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BALED SILAGE

HARVESTING COSTS AND WORK ORGANISATION 1955

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Summary:

Studies in the cost of harvesting silage by pick-up baler in 1955 confirm the results obtained the previous year. The average cost of harvesting on 14 farms in 1955, including labour, materials, and depreciation on machines was £5.5.8d. per acre for an average crop of 6.3 tons of green material per acre. The cost per ton was 17/4d and per bale 6d. This is compared with a cost of 16/9d per ton for silage made by other methods and it is concluded that there is no appreciable difference in cost between the two methods. Figures for the number of man-hours per ton required for harvesting suggest that baled silage requires only about half the labour needed for loose silage.

The organisation of the work on three farms is described and it is shown that good quality silage was made with a low density p.t.o. model baler but, compared with the high density type, more carting was required, because fewer full sized bales could be accommodated in a trailer load.

The best method of feeding was where the silage was brought to the cowshed in large capacity hand trucks and a bale distributed between two cows - cutting the strings in the stall. The full advantage of baling is lost where strings are cut at an earlier stage and the silage distributed by hand fork.

Analyses of silage showed that there was no significant difference in quality between baled silage and silage made by other methods.

In a preliminary report on the cost of harvesting baled grass silage in 1954[1], it was shown that the overall cost did not appear to differ greatly from the cost of harvesting by other methods. These results are confirmed by studies made on 14 farms in the South West of Scotland in 1955 which are described below.

PART I

HARVESTING COSTS

The fourteen farms on which costs were recorded are situated in the counties of Ayr, Dumfries and Lanark. Information of a more general nature was obtained from 18 other farms. The costs were derived from records of the labour used for harvesting and the time taken to complete the operations together with other relevant data. The report refers to grass silage only.

The method of harvesting is the same as that described last year. All but one of the balers recorded were of the common high density p.t.o. type, but the machine on farm A was a low density p.t.o. model. Harvesting is taken to include the operations of cutting, side-raking or swath-turning where this was carried out, baling, loading, carting and filling and rolling the pit. The yields quoted are the estimated yields of grass ensiled, calculated from the number of bales produced.

The charges made for labour and power were as follows:-

Man	3/5d per hour
Wheeled tractor	3/9d " "
Crawler "	5/9d " "
Horse	1/6d " "

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(1) West of Scotland Agricultural College, Economics Department, Report No.21. Nov. 1954.

The method of estimating depreciation on machines is the same as that followed last year. The farmer's opinion was obtained of the average number of hours each machine worked, together with his forecast of its expected life and scrap value, if any. From this, and from the initial cost of the machine, the depreciation per hour was calculated. To cover the average annual cost of repairs, $\frac{1}{3}$ of the depreciation was charged in the case of balers and $\frac{1}{4}$ for other machines. Each farm was charged with its own individual estimate of depreciation and repairs. Where possible, the cost of baler twine charged was calculated from the farmers' own records, but where this was not available the cost was estimated at the rate of one ball of twine for 360 bales. On farms F and N, where baling was on contract, the cost of twine was included in the contract price. Where costs were available for more than one field on a farm, the figures shown are the unweighted averages of all the fields costed, and where two cuts were taken from the same field they were treated as if they were from separate fields.

Cost of Harvesting

The costs of harvesting on each of the 14 farms are shown below.

Table I

Farm No.	Area Harvested acres	Yield in tons of green grass per acre	Cost per acre	Cost per ton	Man Hours per ton
A	33	3.6	£3.18. 1	£1. 2. 3	3.1
B	18½	4.2	3. 8. 1	-.17.11	1.9
C	7	9.3	5.13. 0	-.12. 3	1.5
D	7¼	5.75	5.11.11	-.19. 6	1.7
E	17½	4.0	2.17. 2	-.14. 4	1.5
F	12	3.6	3.14.11	1. 0. 9	2.5
G	11	6.8	5. 1. 5	-.14.11	1.5
H	11	9.1	7. 0. 7	-.15. 5	1.5
J	72	7.25	4. 2. 9	-.11. 5	1.2
K	29½	7.0	5.13.10	-.16. 4	2.5
L	51	5.9	8. 0. 7	1. 6. 7	3.9
M	21	4.7	3.15. 2	-.16. 0	1.6
N	22	4.9	4. 2. 2	-.16. 9	1.2
O	11	12.5	10.19.11	-.17. 7	2.5
Average		6.3	£5. 5. 8	£-.17. 4	2.0

The cost per acre varied from £2.17.2 to £10.19.11d. It is to be expected that the heavier crops would cost more to harvest than the lighter ones and this is amply borne out by the figures, which show a direct and very significant relationship between the yield and the cost per acre of harvesting. The cost per ton lay between 11/5d and £1.6.7d, with the average at 17/4d. These figures also confirm fully that the cost per ton becomes less as the yield per acre increases. The average cost of harvesting a bale worked out at 6d.

The number of man-hours required to harvest a ton of silage gives a measure of the labour used and this varied from 1.2 to 3.9 man-hours per ton. The average was 2 man-hours, but 6 out of the 14 farms were able to harvest the silage using only 1.5 man hours or less per ton. It is suggested that 1.5 man hours per ton might therefore be taken as a standard for efficient use of labour.

The distance between the field and the pit varied from 200 yards to 3 miles, but on the majority of farms it lay between $\frac{1}{4}$ and $\frac{1}{2}$ a mile. It would be expected that for the longer hauls the cost per ton would be increased. While this is true up to a point, there is evidence to suggest that where most of the transport is done on good roads or where large capacity trailers and lorries are used, the cost of transport can be kept low.

It is not easy to obtain an accurate record of the amount of twine used because of the difficulty of estimating what is left in partly-used balls. Based however on the quantity of twine said to be contained in a ball, the ball should tie 365 bales. Allowing a round figure of 360 bales per ball, at a price per ball of £1.6.1d., the cost of twine amounts to approximately .85d per bale.

Baled Silage and other Methods of Harvesting

For comparison of the costs of baled silage with methods other than baling, it is necessary to use figures from the last reports on grass silage costs available for this area. These are to be found in the West of Scotland Agricultural College, Economics Department Reports No.3 of 1950 and No.4 of 1951 and relate to the crops for 1949 and 1950 respectively. From the data given, the costs have been recalculated at 1955 prices and the yields are expressed in terms of green crop ensiled.

Table II

Year	No.of Crops (single cut)	Average Yield Per Acre Tons	Average cost per Ton	Average Man hours per Ton
1949	19	5.9	17/-	4.2
1950	8	5.4	16/6	3.0
Average		5.65	16/9	3.6

These figures include the cost of covering the silo which is not included in the current year's costs but this is not likely to amount to more than a few pence per ton.

The average cost per ton of harvesting baled silage, 17/4d, is not significantly greater than 16/9d the cost per ton of harvesting by other methods. If the rather high cost on farm L is omitted from the former, the average cost of harvesting baled silage on the remaining 13 farms becomes 16/7d. It therefore seems fair to conclude that there is little or no difference in cost of harvesting between silage handled by pick-up baler and by other methods.

Comparing the number of man hours required per ton, the figures suggest that the labour required for harvesting baled silage was little more than half that required for harvesting by other methods.

Implement Costs

Considering only the 12 farms which used their own baler, it was estimated that the average number of hours per annum the baler was in use, for all purposes, was 174, the estimates for different farms varying from 80 hours per annum on Farm H to 400 on Farm O. On 3 of the farms the annual amount of use was round about 100 hours and the farmers concerned were satisfied, after two or three years' experience, that the baler was an economic proposition for them. It is suggested therefore, that until more accurate information becomes available, 100 hours' use per annum might be tentatively regarded as the minimum amount of use which justifies a farmer having his own baler. In the absence of accurate knowledge of the life of a baler, the farmer's forecast is largely intelligent guesswork, and it probably reflects the fortune, good or bad, which has attended the baler in its early years. These forecasts vary from a total life of 800 hours to 2,575 hours, and the variation in these determines, to a large extent, the charge for depreciation.

This estimated cost of depreciation varied from 4/6d to 16/3d per hour and the average was 9/4d. The average cost per hour of baling was therefore as follows:-

	Cost per hour
Depreciation	9/4d.
Repairs	3/1d.
Tractor	3/9d.
Twine ($6\frac{1}{2}$ tons of grass per acre and baling 1 acre per hour)	16/3d.
	32/5d.
Add Wages of tractor driver	3/5d.
Total cost of Operation.	35/10d.

The average rate of baling was an acre per hour, so that the cost per acre also is 35/10d. No account has been taken of interest on capital but on a baler costing £645 and used for 174 hours per annum the interest charge would amount to 3/8d per hour, bringing the full cost to 39/6d per hour or per acre.

The average cost of mowing was 1/5d per hour and the average time the mower was used during a year was estimated to be 128 hours.

PART II

ORGANISATION OF THE WORK

The work of harvesting on Farms A, B and E was studied in detail. In doing this, the whole job was broken down into the following operations:-

Baling,
Loading,
Carting,
Unloading,
Rolling pit (Farm A only),

and time studies were made on each. A description of the organisation of the work on these farms may be of interest and will help to illustrate the advantages of different types of baler.

Farm B

The staff at work here consisted of 2 men, with a third assisting for a short time only. The baler was a high density p.t.o. model. No side raking was done, so the baler picked up a single swath. It was driven by the farmer himself, and worked round the four sides - subsequently reduced to three - of an irregularly shaped field, taking an average of 61 minutes to bale an acre. The yield of silage was just under $4\frac{1}{2}$ tons per acre.

Loading and carting were done by two men with a tractor and trailer. The tractor was driven to various points in the field and nearby bales were picked up and loaded by each man working independently, but as the load became higher it was necessary for one of the men to mount the cart to place the bales lifted up by the other. About 40 bales were carried in a load. The distance from the field to the pit was about $\frac{1}{4}$ of a mile and the average speed of the tractor during the journey was just over 4 miles per hour.

The pit was situated at the farm steading. It had raised sides so that when the trailer was backed in to the side the bales had to be lifted up when unloading. It took an average of 12.4 minutes to unload a cart of 40 bales.

Farm E

The method of harvesting on this farm was similar to that on Farm B. Cutting and baling were carried out independently, usually in the morning, and in the afternoon the cut silage was carted to the pit by two men with a tractor and trailer. The mower was fitted with a winnowing attachment consisting of spring steel fingers fixed behind the cutter bar and this made a compact swath for the baler to pick up.

Baling was done - again by the farmer himself - round the four sides of a roughly rectangular field, and it required, on an average, 53 minutes to bale an acre. The yield of the crop was estimated to be just under 4 tons per acre.

Observations on loading had to be made in a different field, but the yield of the crop appeared to be about the same as in the previous field. The distance from the field to the pit was $\frac{1}{2}$ a mile and the average speed of travel was about $4\frac{1}{4}$ miles per hour.

The pit, which was situated at the steading, measured 100 ft. long and 26 ft. wide. The top of the sides protruded only a little above ground level so that when the trailer was backed in to the side, the bales could be tipped off with little effort. A bale was placed in the pit just behind the trailer so that as each bale was pushed off it landed on its edge on this bale and turned end over end to the place where the bales were being packed. On such a wide pit as this, the method of unloading saved the worker who was making the pit considerable effort.

In an attempt to make the removal of silage easier, the pit was divided into sections, about 4 yards long, by paint marks on the sleepers which formed the sides of the pit. At the junction of each section with the next, the bales were built in a line across the pit. As each layer was built, care was taken that the bales on this line were directly above each other so that a vertical wall of bales was formed across the pit dividing each section from the next.

When the pit was opened, the bales were removed from the whole of one section before going on to the next, so that it was unnecessary to have a large area of silage exposed to the air at a time.

The average time taken to unload a cart of 70 bales was 11.2 minutes. For a cart of 40 bales the estimated time would be 6.4 minutes which is about half the time required for discharging the cart on Farm B.

Farm A

The baler used on this farm was a low-density p.t.o. model which delivered full-sized bales measuring 36" x 12" x 15" and weighing about 75 lbs. each. The baler was fitted with a loading ramp for delivering the bales on to a trailer attached behind. This outfit was drawn by a tractor of 2700 c.c. capacity. The grass was ensiled in a clamp in the hayshed which had both sides built up and was closed at one end.

The team of workers employed was:-

1 man and 1 tractor cutting and swath-turning alternately.
2 men and 1 tractor baling and loading a trailer
1 man and 1 tractor carting.
1 man building bales at the silo.

The field which was being harvested was over 400 yards long and the ground was fairly level. After cutting, a swath turner was used to combine two swaths into one. The baler travelled to and fro along the field with one worker driving the tractor and the other loading the bales on the trailer attached behind. At each end of the field the trailer was unhitched from the baler and an empty one hitched on. The average time taken to bale and load an acre, including the time taken for hitching and unhitching trailers was 50 minutes.

Empty trailers were brought to the end of the row, where they were unhitched and the loaded trailer hitched on and hauled to the silo. Each trailer carried a jack, which supported the tow-bar while it was unhitched and greatly facilitated the transfer. The tractor collected the trailer from either end of the row alternately and, as the far end of the field was some 400 yards further away from the silo than the near end, it had, at times, to wait for the baler and vice versa. (It is possible that if tractors were changed at a point midway down the field a more even rhythm of work would be obtained and waiting time would be reduced). About 30 bales were normally carried in a trailer load but 44 were taken on one occasion.

At the closed end, the silo was filled from the side by means of an elevator which delivered the bales on to the clamp, from where they were carried into position by the worker stationed there. When half the length of the stack was filled with a layer of bales, filling was transferred to the open end. The worker again had to carry the bales into position because lack of space to manoeuvre prevented the tractor and trailer from mounting the pit. The worker at the pit was not fully occupied when the tractor was away fetching another load but because the work of carrying the 75 lb. bale at the clamp was heavy, he required some time for rest and recovery.

About 6 cart loads were required to fill one layer of bales on the stack and, after each layer, the stack was rolled by the tractor, which was temporarily detached from baling for this purpose. (Carting also had to stop but as the men were required to assist in manoeuvring the tractor up to the stack, and in consolidating the silage, no one was idle). Owing to the situation of this silo, unloading cost rather more than on the two farms with open pit silos.

Comparison of Low and High Density Balers

Apart from technical details, this low density baler differs from the high density ones observed in two important respects.

1. It delivers the bales direct to a trailer towed behind so that the work of loading is greatly reduced.

2. The length of the bales is double that of those from the high density baler so that larger and slightly heavier bales have to be handled.

In making a comparison of the operation of these two types of baler, the effect of these two differences must be kept separate.

In order that the comparison shall be a true one, it is necessary to assume the same working conditions for both balers and to calculate the figures on this basis for comparison. The situation assumed is, therefore, as follows:-

Yield of silage	4 tons per acre
Weight of bale H.D. baler	64 lbs.
" " " L.D. "	75 "
Length of baler run	420 yards
Distance from field to pit	$\frac{1}{4}$ mile
No. of bales per tractor load H.D.	70
" " " " " " L.D.	40

It is assumed that two swaths are raked into one before baling, and that baling takes place backwards and forwards on a 420 yard length of field. It is calculated that the number of bales to be carried per acre are:- H.D. 140, L.D. 120, and the number of trailer loads necessary to clear these are:- H.D. 2, L.D. 3. Based on the observations of actual times for the various parts of the job, made on the three farms, the estimated time that would be taken to carry out the operations under the conditions assumed is given below.

Table III

Time Required per acre harvested

High density Baler	man minutes	Low density Baler	man minutes
Baling	35	Baling and Loading	76
Loading	72	Hitching carts	32
	107		108
Carting (2 trips)	33	Carting (3 trips) (including proportionate time of man at pit)	67
Difference in favour of H.D. baler	34		
	67		67

Net difference = 33 minutes in favour of H.D. Baler

The bale loading device on the low density baler therefore does not save any time under the conditions given, but it must be remembered that it obviates lifting the bales on to the trailer, which is generally regarded as the hardest part of the work in making baled silage. This method is suitable only for farms where the staff available is sufficient to enable baling, carting and filling the silo to proceed simultaneously. Certain makes of high density baler can be adapted for loading direct to the cart, and where conditions permit this method to be used, it would no doubt save effort.

In carting, however, the low density baler is at some disadvantage compared with the high density types. The larger sized bales take up more room on the trailer and consequently more trips are necessary to clear the field. In the situation assumed, the additional time required amounts to over 30 man-minutes per acre, and the greater the distance between the field and the pit the more will be the extra time needed. However, although extra carting may be a disadvantage in this type of baler, there may be a compensating advantage in haymaking when the more lightly pressed bales may dry out more quickly.

Reference to Table IV in Part IV shows that the quality of the silage made was as good as that on other farms. Rather more rolling in the early stages would have been an advantage because some difficulty was experienced in avoiding overheating.

Summing up, it can be said that it is possible to make good silage with the low density type of baler, but the cost may be a little higher than with high density types.

PART III

FEEDING BALED SILAGE

The success of silage making by pick-up baler may very well depend on the way in which the silage is fed. On some farms baling is regarded simply as a convenient means of transporting the silage where the field is a long way from the pit. In such cases the strings are often cut when the bales are extracted from the pit and the silage fed loose. Feeding time, however, may be reduced when the method of feeding is altered to suit the handling of bales.

Particularly good results were obtained on Farm C where the mode of transport to the byre and the method of feeding were carefully thought out. The silage is made in a clamp in the hayshed about 60 yards from the byre dppr. Two flat 4-wheeled trucks are used to transport the silage to the byre, each carrying 15 bales.

The trucks are pushed into the byre and each bale is carried to the head of a stall between two cows and placed between the troughs. The strings are cut and half the bale falls away into each trough. The strings are taken to the passage and dropped there as the byreman goes to the truck for the next bale. After feeding, the strings are collected from the passage.

The weight of the bales is reckoned to be about 60 lbs each so that each cow receives about 30 lbs of silage. The byre houses 60 cows so two truck loads carry enough to feed all the cows.

The time taken to feed the cows in this byre was as follows:-

Loading 2 trucks	6 minutes
Transport	3 "
Distribution	11 "
Total	20

or $\frac{1}{3}$ minute per cow
or 25 minutes per ton of silage.

For comparison, the time taken for feeding loose silage, harvested by crop loader, on a well run farm, may be taken for comparison. The same quantity of silage was fed to each cow as on Farm C. The silage was carted by outside staff from the pit to a dump in the yard which was the same distance from the byre door as the silo on Farm C. From there it was taken to the byre in an open tank type of truck, known in Scotland as a "cooler", and fed to the cows by hand fork. The byre contained 44 cows. By making an adjustment for the number of cows and excluding the time taken for carting from the pit to the heap in the yard, the following figures are obtained for the time taken to feed 60 cows with loose silage.

Cutting out at pit	$14\frac{1}{2}$ minutes
Filling coolers	15 "
Transport heap to byre	$4\frac{1}{2}$ "
Distribution	13 "
	47

or just over $\frac{3}{4}$ minute per cow.

Even allowing for the fact that the situation on Farm C allows for a very efficient method of feeding, it seems that baled silage can be fed in about half the time required for feeding silage loose.

Further confirmation of the time taken to feed loose silage can be found in the N.A.A.S. Technical Report No.5. "Labour and Equipment in Feeding Silage". Considering only the farms which used a hand truck for transport, the lowest time in man minutes per ton for cutting out, loading, transporting and distributing was 35.9 minutes, while the average of 4 farms was 58.3 man minutes. (A fifth farm is excluded, because the figures were exceptionally high). This compares with 25 man minutes per ton for feeding baled silage on Farm C.

It seems clear therefore that if the method of feeding is planned to suit baled silage, considerable saving can be made in the time taken. In this conncection it must be pointed out that the weight of the mature bales should be such that half a bale forms the desired ration for a cow for one feed. To

calculate the weight of the mature bale from the weight of the green bale, it is necessary to know the loss in weight to be expected in the pit. This varies with the quality of the silage made, and, while there is no direct experimental evidence, observations on baled silage have suggested that for well made silage this may be round about 10%.

PART IV

THE QUALITY OF THE SILAGE

Samples of silage were taken from the pits or clamps of baled silage on the co-operating farms during the winter. The samples were taken from the unopened pits by means of a special corer designed by the staff of this college. The analyses of the samples are given below.

Table IV

Analysis of Silage

Farm	Percentage of Dry Matter	Estimated Starch Equivalent	Percentage of Crude Protein in Sample	Percentage of Crude Protein in Dry Matter
A	34.95	17.5	4.50	12.95
B	20.50	10.25	2.45	11.95
C	23.50	11.75	3.00	12.75
D	23.15	12.75	3.65	16.20
E	21.45	10.75	2.60	12.15
F	14.25	7.15	2.00	14.15
G	21.25	10.65	3.25	15.30
H	33.00	16.5	4.70	14.30
J	37.15	16.6	2.90	7.75
K	20.25	10.15	2.35	11.70
L	22.80	11.35	2.55	11.20
M	21.40	10.75	3.05	14.20
N	18.80	9.4	2.05	10.85
O	Not recorded			
P (Not in Cost figures)	33.30	16.6	4.05	12.20
Means	24.70	12.3	3.10	12.70

The p.H. of these samples ranged from 4.0 on Farm K to 5.6 on Farm F.

For comparison with these figures analyses were taken from 30 farms situated in the same areas but making silage by other methods. The average and range of these are shown below.

Table V

	Mean	Range
Percentage of Dry Matter in Sample	23.45	14.0 to 39.55
Estimated Starch Equivalent	11.55	7.0 to 19.75
Percentage Crude Protein in Sample	2.7	1.7 to 5.5
Percentage Crude Protein in Dry Matter	11.7	8.75 to 23.30
p.H.		3.75 to 5.3

Comparison of the means of the two sets of samples shows that there is no significant difference between them in the content either of dry matter, starch equivalent or protein.

It must be remembered that the quality of silage fed is governed primarily by the quality of the grass harvested and is also affected by the care taken in the process of ensiling and by the design and construction of the silo. The analyses shown reflect the combined effect of all factors and from the results, it can be concluded that the quality of the silage made by a pick-up baler is as good as that of silage made loose by other methods of harvesting.

To sum up, it may be said that baling can take its place as one of the standard methods of harvesting silage. It is suitable for all but the smallest farms. The job can be split up into the various operations so that not more than one tractor and two men are required at a time but, on larger farms, this organisation can be easily expanded to deal with big acreages. Baling also provides an easy and convenient method of carrying grass for ensilage from distant fields to pits at the steading. On farms where a baler is already used for haymaking and baling straw, the additional use of the machine for silage-making helps to reduce the cost of operation by spreading the overhead charges on the baler over a wider range of work.

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