties and one man to return the ties and place the division blocks. Although the feed is operated automatically, it was not found practicable to dispense with the feeder. It was observed, as set forth more definitely later, that the capacity of the machine varied very much as the skill of the operators developed with experience. This is particularly true of the
Fig. 2. An early cornstalk field-baling outfit. Cornstalks were mowed, gathered and baled. Four operators were required.

bale tier whose skill largely determines the output of the machine. If the bale tier can ably handle his work, the feeder largely determines the rate of baling.

It is to be noted that there were no arduous tasks connected with the operation of the baler.

FACTORS DETERMINING RATE OF BALING

Experience in operating the windrow pick-up baler has shown that the capacity of the machine depends upon a number of factors which must be well coordinated to attain maximum output. The most important of these factors are:

1. A windrow of hay as large as can be handled without choking the machine.
2. Skill in feeding the machine so as to reduce to a minimum the time needed to place the division block and to make a bale with the minimum number of strokes of the baler plunger.
3. Ability to thread and tie the bale ties without loss of time.

Results of Tests of Rate of Baling

Numerous tests were made to determine the most practicable rate of baling. In 36 individual runs varying from 2 to 50 minutes, the number of bales tied per minute varied from 7/10 of one bale to 2.6 bales per minute, with an average of
1.22 bales. A limitation of one or more of the three principal factors mentioned above was effective in most instances in reducing the capacity of the machine.

If the average weight of bales is considered as 75 pounds, the tests indicate an hourly rate of baling from 1.6 tons to 5.1 tons for short periods. The maximum capacity of 5.1 tons was attained in only one instance for 6 minutes through a series of large charges. It was found practicable to make a bale with 12 strokes of the plunger. In addition one idle stroke is needed to clear the chamber at the time a division block is placed. If this idle stroke is omitted, the ends of the bales will not be even, and the damage to the blocks will be excessive because the blocks occasionally are not placed on the bottom of the chamber.

Upon the foregoing basis of a total of 13 strokes per bale, it is possible to estimate the maximum capacity of the machine. The baler at normal operating speed makes 27 strokes per minute; if 13 strokes are required per bale, a bale could be formed in .48 minutes or at the rate of 4.7 tons per hour, a rate slightly less than the rate actually attained in a short run of 6 minutes by extra large charges.

A tractor traveling 2.63 miles per hour, the low speed of the tractor used in the tests, moves 229 feet per minute or 109 feet in .48 minutes, the minimum time required to make a bale.

**Size of Windrow**

This analysis of baling capacity was fully checked in 22 separate trials with windrows of various sizes. Bales were successfully made with a travel of the baler varying from 96 to 123 feet. A travel of about 115 feet was the most desirable. These trials revealed that windrows requiring more than 123 feet were definitely too light and those requiring less than 100 feet resulted in frequent stops and delays.

The making of windrows of the correct size was fully demonstrated to be a most important factor in operating efficiency. Hay cannot be baled any faster than it can be gathered by the machine; on the other hand, if the hay is gathered faster than it can be baled, there are frequent stops and delays.
Skill of Operators

The skill of the operators, particularly the bale tier, was the limiting factor at the beginning of the tests. At first the tier found it impossible to tie more than 60 bales per hour, but after several days he was able to take care of more than 100 bales per hour—when the rate of tying no longer became a limiting factor. Various methods of making knots or splices in the bale ties are in use, but in the tests reported a hard knot was found to be simpler and quicker than the threading of the end of the tie through the eye and twisting.

The crew operating the baler was in the beginning inexperienced, a condition which should be accepted as a natural situation. The influence of skill upon rate of baling is brought out by the investigations.

Table 1 gives the actual record of the rates of baling for the season.

<table>
<thead>
<tr>
<th>Run</th>
<th>Dates</th>
<th>Total time in field</th>
<th>Actual time in operation*</th>
<th>Total acres</th>
<th>Total tons</th>
<th>Tons per hour**</th>
<th>Man hours per ton</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>6/17-20</td>
<td>21 18</td>
<td>52 31</td>
<td>1.45</td>
<td>2.75</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>6/22-23</td>
<td>14 36</td>
<td>22 26.5</td>
<td>1.82</td>
<td>2.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>7/20-25</td>
<td>17 50</td>
<td>50 27.4</td>
<td>1.53</td>
<td>2.6</td>
<td>(2.19)</td>
<td>(1.82)†</td>
</tr>
<tr>
<td>D</td>
<td>7/27-28</td>
<td>2 10</td>
<td>5 3.3</td>
<td>1.53</td>
<td>2.62</td>
<td>(3.00)</td>
<td>(1.35)‡</td>
</tr>
<tr>
<td>E</td>
<td>7/27-28</td>
<td>7 48</td>
<td>18 12.8</td>
<td>1.64</td>
<td>2.44</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Average</td>
<td></td>
<td></td>
<td>1.59</td>
<td>2.52</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Actual time in operation obtained by service recorder mounted on baler which recorded actual time machine was in motion.
**Item in col. 7 equals item in col. 6 divided by item in col. 3.
† Two acres in field not included in record.
‡ The numbers inclosed in the parentheses indicate the time in actual operation.

As may be expected, the rate of baling for the season is much lower than the capacity for short periods. The actual average capacity for the season was 1.59 tons per hour or 34 percent of the theoretical capacity. In one field a capacity of 2.62 tons
per hour was obtained for the actual time in operation. In the operation of a complicated machine of the character of a windrow pick-up baler, there is necessarily a considerable loss of time due to turns, change of trailer and other causes.

**Convenience of Clutch for Power Take-off**

The tractor used in the tests had but one clutch for the transmission to the drivers and to the power take-off. This arrangement requires that when a stop is made the entire outfit must be started with the baler at rest. In other words, it was found impracticable to speed up the baler with its fly wheel, throw out the clutch, engage the transmission, and engage the clutch, moving forward with the baler up to speed. An auxiliary over-running clutch for the power take-off would be of assistance, or independent clutches for the transmission and power take-off would be of great advantage. In former experiments, tractors with independent clutches for the power take-off were found to offer much convenience. The use of an auxiliary engine to operate the baler would offer the same advantages and would materially increase the output of the baler.

To determine more specifically the advantages of a separate clutch, the baler was operated with two tractors, one furnishing power to operate the baler and the second to draw the outfit, including the first tractor, through the field. A heavy

![Fig. 3. Location of bales in field in which no attempt was made to collect or place the bales in windrows.](image-url)
windrow furnishing sufficient hay to make a bale every 40 feet of travel was found to be very satisfactory for a travel speed of from 1.14 to 1.26 miles per hour. A tractor equipped with a field speed of approximately 1 mile per hour could be used to advantage for field baling.

A slow field speed not only is more economical of power, in that the machine need not be moved as far for a given amount of work, but the men riding on the machine are able to do their work more easily because of the freedom from sudden jerks and jars.

Reduction in the Labor Required

The average labor expenditure of 2.52 man hours per ton actually used during the test seasons represents a large item in the cost, and careful consideration should be given to its reduction. It has been suggested that one man—the feeder—might be dispensed with, thus reducing the labor one-fourth. With the machine tested, dispensing with the feeder resulted in so many delays and a lowering in the capacity of the machine to such an extent that in the end no labor was saved.

In the experiments with the harvesting of cornstalks with a field baler, a machine was arranged to be operated by one man who in addition to the tractor operator made a two-man outfit. This was accomplished by using a threading mechanism with
Fig. 5. Windrow pick-up baler at work with trailer for collecting bales.

the baling wire from spools instead of division blocks and bale ties in conjunction with a self-feeder. This machine is shown in fig. 6.\(^5\)

It is to be noted that with three men to operate the baler the labor is not arduous nor tiring, particularly after some degree of skill is attained in performing the various operations.

POWER REQUIREMENT OF BALER

Tests were made of the power take-off power and draw-bar pull required by the baler by means of a tractor equipped with a dynometer. The results are given in table 2.

TABLE 2. POWER NEEDED TO OPERATE BALER.

<table>
<thead>
<tr>
<th>Test No.</th>
<th>Power to power take-off (horsepower)</th>
<th>Draw-bar pull (pounds)</th>
<th>Speed miles per hour</th>
<th>Draw-bar horse power</th>
<th>Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 and 10</td>
<td>4.62</td>
<td>850</td>
<td>2.45</td>
<td>5.56</td>
<td>Level</td>
</tr>
<tr>
<td>12</td>
<td>4.8</td>
<td>600</td>
<td>2.45</td>
<td>3.9</td>
<td>Down Grade</td>
</tr>
<tr>
<td>1, 2, 3</td>
<td>3.79</td>
<td>1233</td>
<td>2.45</td>
<td></td>
<td>Nearly level—wagon attached loaded with 20 bales</td>
</tr>
<tr>
<td>14, 15, 16</td>
<td>1.25</td>
<td></td>
<td></td>
<td></td>
<td>Machine idling</td>
</tr>
<tr>
<td>17</td>
<td></td>
<td>850</td>
<td>2.45</td>
<td>5.6</td>
<td>Baler idle—wagon attached</td>
</tr>
</tbody>
</table>

\(^5\) Further information in regard to this machine may be obtained from "Harvesting Cornstalks for Industrial Uses." Iowa Agr. Exp. Station, Bul. 274, November, 1930.
The effect of grade was very pronounced, as should be ex-
pected in drawing a machine weighing 5,395 pounds. It is a
well-known fact that the draw-bar pull re-
quired to move a ma-
chine up a grade in-
creases in a direct pro-
portion to the grade
stated in percent. This
influence of grade is in-
dicated in table 3.

**TABLE 3. INCREASE OF DRAW-BAR
HORSE POWER REQUIRED WITH AN
INCREASE OF GRADE.**

| Percentage of grade | Draw-bar pull required (pounds) | Draw-bar horse-
<table>
<thead>
<tr>
<th></th>
<th></th>
<th>power required at 2.45 miles per hour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level</td>
<td>850</td>
<td>5.56</td>
</tr>
<tr>
<td>2</td>
<td>956</td>
<td>6.24</td>
</tr>
<tr>
<td>4</td>
<td>1061</td>
<td>6.94</td>
</tr>
<tr>
<td>6</td>
<td>1166</td>
<td>7.62</td>
</tr>
<tr>
<td>8</td>
<td>1272</td>
<td>8.30</td>
</tr>
<tr>
<td>10</td>
<td>1379</td>
<td>9.00</td>
</tr>
</tbody>
</table>

**COLLECTING AND HANDLING BALES**

The labor required to collect and haul the bales to storage is
great. In the first runs the bales were dropped in the field.
Later a trailer was attached to the baler onto which the bales
were pushed direct from the baler over an extension chute.
The division blocks were returned by means of a slide. One
extra man was required on the wagon to receive the bales and
build them into a load. When the trailer load was completed
it was unhitched and an empty trailer attached which resulted
in some loss of time. It is to be noted from the data in table 4
that the use of a trailer saved considerable time.

**TABLE 4. LABOR OF COLLECTING AND HAULING BALES.**

<table>
<thead>
<tr>
<th>Run</th>
<th>No. men</th>
<th>Total tons</th>
<th>Total man hours</th>
<th>Man hours per ton</th>
<th>Equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>4</td>
<td>31</td>
<td>50.22</td>
<td>1.62</td>
<td>Truck</td>
</tr>
<tr>
<td>B</td>
<td>4</td>
<td>26.5</td>
<td>59.</td>
<td>2.23</td>
<td>Truck</td>
</tr>
<tr>
<td>C</td>
<td>2</td>
<td>27.4</td>
<td>53.5</td>
<td>1.95</td>
<td>Wagon and team</td>
</tr>
<tr>
<td>D</td>
<td>2</td>
<td>3.3</td>
<td>4.33</td>
<td>1.44</td>
<td>Trailers and team</td>
</tr>
<tr>
<td>E</td>
<td>4</td>
<td>12.8</td>
<td>23.4</td>
<td>1.82</td>
<td>Wagon and team</td>
</tr>
</tbody>
</table>

**MOWING AND RAKING**

The harvesting of alfalfa with the windrow pick-up baler
necessarily includes mowing and raking. It would only be in
extremely heavy cuttings that it would be practicable to bale from the swath on account of the excessive travel required with the heavy outfit. Furthermore, in Iowa the curing and the protection of alfalfa from excessive drying requires that the alfalfa be placed in a windrow.

The data submitted herewith do not represent the most efficient practice possible, nor are they extensive on account of the use of a wide assortment of equipment in the same field, such as horse and tractor mowers and the use of horses and automobile for raking. Table 5 however, indicates the time actually expended with the equipment used.

**TABLE 5. MACHINE AND MAN HOURS REQUIRED PER TON FOR MOWING AND RAKING.**

<table>
<thead>
<tr>
<th>Run</th>
<th>Acres</th>
<th>Mowing</th>
<th>Raking</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Equipment</td>
<td>Machine or man hours per acre</td>
</tr>
<tr>
<td>C</td>
<td>53</td>
<td>7 ft. tractor mower</td>
<td>.364</td>
</tr>
</tbody>
</table>

**Reports from Owners of Windrow Pick-up Balers**

All of the owners of windrow pick-up balers, who were consulted in regard to their success with the machine, expected to
continue to use the machine. They considered its use to be an economical method of harvesting hay and straw. In some instances the capacity of the machine reported was larger than that obtained in our tests.

The owners of three machines of the same size as that used in the investigations, reported an average capacity of 2.75 tons per hour when baling alfalfa and 2.3 tons per hour when baling straw. The maximum capacity was given as 4.75 tons per hour for alfalfa and 3.8 tons per hour for straw.

Cost of Baling Hay with Windrow Pick-up Baler

The cost of baling hay with a windrow pick-up baler of the size used in the tests reported in this bulletin will vary widely with the conditions involved—the size and kind of hay baled, the labor costs and the amount of baling done each year. With the capacities indicated in the tests, the ton cost of baling may be estimated. The following estimate indicates what may be expected under average conditions:

ESTIMATE OF COST OF BALING WITH WINDROW PICK-UP BALER

(Based upon the data obtained from one season's work.)

Cost per hour:

<table>
<thead>
<tr>
<th>Labor:</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 men at 30c ...........................................</td>
</tr>
<tr>
<td>1 man at 40c ............................................</td>
</tr>
<tr>
<td>Tractor 20-30 H. P. ....................................</td>
</tr>
<tr>
<td>Wire 40c per ton .........................................</td>
</tr>
<tr>
<td>Charge for baler .................................</td>
</tr>
</tbody>
</table>

Total per hour ........................................... $3.45

Cost per ton:

| Rate of baling 1.59 tons per hour | $2.17 |
| Rate of baling 2.75 tons per hour | 1.42 |

KEEPING QUALITY OF FIELD BALED HAY

The conditions under which satisfactory results may be expected when hay is baled direct from the field were studied by

---


*Davidson, J. B. Life, service and cost of service of farm machinery. Iowa Agr. Exp. Sta., Bul. 260, June, 1929. (Estimate based on cost of machine as $1,000. Annual cost, 15 percent, divided over 300 working hours.)

*Prepared by Prof. H. D. Hughes, Farm Crops and Soils Section, Iowa Agricultural Experiment Station.
Fig. 7. Hauling bales to storage with team drawing the trailer.

the Farm Crops Subsection during the 3-year period 1927-29.⁹

In 1927, hay with 23 percent of moisture at the time of baling graded No. 2. This hay had a good green color. Hay with 26 percent of moisture lost all of its green color and was classed as "sample grade."

In one series of comparisons in 1928, in which the moisture content of different lots varied from 16 to 30 percent, the results were erratic. Four bales with 30 percent of moisture produced hay which graded No. 1, No. 1, No. 2 and No. 3, while three bales with 23.5 percent of moisture graded No. 2, No. 2 and No. 3. In another series, in which the moisture content varied from 26 to 37 percent, the hay with 26 percent moisture heated sufficiently to destroy the green color to a considerable extent and was graded No. 3, while hay with more moisture lost all green color and was classified as "sample grade."

In 1929 the results were again somewhat erratic. In one case, hay with $17\frac{1}{2}$ percent of moisture was classified as "sample grade" while hay with 22.7 moisture when baled produced a better quality, grading No. 2.

These results would seem to indicate that hay containing as much as 23 percent of moisture can be baled with reasonable safety though under some conditions there might be sufficient heating to result in loss of color and a consequent lowering of the grade. In some cases hay with considerably more moisture than that indicated has been stored safely. It is believed that the degree of compression is a factor needing additional study; hay with the higher moisture contents probably should be baled more loosely than hay which is more completely cured before baling.

The Ohio Experiment Station\textsuperscript{10} reports that in field baling experiments at Columbus all hay which contained 24 percent, or more, moisture when baled molded when stored in open stacks.