Silage — Costs/production O.S

NORTH OF SCOTLAND COLLEGE OF AGRICULTURE
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Economics of Silage Production in the North of Scotland 1967

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THE NORTH OF SCOTLAND COLLEGE OF AGRICULTURE

AGRICULTURAL ECONOMICS DIVISION

ECONOMICS OF SILAGE PRODUCTION IN THE NORTH OF SCOTLAND, 1967

by

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ECONOMICS OF SILAGE PRODUCTION IN THE NORTH OF SCOTLAND

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SUMMARY

1. The practice of ensilage has been known for more than a century, but only in the last decade has it attained major importance in livestock feeding in the North of Scotland. In Aberdeenshire in particular it now rivals haymaking as the main method of conserving grass. The acreage of grass cut for silage is still increasing.

2. This report presents the results obtained and conclusions drawn from an investigation into the costs and practices of silage-making in the North-East of Scotland in 1967.

3. The sample consisted of 38 farms in the counties of Aberdeen, Banff and Kincardine. The farms varied considerably in type, size, location, quantity of silage made and type of stock fed. The average area of crops and grass per farm was 279 acres and the average quantity of silage made was 425 tons.

4.

Item	Per Acre Per Cut	Per Ton	Per Ton Dry Matter	Per Ton Starch Equivalent
	£ s.	£ s.	£ s.	£ s.
Average Variable Costs	3:16	-:14	3: 4	6:11
Average Total Cost	13: -	2: 8	10:19	22: 8

There were wide variations in the costs incurred on individual farms. The cost of £22: 8: - per ton of starch equivalent can be compared with the cost of starch equivalent from an alternative feedingstuff - e.g. approximately £30: -: - per ton in the case of barley.

5. The average yield per acre per cut was 5.5 tons of made silage, being equivalent to 1.20 tons of silage dry matter or 0.58 tons of silage starch equivalent. This was achieved with an average application of 63 units of nitrogen per acre per cut.

6. The average labour and tractor requirements were 1.0 man hours and 0.8 tractor hours per ton of made silage, 44 per cent of the man hours being spent at the silage pit. An average rate of harvesting of 20 tons of made silage per working day was achieved.

7. Two farmers hired a contractor for the cutting and carting. On the basis of their results it appears that, if regular farm staff can readily

cope with the cutting and carting, it is cheaper to buy harvesting machinery and use the regular staff if more than approximately 150 tons of silage is to be made, but it is cheaper to hire a contractor if less than that is required. The 'break-even' scale of production may be much higher if the regular staff cannot readily cope with the task.

8. It appears that efficient sealing of silage with polythene sheeting may save about 2 in. of surface wastage. This saving alone will more than cover the cost of 500 gauge polythene in one season. There should also be a better fermentation and reduced loss of nutrients in the silage due to excluding the passage of air and the sheets may serve for another season.

9. One farmer made vacuum silage. In this case it seemed to be a successful method of making good silage without the large capital cost of erecting a concrete silage pit.

10. The results showed notable economies of scale arising in silage production. The main economies were achieved in harvesting. The average harvesting cost per ton of silage starch equivalent in the group of farms making over 1,000 tons of silage was less than half that in the group making less than 200 tons of silage.

11. A positive response was found to increasing applications of nitrogenous fertiliser up to the level of 80 units per acre per cut. The average increase in yield of silage starch equivalent was 1.41 cwt. per 10 units of nitrogen applied. Thus an outlay of about 8s. can provide additional starch equivalent which would cost over £2 in the form of purchased barley. Alternatively, on the average farm in this sample an additional 10 units of nitrogen per acre per cut would enable the same quantity of silage to be made with a 12 per cent reduction in the acreage of grass cut.

12. Where the silage was wilted a considerably superior product was obtained on average. This was probably because younger, more nutritious grass could be, and was successfully ensiled when wilted. The total cost per ton was slightly higher for the wilted silage, but the total cost per ton of silage starch equivalent was a little less. The labour requirements were no higher where wilting was carried out.

13. The silage analyses confirmed that farmers making silage for intensive livestock, dairy cattle in particular, tended to cut the grass at a less mature stage to give a more nutritious product. Those with less intensive livestock, such as suckler cows and sheep, tended to cut the grass at a later stage to give a larger bulk of crop. In the latter case the costs per ton of silage and per ton of dry matter were slightly lower but not the cost per ton of silage starch equivalent.

14. Results were also obtained for two farms making high dry matter tower silage. The main difference in the cost of this system arose from the large investment in machinery, amounting to over £2,600. Some saving in labour was achieved compared with conventional silage, and the high average yield of haylage suggests that some reduction in losses was achieved. Nevertheless, the average total cost per ton of starch equivalent for these two farms was £24: 8: - compared with the average of £22: 8: - for the 38 farms making conventional silage. The value of the system depends on the extent to which savings in purchased concentrates can be achieved due to the more concentrated nature of haylage. The great variations found in the dry matter content of haylage in a tower may cause problems in controlling rations so that it is difficult to achieve a large measure of increased production from the haylage.

15. The most striking feature of the results of the survey was the great variation between farms in the values of the various efficiency measures and items of cost. Some of the variation was due to the characteristics of the farms - soil, elevation, slope, local climate, layout of fields and buildings, etc. - which cannot be altered in general. Some of the variation was due to different farming systems or enterprise combinations, which influence the scale of silage production and labour availability and this must be considered when planning the farming system. Some of the variation was due to varying practices with regard to manuring, time of cutting, wilting, sealing, etc. and the analysis of the results has shown the influence of some of these. However, probably the most important factor influencing the costs and efficiency of silage production is the farmer or manager himself. The greatest variations between farms were in

harvesting costs and labour and tractor requirements, which are dependent on the farmer's ability and effort in organising the harvesting and ensiling. The results of this investigation have indicated some of the practices which help to produce good silage at the least cost, but, as with most farm activities, only with careful organisation and attention to details can efficiency be maximised and costs minimised.

HISTORICAL AND STATISTICAL BACKGROUND OF SILAGE-MAKING

History of Silage-Making

Many people regard silage-making as a relatively new technique of conserving grass, but reports of making silage from grass, clover or vetches were available from Germany in the 1840's.(1) Many of the basic principles involved in making silage were already known at that time. For instance, emphasis was placed on rapid filling of the pit and compaction of the grass for exclusion of the air. There were also some more doubtful practices, such as the application of water to grass which was ensiled in a drier condition. At that time pits were dug in the earth from ten to twelve feet square and approximately ten feet deep and the sides lined with wood or bricks.

By the 1880's silage was gaining popularity fast in this country. The Silage Society Report 1888 set out comprehensive information on the making of good silage:

"The correct time for cutting crops intended for silage is a highly important consideration:

1. Grasses and clovers - as they come into flower
2. Legumes - when the pods begin to fill
3. Cereals - when the corn is coming into ear

The character of the silage depends on the temperature. The best silage is made when the temperature ranges between 120 and 130 deg. F.

Coarse, stemmy grasses should be chaffed before being put into the silo, but young material is better unchaffed.

Grass for ensilage should be cut before the hay stage and cereals should be chaffed before ensiling.

It is essential that the silage clamp be compact, and that air is excluded. This may be done either by applying pressure mechanically, by applying weights or by constant treading with horses and men as the clamp is being made, and immediate sealing of sides and top with soil or vacuum".(2)

In 1882, six farmers were known to make silage in Great Britain and by 1888, the number had grown to 6,000. The situation in Scotland at that time is difficult to assess, but in 1885, 70 farmers were known to make silage of which 16 were in the North-East - 8 in Aberdeenshire,

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(1)Transactions Highland Society - 1843-45 - On the Feeding Qualities of the Natural and Artificial Grasses in Different States of Dryness.

(2)Farmer's Weekly. March 22, 1968 - The Answer to the Farmer's Terror.

2 in Banffshire, 1 in Morayshire, 3 in Invernessshire, 1 in Sutherland and 1 in Orkney.[3] The silage in Scotland would appear to have been made from a variety of materials varying from arable mixtures of tares, beans and oats, ryegrass and clovers to natural grass from woods, roadsides, etc. The dates of filling were considerably later than at present, the majority of first fillings not taking place until the end of July or the beginning of August and some as late as September.

Many trials were undertaken in the 1880's to assess the feeding value of silage and even detailed costings of growing and making silage were kept. Many agriculturalists at that time forecast that silage would have superseded hay on British farms by the end of the century, but this was not to be. Silage instead went out of favour perhaps because of the unpredictability of the finished product, and the fact that it was made from a variety of materials. Deaths may also have occurred in stock being fed silage because of the presence of poisonous weeds in the finished material.

Silage began to regain favour during the first World War when tower silos were introduced into Britain from America. Arable silage made from a mixture of beans, peas and tares was generally made in these towers. The first concrete tower silo in the North-East was erected at Cruden Bay in 1918, followed by others in Aberdeenshire, Kincardineshire and Morayshire in the early 1920's.[4] This method of ensiling green fodder was generally short-lived because of the amount of back-breaking work involved in collecting and carting the green material and filling the tower silos. Green-crop loaders, based on the adaptation of hay loaders, appeared on the market, but the physical effort involved was scarcely any less because the man on the load had to work very hard to keep pace with the machine. About 1946, however, the buckrake appeared and it is possible that the introduction of this simple implement was responsible for the upsurge of interest in silage-making once again.[5]

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(3)Transactions of the Highland and Agricultural Society of Scotland - 1885. Report of Proceedings of Ensilage Committee.

(4)Transactions of the Highland and Agricultural Society of Scotland - 1925 - Clay Farming and Ensilage.

(5)Journal of the British Grassland Society - 1959 - Forage-Harvester Performance in Field Tests.

Acreages of grass cut for silage and hay in the North of Scotland, 1955 - 1967, are given in Table I. It is interesting to note that the number of acres of grass cut for silage has doubled since 1960, but even though this has happened the acreage of grass cut for hay has also increased. The acreage cut for silage has been increasing at the rate of approximately 7,000 acres per year and there does not appear to be any definite slackening of this rate. However, the number of acres cut for hay would appear to have reached saturation point in the past three years. The number of forage harvesters in the North of Scotland has increased considerably, from 130 in 1965 to 2,712 in 1967 (Table II). It would seem probable from these figures that silage-making has now found a place in the agriculture of this country and that silage will be made eventually on the great majority of livestock farms.

TABLE I

Changes in the Acreages of Grass Cut for Silage and Hay in the North of Scotland, 1955 - 1967

Year	Acreage of Grass Cut for Silage in North of Scotland*	Acreage of Grass Cut for Hay in North of Scotland*
1955	18,878	121,742
1960	49,003	140,283
1965	84,358	163,478
1966	93,077	167,362
1967	98,237	163,023

Source: D.A.F.S. December Census.

*See Table III or IV for counties included.

TABLE II

Changes in the Number of Forage Harvesters in the North of Scotland, 1956 - 1967

Year	Forage Harvesters in the North of Scotland*
1956	130
1959	190
1961	916
1964	2,008
1967	2,712

Source: D.A.F.S. Machinery Census.

*See Table III or IV for counties included.

Grass Conservation in the North of Scotland - 1967

Since livestock production is the main feature of agriculture in the North of Scotland, grass conservation is an important activity. In Table III the estimated quantities of silage made in the counties served by the North of Scotland College of Agriculture are shown for 1967.

TABLE III

Silage Production in the North of Scotland, 1967

County	Estimated Tons of Silage		
	Grass	Arable	Total
Aberdeen	297,179	14,816	311,995
Banff	58,831	3,641	62,472
Caithness	18,741	3,467	22,208
Inverness	28,505	8,045	36,550
Kincardine	33,246	5,166	38,412
Moray	41,264	2,813	44,077
Nairn	8,205	2,264	10,469
Orkney	42,037	7,182	49,219
Ross	37,198	4,890	42,088
Shetland	6,035	865	6,900
Sutherland	5,890	1,353	7,243
Total N.O.S.C.A. Area	577,131	54,502	631,633

Source: D.A.F.S. December Census, 1967.

A total of over 600,000 tons of silage was made in the area which represented more than a third of the total quantity made in Scotland as a whole. Most of the silage was made from grass, less than 10 per cent being arable silage. Almost half of the silage in the area was made in Aberdeenshire, but Banff, Moray, Orkney and Ross were also important areas of silage production.

Haymaking is the main alternative method of conserving grass. Table IV shows the acreages of grass cut for silage and for hay in the counties served by the North of Scotland College of Agriculture in 1967 together with the total acreages of crops and grass.

TABLE IV

The Relative Importance of Silage and Hay in the North of Scotland, 1967

County	Acreage of Grass Cut for Silage	Per Cent of Grass Acreage Cut for Silage	Acreage of Grass Cut for Hay	Per Cent of Grass Acreage Cut for Hay	Total Acreage of Grass	Total Acreage of Crops and Grass
Aberdeen	53,534	14.8	53,606	14.8	361,736	624,767
Banff	9,256	9.9	14,382	15.4	93,383	157,384
Caithness	2,783	4.1	13,379	19.9	67,274	93,467
Inverness	5,508	6.5	17,738	21.0	84,337	116,322
Kincardine	5,383	9.1	11,234	18.9	59,286	117,866
Moray	7,050	14.7	9,449	19.7	47,975	91,543
Nairn	1,157	8.9	2,815	21.7	12,986	24,340
Orkney	6,055	6.9	15,242	17.3	87,929	113,183
Ross	5,661	6.9	15,391	18.9	81,608	134,421
Shetland	849	5.5	4,514	29.5	15,316	19,644
Sutherland	1,001	4.7	5,273	24.7	21,351	28,102
Total N.O.S.C.A. Area	98,237	10.5	163,023	17.5	933,181	1,521,039

Source: D.A.F.S. June and December Censuses, 1967.

The total acreage of grass cut either for silage or hay, in the area as a whole, amounted to more than a sixth of the total acreage of crops and grass and to 28 per cent of the acreage of grass. Considerably more grass was conserved as hay than as silage in the area as a whole, despite the great increase in silage production over the last 12 years (see Table I), but in Aberdeenshire the acreage of grass cut for silage was virtually as great as for hay.

RESULTS OF THE INVESTIGATION

Introduction

Since several farmers had shown an interest in the economics of silage production and information on this is also of value for farm planning and cost studies of ruminant livestock, it was decided to carry out a survey on various aspects of silage production in 1967. Farmers were approached to co-operate in this who had either expressed interest or were expected to be interested in such a study, the majority being members of The North of Scotland Grassland Society. Thus it was not a random sample and grassland efficiency was probably somewhat above average, giving a slightly lower average cost of production than for the area as a whole.

An analysis of the average cost of production is presented together with general data and efficiency factors. Particular consideration is given to contract harvesting, sealing, scale of production, fertiliser use and wilting.

The Sample

Full results were obtained from 40 farms. Of these farms two were making high dry matter silage in tower silos. Since this is a somewhat different method of conservation with differences in cost structure, the results from these farms have been omitted from the general analysis and are considered in a separate section of the report.

Of the 38 farms, 27 were located in Aberdeenshire, 5 in Banffshire and 6 in Kincardineshire. They varied considerably in type, size and location. On 18 farms the silage was made primarily for feeding to growing and fattening beef stock, while 10 farms used the silage mainly for their beef breeding and rearing herds and another 10 farms made silage for their dairy herds. The average acreage of crops and grass per farm was 279, with a range from 65 to 1,428 acres. The size distribution is shown in Table V below. Five of the farms could be described as 'upland farms' being at an altitude above 500 feet with rough grazing forming over a third of the farm acreage.

TABLE V

Distribution of Sample According to Acreage of Crops and Grass (excluding rough grazing)

Acres of Crops and Grass	Less than 100	100-199	200-299	300-399	400-499	500 and Over
Number of Farms	3	16	7	4	3	5

Weather Conditions

The summer of 1967 was one of the finest for many years in the North-East of Scotland. The costs of harvesting the silage were therefore probably somewhat lower than average. There were relatively few occasions when work had to stop because of a change in the weather, and it would be expected that cutting and loading proceeded at a rather faster rate in the generally dry conditions. There was plenty of rain in the Spring to give a good yield of first-cut silage, but in many cases the yield of second-cut silage was adversely affected by the dry conditions, particularly where the first-cut was taken rather late.

The Cost Structure of Silage Production

The costs are presented in four forms. The costs 'per acre per cut' are the most accurate, since yield estimation is not involved. The cost 'per ton' is the simplest measure of cost per unit output, being based on estimation of the tonnage of silage in the pits. Comparisons of costs per ton can be misleading if there are differences in dry matter content of the silage. The cost 'per ton dry matter' overcomes this, being based on the per cent dry matter determined in the silage analysis. The ultimate objective of producing silage is as a feed for ruminant stock. The costs 'per ton starch equivalent' have therefore been calculated, based on the estimate of starch equivalent content made in the silage analysis, to give a measure of the cost per unit of feed energy produced.

TABLE VI

Average Costs of Silage Production, 38 Farms, 1967

Item	Per Acre Per Cut	Per Ton	Per Ton Dry Matter	Per Ton Starch Equivalent
	£	£	£	£
Fertilisers and Lime	3.15	0.59	2.65	5.42
Seeds	0.42	0.08	0.36	0.73
Additives	0.07	0.01	0.05	0.10
Contract and Casual Work	0.16	0.03	0.14	0.29
TOTAL VARIABLE COSTS (Range)	3.80 (2.36-7.06)	0.71 (0.37-1.31)	3.20 (1.63-5.91)	6.54 (3.68-12.76)
Regular Labour	1.58	0.30	1.33	2.74
Tractor Work	1.06	0.20	0.90	1.83
Depreciation and Repairs for Specialised Machinery	0.93	0.16	0.75	1.56
TOTAL HARVESTING COSTS (Excluding Contract and Casual Work) (Range)	3.57 (0.68-7.50)	0.66 (0.15-1.17)	2.98 (0.70-5.29)	6.13 (1.46-12.86)
Silo Depreciation	1.16	0.21	0.95	1.93
Labour and Tractor Costs for Spreading Fertiliser	0.47	0.09	0.40	0.82
Labour and Tractor Costs for Establishment of Ley	0.18	0.03	0.15	0.30
Rent	1.32	0.25	1.13	2.30
Overhead Costs	2.52	0.47	2.14	4.38
TOTAL OTHER COSTS (Range)	5.65 (2.70-8.30)	1.05 (0.60-1.79)	4.77 (2.73-7.40)	9.73 (5.59-15.82)
TOTAL COST (Range)	13.02 (8.13-19.79)	2.42 (1.52-3.72)	10.95 (6.81-14.96)	22.40 (14.32-36.34)

If a farmer has fields in grass and possesses the equipment for silage production, the direct outlays which he has to make to produce silage are quite small. In fact, virtually the only direct cost may be for fertilisers and this amounted to less than 12s. per ton of silage on average or about £5 per ton of starch equivalent for this sample of 38 farms. The cost of seeds may be directly attributable to the silage where special short-term leys are established specifically for silage production. In other cases a proportion of the costs of lime and seeds has been included in the variable costs shown in Table VI in order to conform with standard costing procedure. Some farmers employed a contractor or extra casual labour for silage-making and some applied additives to the silage. These direct outlays are naturally also included in the variable costs.

The average total variable costs for the sample of 38 farms was approximately 14s. per ton of silage, or £6:11: - per ton of starch equivalent, making up less than a third of the total cost of silage. The variable costs for individual farms ranged from 7s. 5d. to £1: 6: 2.

per ton of silage and from £3:13: 7 to £12:15: 2 per ton of starch equivalent.

Regular labour for harvesting and securing the silage crop on average cost 6s. per ton of silage and about £2:14: - per ton of starch equivalent. This was the largest single cost item after the cost of fertilisers. The cost of tractor work was about two-thirds of the labour cost and the cost of depreciation and repairs to silage machinery was less again, amounting to 3s. 2d. per ton of silage and £1:11: 2 per ton of starch equivalent. Total harvesting costs, excluding contract and casual work, at approximately 13s. per ton of silage and £6: 3: - per ton of starch equivalent formed rather more than a quarter of the total cost of silage production.

Silo depreciation and the share of rent were quite important cost items, but the cost of spreading fertiliser and the share of the cost of establishing the grass were of minor importance. For the 10 farms which were tenanted the average rent paid was £3: 4: - per acre. The item called 'Overhead Costs' is a composite charge, calculated by a standard procedure (see Appendix), to cover a share of all the general farm expenses. It constituted almost a fifth of the total cost of silage production.

The average total cost of silage production amounted to approximately £2: 8: - per ton of silage or £22: 8: - per ton of starch equivalent. The cost on individual farms ranged from £1:10: - to £3:14: - per ton of silage and from £14: 6: - to £36: 7: - per ton of starch equivalent. On almost three-quarters of the farms the cost per ton of starch equivalent was between £15 and £25 and on only two farms was the cost above £30 per ton of starch equivalent, as shown in Table IX.

The cost of starch equivalent from silage can be compared with the cost of starch equivalent in an alternative feedingstuff such as barley. Barley contains approximately 71 lb. of starch equivalent per 100 lb. grain. At an average sale price of £21 per ton the cost of feeding home-grown barley is approximately £29:12: - per ton of starch equivalent. At an average purchase price of £22:10: - per ton the cost of bought barley is approximately £31:14: - per ton of starch equivalent. Thus in almost all cases the cost of starch equivalent from silage was less than that from barley. In addition the relatively high protein content of silage must be borne in mind.

General Data and Efficiency Factors

The average quantity of silage costed per farm was 355 tons, but a few farmers made further silage which was not costed and some shared their machinery with a neighbour, so that the total quantity of silage harvested by the silage machinery on the average farm amounted to 425 tons. The range on the individual farms was from 100 tons to over 2,000 tons of silage, though, as the distribution in Table IX shows, only 4 farms made over 1,000 tons.

The average acreage from which the costed silage was harvested was 50 acres, 16 acres of this being cut twice, giving a total of 66 acres grass cut for silage. On 11 farms only one cut of silage was made. The average yield of silage was 7.1 tons per acre or 5.5 tons per acre per cut. On the basis of the silage analyses this was equivalent to a yield of 1.20 tons of dry matter per acre per cut and 0.58 tons of starch equivalent per acre per cut. Individual yields ranged from 3.6 to 7.9 tons of silage per acre per cut or 0.42 to 0.81 tons of starch equivalent per acre per cut. These yields were obtained with applications of nitrogen varying from 30 to 103 units per acre per cut, the average nitrogen use being 63 units per acre per cut.

TABLE VII

General Data and Efficiency Factors

Item	Average of 38 Farms	Range
Tons of Silage Costed	355	100 - 1,120
Total Tons of Silage Made	425	100 - 2,240
Acres Costed	50	16 - 194
Costed Acreage Cut Over (Acreage Cut Once + Acreage Cut Twice)	66	16 - 287
Tons of Made Silage per Acre	7.1	4.8 - 10.8
Tons of Made Silage per Acre per Cut	5.5	3.6 - 7.9
Tons of Silage Dry Matter per Acre per Cut	1.20	0.72- 1.73
Tons of Silage Starch Equivalent per Acre per Cut	0.58	0.42- 0.81
Units of Nitrogen Applied per Acre per Cut	63	30 - 103
Labour Hours per Acre per Cut	5.5	2.7 - 9.2
Labour Hours per Ton of Made Silage	1.0	0.5 - 2.0
Labour Hours per Ton of Silage Dry Matter	4.5	2.4 - 8.5
Labour Hours per Ton of Silage Starch Equivalent	9.3	4.3 - 18.6
Tractor Hours per Acre per Cut	4.6	2.5 - 8.1
Tractor Hours per Ton of Made Silage	0.8	0.4 - 1.6
Tractor Hours per Ton of Silage Dry Matter	3.8	2.1 - 7.2
Tractor Hours per Ton of Silage Starch Equivalent	7.8	3.8 - 14.3
Average Number of Men in Harvesting Team	3	1 - 6
% of Labour Hours Spent in Work at Silage Pits	44	20 - 77
Rate of Harvesting - Tons of Made Silage per Day	20	6 - 82
Silage Analysis		
pH	4.0	3.6 - 4.8
% Dry Matter	21.7	18.0 - 33.1
% Crude Protein in Dry Matter	12.92	6.88- 24.58
Lb. Starch Equivalent per 100 lb. Silage	10.9	8.7 - 13.1
% Digestible Crude Protein	1.87	0.70- 3.84
Size of Farm - Acres Crops and Grass	279	65 - 1,428

Labour

The labour and tractor work involved in harvesting and securing the silage crop varied from 0.5 to 2.0 man hours per ton and from 0.4 to 1.6 tractor hours per ton, the averages being 1.0 man hours per ton and 0.8 tractor hours per ton. The average number of men in the harvesting team was 3 and the average proportion of labour hours spent working at the silage pits was 44 per cent. The silage was harvested at an average rate of 20 tons of made silage per working day, though on one farm a rate of 82 tons per day was achieved.

The wide range in values of these efficiency measures may be due to various factors - e.g. field size, farm and building layouts, local weather conditions, labour requirements of other enterprises, etc. However, in large measure they must indicate the efficiency of the farmer or manager in organising and supervising the harvesting and ensiling of the grass. To minimise the labour and tractor work involved it is essential to have the

most suitable machinery for the particular farm situation, well maintained and serviced and to plan the job in advance as far as possible, with adjustments as seem necessary in practice. A little careful thought can usually improve the system. The two main aims must be (1) to synchronise the various operations as far as possible to reduce idle time and (2) to minimise the amount of travelling.

Silage Analysis

Most farmers appear to have achieved a reasonable fermentation of the silage, the highest pH being 4.8. The average dry matter in the silage was 21.7 per cent, but it varied from 18.0 to 33.1 per cent between different farms since some wilted the silage while others did not adopt this practice. Variations in crude protein and digestible crude protein content were particularly great. The largest value for crude protein of 24.58 per cent seemed exceedingly high, but the analysis was repeated and confirmed. The starch equivalent varied from 8.7 to 13.1 per cent, the average being 10.9 per cent. All or most of the silage was wilted on 13 farms and on 4 others a part of the silage was wilted.

Seeds

The majority of the farmers in the sample made silage from medium or long-term leys sown with general-purpose seeds-mixtures. However, 11 farmers did sow special 1 or 2 year seeds mixtures specifically for silage production. These mixtures consisted mainly of Italian and perennial ryegrass, but on these farms other leys were cut as well. On 4 farms some or all of the silage was cut from newly established leys under cereal nurse crops, so that the cereal provided most of the silage.

Additives

Molasses were added to the silage on 4 farms and on one farm a commercial preparation was used, but only part of the silage was treated in some of these cases. The average cost of the additive per ton of silage treated was approximately 3s. both for the molasses and the commercial preparation. No significant effect on the silage analyses could be determined with this limited number of farms. Again, without knowledge of the yield and analyses of the fresh grass one cannot know whether the loss of nutrients in conservation was reduced.

Contract Harvesting

On 2 farms the cutting and transporting of the silage was done by a contractor, but with regular labour working at the pit. In one case the contractor supplied a man, a tractor, a forage harvester and a cart at a charge of £1 per hour and in the other case 2 men, 2 tractors, 2 carts and a forage harvester were supplied at a cost of £1:15: - per hour. Enquiries showed that these were the normal contracting rates at the time. Table VIII compares the average harvesting costs for these 2 farms with those for farms using no contract or casual labour. One cannot make categorical statements on the basis of 2 cases, but it is interesting to find that the average harvesting costs and total cost of silage for these farms was similar to the average costs on those farms which used no contract or casual labour. As one would expect, the 2 farms were not making particularly large quantities of silage - 135 tons and 350 tons - so that their moderate costs are the more notable, considering the relationship between scale of production and costs (see Table X).

TABLE VIII

Harvesting Costs on Farms Employing a Contractor Compared with Farms Using no Contract or Casual Labour

Item	Farms Employing a Contractor	Farms Using no Contract or Casual Labour
Costs per Ton	£	£
Contract Work	0.40	-
Regular Labour	0.13	0.30
Tractor Work	0.07	0.20
Depreciation and Repairs for Specialised Machinery	0.06	0.17
TOTAL HARVESTING COSTS (Including Contract Work)	0.66	0.67
TOTAL COST	2.19	2.39
Cost per Ton of Starch Equivalent		
Contract Work	3.89	-
Regular Labour	1.35	2.80
Tractor Work	0.69	1.85
Depreciation and Repairs for Specialised Machinery	0.56	1.63
TOTAL HARVESTING COSTS (Including Contract Work)	6.49	6.28
TOTAL COST	21.35	22.24
Other Data		
Number of Farms	2	36
Total Tons of Silage Made	242	448
Tons of Made Silage per Acre per Cut	5.7	5.5
Tons of Silage Starch Equivalent per Acre per Cut	0.59	0.58
Labour Hours per Ton of Silage (Excluding Contract)	0.4	1.0
Labour Hours per Ton of Starch Equivalent (Excluding Contract)	4.2	9.0
Tractor Hours per Ton of Silage (Excluding Contract)	0.3	0.8
Tractor Hours per Ton of Starch Equivalent (Excluding Contract)	3.0	7.7
Rate of Harvesting - Tons of Made Silage per Day	18	20

For a situation in which regular labour is readily available on the farm for silage-making it is fairly easy to estimate the 'break-even' scale of production below which it is cheaper to hire a contractor than to buy silage machinery because it is a direct comparison between the machinery costs and the cost of a contractor. This has been done below. The costs of the new forage harvester and silage sides have been depreciated over 10 years since we are considering situations where relatively small quantities of silage are to be made.

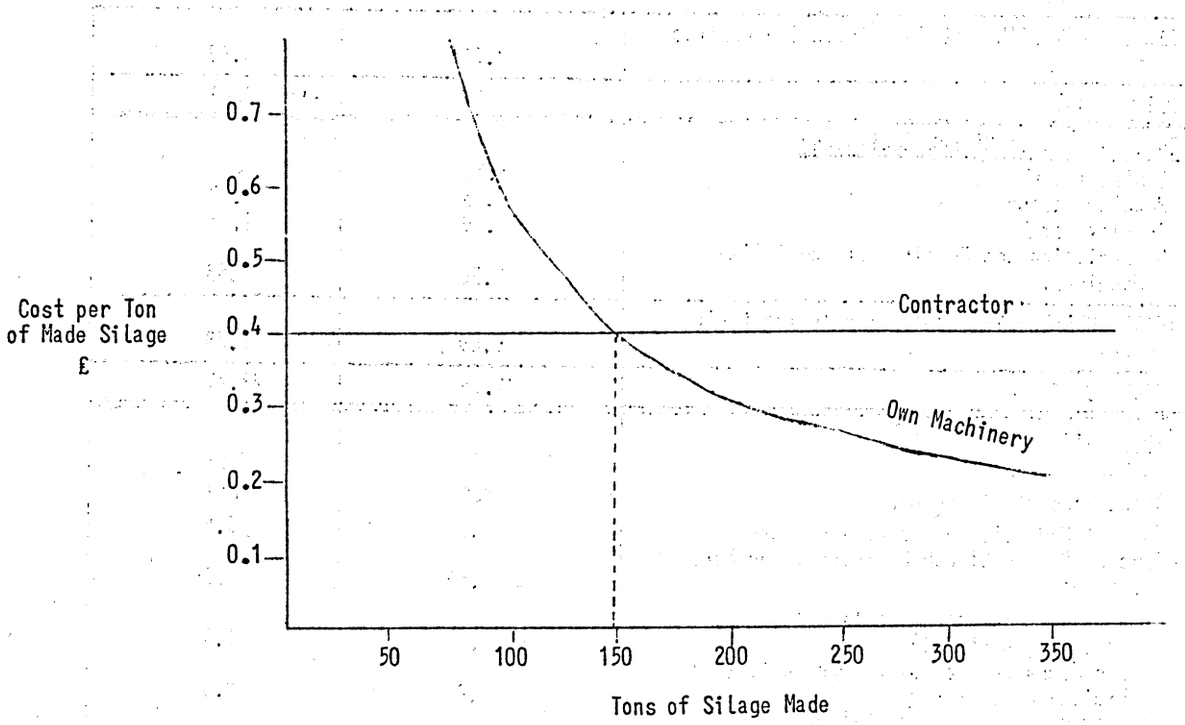
	Costs per Annum
	£
Depreciation on Forage Harvester at £250	25
Depreciation on Silage Sides for Trailer at £50	5
Interest on Capital - 10% on £150	15
Repairs	5
TOTAL MACHINERY COSTS	£50

In addition, the cost of tractor fuel and repairs is estimated at £0.07 per ton for cutting and carting.

On this basis the machinery costs per ton for cutting and carting the silage have been derived for making various quantities of silage. These are presented graphically in Figure I in comparison with the cost of hiring a contractor, taken as £0.40 per ton (from Table VIII).

Figure I

Alternative Costs of Hiring a Contractor or Owning Machinery for Harvesting Silage



The dotted line shows the 'break-even' scale of production as 150 tons of made silage - i.e. it would probably be cheaper to hire a contractor rather than buy a new forage harvester and silage sides where less than 150 tons of silage are to be made, even if regular labour is available for the cutting and carting of silage.

If reasonable second-hand machinery can be obtained, then the scale below which it is cheaper to hire a contractor may be somewhat lower. On the other hand, if other crops and stock, such as roots and sheep, make large demands on the regular farm labour at the time of silage-making, then there will be additional costs for the farmer doing his own harvesting to weigh against the cost of hiring a contractor. If the farmer carries on with just the regular staff, then untimeliness of operations are likely to result in a lower output of at least one enterprise in terms of quality or quantity. If casual labour is hired, then this is clearly an additional cost which would not be borne if a contractor was used. Again, if labour requirements are at a peak at silage-making, but the regular farm staff can cope adequately, the possibility of reducing the regular staff must be considered, perhaps with adjustment of labour requirements at other periods of peak demand. Thus it may be profitable to hire a contractor to make quantities of silage considerably greater than 150 tons.

Machinery

The normal complement of silage machinery consisted of a buck-rake, a forage harvester and one or two trailers with high-sides, plus a mower where wilting was carried out. The average initial cost of the machinery was £430, varying from £66 to £1,715 on individual farms. Flail forage harvesters numbered 32, 6 farms used 'double-chop' harvesters and 1 a 'full-chop' machine, while on 1 farm a green-crop loader was used. The average age of these machines was 3-4 years.

The average cost of repairs and new parts for the silage machinery did not appear to be high, amounting to about £5 per farm on average.

Silage Pits

A total of 70 silage pits were costed, 47 of these being roofed and 23 uncovered. Of the 47 covered pits only 21 were initially built as silage pits, the rest being conversions of old buildings. In almost all cases straw or hay was stored above the silage in the roofed pits.

Sealing and Wastage

In 30 pits the silage was covered with some form of plastic or rubber sheeting after filling and rolling. Another 4 pits were covered with empty plastic fertiliser bags, while the remaining 36 were not sealed in any way apart from rolling. Only two farmers covered the silage each night, but a few others put sheets over when ensiling was stopped for a day or more.

The depth of visible waste on the top of the silage varied considerably. In some outside pits it was 6 inches or more, while in unsealed but roofed pits it varied from 1 to 4 inches and in sealed pits the range was from nil to 3 inches. In many cases sealing was not very efficient because:

(a) there was not an effective seal at the junction of the plastic sheet and the pit walls,

(b) the sheets were rather thin and had torn in places,

(c) the sheets were not effectively held down on the silage, and

(d) sealing was not carried out soon enough.

If it can be arranged that some of the sheeting hangs at least part of the way down the pit walls during filling then the pressure of the silage ensures a good seal with the walls. Probably the minimum thickness of polythene to avoid a lot of tears is 500 gauge. It appeared that the best method to avoid the passage of air underneath the polythene was to cover with one complete layer of straw or hay bales and to ensure that sealing is carried out as soon as possible after filling the pit. Where these principles are followed the amount of visible wastage should be negligible. One farmer was very successfully using thick rubber sheets, the weight of which was sufficient to prevent the passage of air beneath them.

The cost of 500 gauge polythene is about 1.33d. per square foot. If a 2 inch depth of silage is saved from wastage, this amounts to 0.167 of a

cubic foot per square foot of surface or approximately 0.003 of a ton of silage. At a cost of £2: 8: - per ton the value of the silage saved per square foot of surface is almost 2d. Thus the polythene can pay for itself in one year by the saving in visible wastage alone, although it can probably be used for 2 or 3 years. One must also bear in mind that by preventing the passage of air through the silage, oxidation of sugars in the silage is reduced, resulting in a better fermentation and less nutrient losses. The rubber sheeting mentioned in the previous paragraph was rather more expensive at about 1s. 6d. per square foot, but it is likely to last for at least 5 years and does not really need to be weighted down as the polythene does.

Vacuum Silage

One farmer made about 60 tons of vacuum silage as well as 75 tons of sealed silage. The building and shaping of the stack of vacuum silage, which was made outside with no supporting walls, required rather more labour than the filling of the silage pit. However, the method of vacuum sealing enabled good quality silage to be made without a large capital outlay for building a silage pit. The initial cost of the polythene sheeting and sealing equipment was about £45 and it seemed that one sheet per year might need replacement at a cost of £18. The vacuum pump was a simple conversion of an old car engine, at a cost of £12 and was driven from the tractor power take-off. Thus the annual cost, at little more than £20, was considerably less than the costs of depreciation, interest on capital and polythene sheeting would have been, had a new pit been built for making sealed silage.

Effluent

Under the Rivers (Prevention of Pollution) (Scotland) Act 1965 it became obligatory for farmers to obtain the consent of the River Purification Authority both for any existing discharges of effluent which find their way into watercourses and any proposed effluent discharges. Restrictions on silage effluent discharge are likely to be particularly strict because of its extremely noxious character. Thus, many farmers will have to make special arrangements for the disposal of silage effluent. Of the farms in

the sample 16 have made some provision for this. In 6 cases soakaways have been constructed and in 10 cases tanks have been made to collect the effluent, which can then be pumped out and spread on the land by a sludge cart.

Scale of Production

There was a wide range in the scale of production of silage on the farms in the sample, as Table IX shows. It also shows the distribution of the sample according to both the quantity of silage made and the cost per ton of starch equivalent. It appears from this that where larger amounts of silage were made the costs of production tended to be lower, although there was clearly considerable variation in cost within the size groups.

TABLE IX

Distribution of Sample According to Scale of Production and Cost per Ton of Starch Equivalent

Cost per Ton Starch Equiv. \ Tons of Silage Made	Less than 200 tons	200-299 tons	300-399 tons	400-499 tons	500-999 tons	1,000 tons and over	TOTAL
Less than £15.0	-	-	-	-	1	-	1
£15.0 - 19.9	-	1	4	1	3	3	12
£20.0 - 24.9	4	1	4	3	2	1	15
£25.0 - 29.9	3	3	-	-	2	-	8
£30.0 - 34.9	-	-	1	-	-	-	1
£35.0 and over	1	-	-	-	-	-	1
TOTAL	8	5	9	4	8	4	38

To throw further light on the association between scale of production and costs of production the farms have been grouped according to the quantity of silage made and Table X presents the average results of the groups for comparison. It appears from this that there are notable economies of scale in silage production. The costs of labour, tractor work and silage machinery all show a declining trend as larger quantities of silage are made. In consequence the total harvesting costs on those farms making over 1,000 tons of silage were about half what they were on farms making less than 200 tons.

The economies arise primarily in two ways. Firstly, machines can be utilised to the maximum where larger quantities of silage are made, so that the depreciation cost per ton of silage is minimised. Secondly,

machines with a greater output can be used. These machines cost less in depreciation per ton of output and also increase the productivity of the men and tractors, as the labour and tractor requirements in the different groups show.

The use of a larger team of men may enable a better organisation of the cutting and carting in some situations, but it was only on the farms making over 1,000 tons of silage that the teams were notably greater. Grouping the farms according to team size itself did not show any clear advantage for larger teams.

TABLE X

Production Costs in Relation to Scale of Production

Total Quantity of Silage Made	Less than 200 tons	200-299 tons	300-399 tons	400-499 tons	500-999 tons	1,000 tons and over
Costs per Ton	£	£	£	£	£	£
Contract and Casual Work	0.04	0.06	0.07	-	-	-
Regular Labour	0.36	0.28	0.28	0.34	0.26	0.23
Tractor Work	0.22	0.25	0.18	0.22	0.18	0.16
Depreciation and Repairs for Specialised Machinery	0.29	0.21	0.11	0.09	0.13	0.11
TOTAL HARVESTING COSTS (Including Contract and Casual Work)	0.91	0.80	0.64	0.65	0.57	0.50
Silo Depreciation	0.27	0.24	0.15	0.17	0.14	0.35
TOTAL COST	2.76	2.72	2.34	2.36	2.05	2.31
Costs per Ton of Starch Equivalent						
Contract and Casual Work	0.35	0.46	0.65	-	-	-
Regular Labour	3.33	2.53	2.54	3.20	2.61	1.95
Tractor Work	2.04	2.17	1.67	2.02	1.76	1.30
Depreciation and Repairs for Specialised Machinery	2.88	1.87	1.02	0.90	1.28	0.98
TOTAL HARVESTING COSTS (Including Contract and Casual Work)	8.60	7.03	5.88	6.12	5.65	4.23
Silo Depreciation	2.61	2.21	1.30	1.60	1.45	2.93
TOTAL COST	26.08	24.32	21.29	22.27	20.32	19.34
Other Data						
Number of Farms	8	5	9	4	8	4
Tons of Silage Made	164	255	351	425	681	1,374
Tons of Made Silage per Acre per Cut	6.0	5.2	5.2	5.0	6.3	5.5
Tons of Starch Equivalent per Acre per Cut	0.63	0.59	0.57	0.52	0.63	0.65
Labour Hours per Ton of Made Silage	1.2	1.1	1.0	1.1	0.9	0.7
Labour Hours per Ton of Starch Equivalent	11.2	9.8	9.3	10.4	8.4	6.3
Tractor Hours per Ton of Made Silage	1.0	1.0	0.8	0.9	0.7	0.6
Tractor Hours per Ton of Starch Equivalent	8.9	9.1	7.7	8.5	7.4	5.5
Average Number of Men in Team	3	3	3	4	3	5
Rate of Harvesting - Tons per Day	16	15	19	20	24	49
Size of Farm - Acres Crops and Grass	172	197	236	290	326	716

It must be noted that the 'Tons of Silage Made' on which the grouping is based, does not in every case mean only the quantity of silage made on the particular farm. Where machines, and usually a common team of men, were shared with a neighbouring farmer, an estimate of the total quantity of silage made by the machinery and the team was used. The sharing of machines and, where necessary, men enables farmers making small or medium quantities of silage to gain some of the economies of scale.

Table X also reveals some tendency towards lower depreciation costs for silage pits where larger quantities of silage are made. However the group making over 1,000 tons of silage does not fit into this pattern. This is because on all the farms in this group new silage pits had been built within the previous 10 years, resulting in considerable depreciation costs, whereas on many of the other farms either pits had been made comparatively cheaply by the modification of old buildings, or else the pits were over 10 years old and could not be considered to bear any depreciation charge.

The cost economies described above are not counteracted to any degree by diseconomies in other costs, so that the total costs of silage production in Table X do indicate the existence of economies of scale.

Nitrogenous Fertilisers

There was considerable variation in the quantities of nitrogenous fertiliser applied for silage production, from 30 to 103 units of nitrogen being applied per acre per cut on different farms. The distribution of the sample according to the use of nitrogenous fertiliser and the yield of silage starch equivalent is shown in Table XI.

TABLE XI

Distribution of Sample According to Use of Nitrogenous Fertiliser and Yield of Silage Starch Equivalent

Yield of Silage Starch Equiv. per Acre per Cut \ Nitrogenous Fertiliser Applied per Acre per Cut	Less than 50 Units	50-59 Units	60-69 Units	70-79 Units	80 Units and Over	Total
Less than 0.45 tons	2	1	-	-	-	3
0.45 - 0.49 tons	-	1	1	-	1	3
0.50 - 0.54 tons	1	2	1	1	1	6
0.55 - 0.59 tons	1	1	1	1	-	4
0.60 - 0.64 tons	2	4	4	-	-	10
0.65 - 0.69 tons	-	1	1	2	1	5
0.70 - 0.74 tons	-	2	2	-	1	5
0.75 - 0.79 tons	-	-	-	-	1	1
0.80 tons and over	-	-	-	1	-	1
Total	6	12	10	5	5	38

An association between the number of units of nitrogen applied and the yield of silage starch equivalent is suggested although the yields obtained at any particular level of fertiliser use show great variation.

In Table XII the farms are grouped according to their level of nitrogen use and the average costs and other data are shown. Again the results indicate that the farms using more nitrogenous fertiliser achieved a higher yield of silage dry matter and starch equivalent per acre on average, at least up to the level of 80 units of nitrogen per acre per cut.

A statistical analysis of this apparent relationship was carried out*. This gave positive confirmation of a response of silage dry matter yield to increasing applications of nitrogenous fertiliser up to the level of 80 units of nitrogen per acre per cut. Beyond this level the stage of diminishing marginal returns appears to have been reached. An average increase of 1.65 cwt. of dry matter was indicated for each additional 10 units of nitrogen applied up to 80 units per acre per cut. This is somewhat greater than the 1 cwt. response found in a recent I.C.I. silage survey, though the range included applications above 80 units in that instance.(6)

The analysis showed that the yield of silage starch equivalent was even more responsive to increasing nitrogen applications. An average increase of 1.41 cwt. of starch equivalent was indicated for each additional 10 units of nitrogen applied up to 80 units per acre per cut. In monetary terms this means that on most farms 1.41 cwt. of starch equivalent, which would cost over £2 in the form of purchased barley, can be obtained for the outlay of approximately 8s. for 10 units of nitrogenous fertiliser. Alternatively, it means that on the average farm in this sample the application of an additional 10 units of nitrogen per acre per cut would enable the same quantity of silage to be made with a 12 per cent reduction in the acreage of grass cut.

The relationships between nitrogen use and the starch equivalent content and per cent digestible crude protein of the silage were also examined but no definite association was revealed in either case.

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*See Appendix for detailed results of the statistical analysis.

(6)Silage: The Quest for Quality. The report of an I.C.I. silage survey covering 92 farms, by J. F. Crozier, R. B. Thompson and W. Thomson. I.C.I. Farming Service, 1967.

TABLE XII

Production Costs in Relation to Nitrogen Use

Item	Nitrogenous Fertiliser Applied Per Acre Per Cut				
	Less than 50 Units	50-59 Units	60-69 Units	70-79 Units	80 Units and Over
Costs per Acre per Cut	£	£	£	£	£
Fertilisers and Lime	2.74	2.98	3.10	3.86	4.01
Other Variable Costs	0.45	0.57	0.85	0.80	0.53
TOTAL VARIABLE COSTS	3.19	3.55	3.95	4.66	4.54
TOTAL HARVESTING COSTS (Excluding Contract and Casual Work)	3.34	3.87	3.37	3.50	4.12
Other Costs	5.57	5.67	6.01	5.78	5.77
TOTAL COST	12.10	13.09	13.33	13.94	14.43
Costs per Ton of Starch Equivalent					
Fertilisers and Lime	5.36	5.10	5.07	5.91	6.42
Other Variable Costs	0.89	0.95	1.54	1.27	0.84
TOTAL VARIABLE COSTS	6.25	6.05	6.61	7.18	7.26
TOTAL HARVESTING COSTS (Excluding Casual and Contract Work)	6.48	6.69	5.43	5.34	6.47
Other Costs	10.61	9.85	9.72	8.93	9.20
TOTAL COST	23.34	22.59	21.76	21.45	22.93
Other Data					
Number of Farms	6	12	10	5	5
Tons of Silage Made	353	346	646	361	771
Tons of Made Silage per Acre per Cut	5.3	5.5	5.9	5.7	5.8
Tons of Silage Dry Matter per Acre per Cut	1.16	1.19	1.28	1.39	1.16
Tons of Silage Starch Equivalent per Acre per Cut	0.53	0.59	0.62	0.65	0.63
Units of Nitrogen Applied per Acre per Cut	42	54	65	75	96
Silage Analysis					
pH	4.0	4.2	3.9	4.0	4.4
% Dry Matter	22.1	22.0	21.9	25.5	20.2
% Crude Protein in Dry Matter	11.78	14.05	12.97	12.57	15.00
Lb. Starch Equivalent per 100 lb. Silage	10.1	10.9	10.7	11.9	11.0
% Digestible Crude Protein	1.53	1.94	1.78	2.13	2.01

The cost of fertilisers and lime per acre per cut was naturally higher where more nitrogenous fertiliser was used. Because the use of more fertiliser increased the yield of silage, other costs which are related to the quantity of silage, such as harvesting and storage costs, also tended to be higher per acre. Thus the total cost per acre per cut showed a marked increase with greater use of nitrogenous fertiliser.

The costs of fertilisers and lime per ton of starch equivalent tended to decrease slightly with the use of more nitrogen per acre per cut, up to the level of 70 units. Beyond this it appears that further nitrogen use added to the cost of fertilisers and lime per ton of starch equivalent. However, the average total cost showed a downward trend with increased use

of nitrogen up to the level of 80 units. This was due to the effect of the yield of starch equivalent per acre per cut, which increased with nitrogen use up to the level of 80 units. Costs which are related to the acreage, such as seeds, establishment, rent and, to some extent, harvesting costs, were therefore spread over a greater tonnage of silage starch equivalent and so amounted to less per ton of starch equivalent.

One must bear in mind the variation in yield shown in Table XI, so that it would be naive to say that 80 units of nitrogen per acre per cut is the optimum level of fertiliser application to minimise the cost per ton of silage starch equivalent. Clearly many other factors influence the yield obtained and conditions vary greatly from farm to farm, so that the optimum level of fertiliser use may vary considerably too. Nevertheless, the results do demonstrate that quite large applications of nitrogenous fertilisers are likely to provide an economic gain.

Wilting

In Table XIII the average results are shown for the 13 farms on which all or most of the grass was wilted before ensiling and for the 21 farms where no wilting was carried out. On the remaining 4 farms in the sample some of the grass was wilted and the rest was not wilted. The wilting period varied greatly from 4 to 48 hours, but in general the grass was only moderately wilted. In only three cases were any operations carried out on the cut crop to aid wilting, a tedder being used for some of the crop on one farm and a turner being used on two farms. On three farms a flail mower or modified flail forage harvester was used to cut the grass, reciprocating mowers being used on the other farms.

The difference in dry matter content between the wilted and unwilted silage was surprisingly little. The relatively high percentage dry matter of the unwilted silage was no doubt due to the warm dry weather when harvesting, but the comparatively low percentage dry matter for the wilted silage is difficult to understand.

TABLE XIII

Production Costs of Wilted and Unwilted Silage

Item	Wilted	Unwilted
Costs per Ton	£	£
Contract and Casual Work	0.01	0.05
Regular Labour	0.32	0.27
Tractor Work	0.21	0.19
Depreciation and Repairs for Specialised Machinery	0.17	0.17
TOTAL HARVESTING COSTS (Including Contract and Casual Work)	0.71	0.68
Silo Depreciation	0.21	0.22
Other Costs	1.70	1.41
TOTAL COST	2.62	2.31
Costs per Ton of Starch Equivalent		
Contract and Casual Work	0.04	0.49
Regular Labour	2.66	2.77
Tractor Work	1.73	1.85
Depreciation and Repairs for Specialised Machinery	1.45	1.75
TOTAL HARVESTING COSTS (Including Contract and Casual Work)	5.88	6.86
Silo Depreciation	1.80	2.23
Other Costs	14.05	14.07
TOTAL COST	21.73	23.16
Other Data		
Number of Farms	13	21
Tons of Silage Made	666	384
Tons of Made Silage per Acre per Cut	5.1	6.0
Tons of Silage Dry Matter per Acre per Cut	1.16	1.29
Tons of Silage Starch Equivalent per Acre per Cut	0.60	0.60
Units of Nitrogen Applied per Acre per Cut	67	62
Labour Hours per Ton of Made Silage	1.1	1.0
Labour Hours per Ton of Silage Starch Equivalent	8.7	9.8
Tractor Hours per Ton of Made Silage	0.9	0.8
Tractor Hours per Ton of Silage Starch Equivalent	7.3	8.2
Average Number of Men in Harvesting Team	4	3
Rate of Harvesting - Tons of Made Silage per Day	27	20
Silage Analysis		
pH	4.1	4.1
% Dry Matter	23.1	21.8
% Crude Protein in Dry Matter	15.35	12.12
Lb. Starch Equivalent per 100 lb. Silage	12.1	10.0
% Digestible Crude Protein	2.38	1.56

Nevertheless, the silage analysis showed a considerable difference in nutrient content between the wilted and unwilted silage. The average starch equivalent content of the wilted silage was about 20 per cent in excess of that of the unwilted silage and the percentage digestible crude protein was about 50 per cent greater than in the unwilted silage. This was probably due mainly to ensiling less mature, more nutritious grass, which can be done successfully with wilting because it encourages a more rapid lactic acid type of fermentation. This could also provide some of the reasons why the dry matter percentage of the wilted material was not higher - i.e. because the initial dry matter of the young grass ensiled would have

been rather low.

As one would expect the yield of made silage per acre per cut tended to be lower where it had been wilted. The yield of silage dry matter was also somewhat lower, perhaps confirming that the grass was cut at a less mature stage for wilting, bearing in mind that the farms wilting the grass also applied rather more nitrogenous fertiliser. The average yield of silage starch equivalent per acre per cut was equally high for the wilted silage as for the unwilted silage however.

Wilting adds another operation to the harvesting procedure and consequently the labour and tractor hours per ton of made silage were higher where wilting was carried out. However, because the percentage of dry matter and starch equivalent in the grass is higher after wilting, a smaller weight and volume of material has to be transported to provide the same nutrient value in silage. In consequence the labour and tractor hours per ton of silage starch equivalent were lower for wilted silage on average. The average harvesting team was made up of four men where wilting was carried out, compared with three men where the silage was not wilted, and the rate of harvesting was faster.

The average costs of wilted and unwilted silage reflect the differences in silage analysis, yield and labour and tractor requirements. Thus the harvesting costs and total cost were higher per ton of silage, but lower per ton of silage starch equivalent where wilting was carried out. It must be pointed out that the farmers who wilted their silage also made a greater total quantity of silage on average and this is likely to have influenced the results. For instance, the depreciation and repairs for specialised machinery were similar per ton of silage for the two groups and lower per ton of starch equivalent on the farms carrying out wilting. Thus it appears that the spreading of these machinery costs over a larger tonnage of silage in the case of the farms where wilting was carried out resulted in a similar cost per ton as for the farms not wilting. The lower average cost of silo depreciation per ton of starch equivalent for the wilted silage may also be partly due to scale, but wilting is also likely to have played a part since the same quantity of silage nutrients can be stored in a smaller space after wilting.

Feeding

Type of Stock

The numbers of the 38 farms feeding silage to the various classes of livestock were as follows:

Type of Stock	Dairy Cattle	Suckler Cows and Calves	Growing and Fattening Beef Cattle	Sheep
Number of Farms	10	10	24	6

In no case was silage made for feeding to sheep alone and the quantities fed to sheep were relatively small. Six of the farms with herds of suckler cows kept some of the weaned calves to sell later as store or fat cattle.

Production of high quality silage is more important for feeding to intensive livestock such as dairy cows and fattening cattle than for suckler cows or sheep. The high nutrient requirements for maintenance and production with intensive stock necessitate feeding a more concentrated diet because of the limitations of appetite. Stock which do not have such high production requirements can obtain sufficient nutrients from a bulkier, less concentrated silage. In Table XIV the farms have been grouped according to the main type of stock being fed to show how this has influenced the cost and the type of silage produced.

TABLE XIV

Production Costs in Relation to Type of Stock Fed

Main Type of Stock Fed	Dairy Cattle	Beef Cattle	Suckler Cows
Costs	£	£	£
Total Cost per Acre per Cut	12.63	13.98	12.70
Total Cost per Ton of Made Silage	2.52	2.47	2.22
Total Cost per Ton of Silage Dry Matter	11.14	11.33	10.03
Total Cost per Ton of Silage Starch Equivalent	21.32	23.27	21.85
Other Data			
Number of Farms	10	18	10
Total Tons of Silage Made	704	368	473
Tons of Made Silage per Acre per Cut	5.2	5.7	5.9
Tons of Silage Dry Matter per Acre per Cut	1.18	1.24	1.28
Tons of Silage Starch Equivalent per Acre per Cut	0.60	0.61	0.60
Units of Nitrogen Applied per Acre per Cut	63	67	57
Silage Analysis			
pH	4.1	4.1	4.1
% Dry Matter	22.8	22.0	22.0
% Crude Protein in Dry Matter	14.71	13.01	12.57
Lb. Starch Equivalent per 100 lb. Silage	11.78	10.72	10.22
% Digestible Crude Protein	2.27	1.78	1.63

The differences in yield and silage analysis between the groups are what one might anticipate. Because more farms were wilting and the grass was cut at a less mature stage, the yield of made silage per acre per cut and the yield of silage dry matter per acre per cut were lowest amongst dairy farms. The farms with suckler cows had the highest average yields of silage and silage dry matter, presumably because they allowed the grass to reach a more mature stage before cutting, since they applied the least nitrogenous fertiliser. The silage analyses also confirm that younger grass was cut on the dairy farms, for the starch equivalent content was higher while the digestible crude protein content was much higher.

Although differences existed in the type of silage made for the different classes of livestock, the costs did not differ very markedly. For no obvious reason the costs were higher on the farms producing store or fat cattle. The total costs per ton and per ton of dry matter were somewhat lower on the farms with suckler cows because of the higher average yield. However, the total cost per ton of starch equivalent was slightly lower on the dairy farms.

Method of Feeding

On 15 farms some or all of the silage was self-fed and on one farm the silage was cut and forked into feeding troughs at the silage face. On the other farms various feeding systems were adopted, involving cutting by hand or machine, or removal of silage with a tractor fork-lift, followed by carting and/or barrowing of the silage to the feeding area.

It was felt that further investigation into the costs of feeding the silage would not provide very useful results because of the great variations in building layouts and feeding methods. Similarly no attempt was made to measure the production achieved from the silage because of the variations in the type of stock fed and the rations used and the difficulty in obtaining information on liveweight gains.

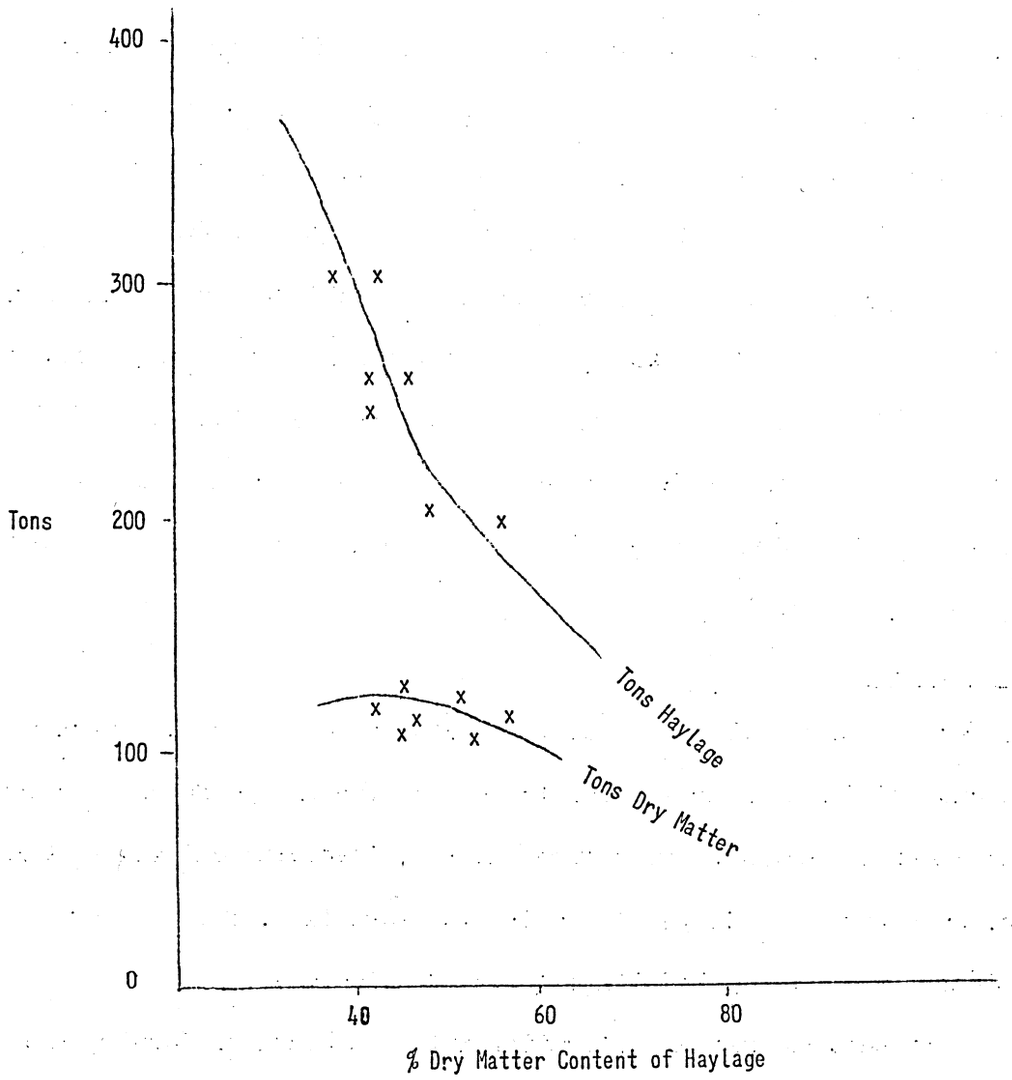
HIGH DRY MATTER TOWER SILAGE

Results were obtained for two farms on which high dry matter tower silage was made (commonly known as 'haylage'). These are presented in Table XV. Costs per ton are not shown because of the difficulty in

estimating the weight of material in a tower. Figure II shows the way in which the capacity of a tower silo varies with the percentage of dry matter in the haylage, based on recorded fillings[7].

FIGURE II

Average Capacity of a 20' x 50' Tower Silo for Haylage with given Per Cent Dry Matter



It can be seen that the tonnage of haylage contained in a tower can vary greatly with the dry matter content of the haylage - e.g. the tonnage contained at 30 per cent dry matter would be almost twice that at 50 per cent dry matter. Given the dry matter content of the haylage, the tonnage in a tower can be estimated from Figure II, with adjustments for any tower of different size.

(7)'Conservation and Storage of Grass', Comparative Study No. 2, M.A.F.F., April 1965.

However, the difficulty is to determine the average percentage of dry matter, because it varies so much through the tower. Four analyses were obtained from one of the farms, showing a range in dry matter from 30 per cent to 57 per cent, and the two analyses from the other farm gave the dry matter as 38 per cent and 56 per cent. With such variations the accuracy of the average must be in question and similarly the accuracy of the weight of haylage based on it. Figure II shows, however, that the tonnage of dry matter in a tower does not vary greatly with the dry matter content of the haylage so that some confidence can be placed in the results per ton of dry matter and per ton of starch equivalent.

The average costs of production and measures of efficiency for haylage given in Table XV can be compared with those for clamp silage in Tables VI and VII.

Variable Costs

The average variable costs for haylage were greater per acre, because more fertiliser was applied on these two farms. However, the estimated average yields of dry matter and starch equivalent per acre were considerably higher than for the farms making clamp silage, so that the average variable costs per ton of dry matter and per ton of starch equivalent were somewhat lower for haylage.

Labour and Tractor Work

The labour and tractor hours per acre per cut were similar to the average of the farms making clamp silage, but more overtime hours were put in on these two farms so that the labour cost per acre per cut was higher. The labour and tractor costs per ton of dry matter and per ton of starch equivalent were lower than for clamp silage because of the difference in yield. The normal sequence of operations in the harvesting of the haylage was as follows: first the grass was cut with a flail mower; then it was spread and teased with a tedder; it was windrowed with a side-rake and then picked up with a full-chop forage harvester and blown into forage trailers in which it was transported to the tower; finally it was tipped into a dump box and blown up into the tower. The average harvesting team consisted of five men - usually three men picking up and carting with two trailers and two others cutting, tedding, side-raking or supervising the operation of the dump-box and blower.

TABLE XV

Costs of Production of Haylage

Item	Costs per Acre per Cut	Costs per Ton Dry Matter	Costs per Ton Starch Equivalent
	£	£	£
Fertilisers and Lime	3.69	2.54	4.99
Seeds	0.49	0.35	0.72
TOTAL VARIABLE COSTS	4.18	2.89	5.71
Regular Labour	1.78	1.15	2.23
Tractor Work	1.15	0.73	1.41
Depreciation and Repairs for Specialised Machinery	3.12	2.02	3.91
TOTAL HARVESTING COSTS	6.05	3.90	7.55
Silo Depreciation	2.27	1.60	3.16
Labour and Tractor Costs for Spreading Fertiliser	0.61	0.40	0.78
Share of Labour and Tractor Costs for Establishment of Ley	0.36	0.26	0.51
Rent	1.50	1.02	1.99
Overhead Costs	3.79	2.44	4.71
TOTAL COST	18.76	12.51	24.41
		Other Data	
Number of Farms		2	
Tons of Dry Matter per Acre per Cut		1.53	
Tons of Starch Equivalent per Acre per Cut		0.80	
Acreage Costed		86	
Costed Acreage Cut Over		134	
Units of Nitrogen Applied per Acre per Cut		73	
Labour Hours per Acre per Cut		5.5	
Labour Hours per Ton of Dry Matter		3.5	
Labour Hours per Ton of Starch Equivalent		6.8	
Tractor Hours per Acre per Cut		4.8	
Tractor Hours per Ton of Dry Matter		3.1	
Tractor Hours per Ton of Starch Equivalent		5.9	
Average Number of Men in Harvesting Team		5	
Silage Analysis			
pH		4.8	
% Dry Matter		47.0	
% Crude Protein in Dry Matter		13.9	
Lb. Starch Equivalent per 100 lb. Haylage		24.3	
% Digestible Crude Protein		4.19	

Machinery

Machinery costs showed the greatest difference between haylage and conventional silage. They were four times as great per acre per cut for haylage and three times as great per ton of dry matter and per ton of starch equivalent. The average prices paid for the machinery involved were as follows, when purchased in 1965 and 1966 -

	£
Flail Mower	400
Tedder	200
Side-Rake	120
Full-Chop Forage Harvester	875
Trailer High Sides (2)	100
Dump-Box	490
Blower	370
Spreader*	80
Total Initial Machinery Investment	£2,635

In comparison, the average initial investment in machinery on the farms making clamp silage was £430, though the average dates of purchase would have been earlier. Farms making an equivalent quantity of silage, using a mower and possibly two flail harvesters or a higher-output double-chop harvester might have an initial machinery investment of up to £900, but this is still very much less than that required for haylage. Some difficulties and breakdowns were experienced with the blower on one of the farms, but no repair expenses were incurred because the machinery was still under guarantee. However, repairs are likely to add to the machinery costs in future years.

Silos

The capital cost of the tower silos differed between the two farms because they were of different size and because a grant was obtained in one case and not in the other. In both cases they were of the concrete stave type of construction. The capital cost, assumed net of grant, amounted to between £11 and £13 per ton of dry matter stored, depending on the height of the silo. Taller silos are cheaper because (a) the constructional cost of a tall tower is less than for a smaller one per unit of volume and (b) the taller a tower is the greater the compaction of the haylage so that more weight of material is contained per unit of volume.(7) The average cost of silo depreciation at £1:12: - per ton of dry matter is higher than one would expect with a 10 per cent depreciation rate on the capital costs mentioned above. This is because no grant was obtained in the one case. The cost of silo depreciation was lower for the farms making

*Electrically driven apparatus for spreading the grass as it comes into the tower from the blower.

(7)'High Dry Matter Silage in Tower Silos. Some Experiences in South West England', V. Baker, N.A.A.S. Quarterly Review, No. 77, Autumn 1967.

clamp silage, but relatively few of these farmers had built completely new pits and of these only one was built as recently as 1965-66. Thus it is difficult to compare the costs of tower silos and silage pits, but it seems likely that the cost of building a new covered silage pit would not be much less than the cost of erecting a tower for the same dry matter capacity and could be a good deal more if a lot of excavation was needed.

Total Cost

The average total cost per acre per cut was £18:15: - for haylage compared with £13 for clamp silage. However, the average costs per ton of dry matter and per ton of starch equivalent did not differ so much, being £12:10: - and £24: 8: - for haylage and £10:19: - and £22: 8: - for clamp silage. It might perhaps be fairer to compare the cost of haylage on these two farms with the cost of silage on the farms making over 500 tons of silage since the scale of production would be more comparable. The average costs per ton of dry matter and per ton of starch equivalent were about £10 and £20 respectively for those farms (see Table IX). The costs and efficiency measures differed quite considerably between the two farms making haylage: for instance, the cost per ton of starch equivalent was £28: 7: - in the one case and £20: 9: - in the other.

Discussion on the Making of High Dry Matter Tower Silage Compared with Clamp Silage.

The comparisons made between the costs of haylage and clamp silage can only be an approximate guide to the differences in costs which would be found for the two systems on a particular farm. Various factors must be borne in mind in relation to this comparison. The estimated average yields of dry matter and starch equivalent per acre per cut for the two farms making haylage were considerably higher than average - about 25 per cent and 30 per cent higher respectively. Some of the difference may have been due to lower nutrient losses with the haylage system, but this would not be likely to improve the yield by more than 15 per cent for dry matter and 20 per cent for starch equivalent. Thus the costs per ton of dry matter and per ton of starch equivalent would tend to be higher on a farm with only an average level of yield. On the other hand the difference in machinery and silo costs is somewhat exaggerated, since most of the machines

and silos used on the farms making clamp silage were older.

A factor which has not been taken into account is the interest on capital invested. In the method of enterprise costing this is covered by the share of overhead costs, but the standard method of calculating this does not allow any variation according to the amount of capital invested in the particular enterprise. The difference in capital invested between a new haylage system and a new clamp silage system would probably only be the difference in the machinery investment, but even this would amount to at least £1,500 initially or £750 over the life of the machinery, giving an additional interest charge at 10 per cent of £75 per annum.

Another factor which is involved is the cost of feeding the silage or haylage, since the costs have only been determined up to the point of storage. The removal of haylage from a tower relies on a mechanical unloader, costing about £600. The depreciation, interest on capital and repair costs for this equipment must be balanced against any saving in labour requirements compared with feeding silage from a clamp silo.

Conclusions on Making High Dry Matter Tower Silage

The results from the two farms making haylage suggest that labour requirements per ton of dry matter and per ton of starch equivalent are somewhat lower for this highly mechanised system than for clamp silage. The high average yield of dry matter and starch equivalent estimated for these farms also suggests some reduction in nutrient losses with the tower system. However, these advantages alone may not be sufficient to justify the large additional capital investment, when compared with an entirely new conventional silage system. The justification for the high dry matter tower silage system stands or falls on the value of obtaining a more concentrated product. This should enable a greater daily intake of conserved grass nutrients per animal and thus achieve a saving in concentrates. Investigations which have attempted to determine the increase in production achieved from haylage as compared with silage have not shown very great improvements in practice.(8)(9) One of the main reasons for

(8)'High Dry Matter Silage in Tower Silos. Some Experiences in South West England', V. Baker, N.A.A.S. Quarterly Review, No. 77, Autumn 1967.

(9)'The Impact of Tower Silos on Grass Conservations and Grain Storage', V. H. Beynon and Carol A. Godsall, University of Exeter, Report No. 160, January 1967.

this appears to be the great variation in the constitution of the haylage, so that the farmers tend to overfeed concentrates to guard against adverse changes in quality of the haylage. Thus, the arguments for making high dry matter are still open to serious doubt.

APPENDIX A

COSTING METHOD

The costing of silage production is complicated by the fact that fields cut for silage are also used for grazing and therefore many costs are shared by the silage and the grazing. The proportion of such costs which should be allocated to the silage crop was determined on the basis of the length of time and period of the year for which each field was taken out of grazing use, in order to produce silage. The following weighting was given to the months of the grazing season:

April	May	June	July	August	September	October
5%	25%	25%	15%	10%	15%	5%

Thus where a field was closed up from early Spring and cut on 1st July, 55 per cent of the costs shared by silage and grazing were charged to the silage.

Variable Costs

These are costs which can both be directly allocated to the enterprise and which vary according to changes in the scale of the enterprises.

Fertilisers and Lime

In most cases fertiliser was applied specifically for the silage crop around the time that the field was closed up for silage. The full cost of this fertiliser was therefore charged to the silage crop. However, in one or two cases large quantities of phosphatic and potassic fertiliser were applied in the Spring to serve for the whole season, including grazing subsequent to the silage. The cost of this fertiliser was shared between the silage crop and grazing. The actual cost of fertilisers to the individual farmer was used, i.e. delivered cost, net of subsidy and any deductions for size of order, etc.

The average annual cost of lime per acre was apportioned between silage and grazing. The cost of slag applied for establishment of the ley was apportioned firstly between the years of the intended length of ley and secondly between silage and grazing in the year under investigation.

Seeds

A share of the cost of seeds was calculated in the same manner as for the slag applied for establishment.

Additives

The delivered cost was charged.

Contract and Casual Work

Charges made by contractors for harvesting work or spreading fertilisers, and wages paid to casual labour for work with the silage crop were charged directly to silage.

Fixed Costs

These are costs which cannot be directly allocated to the enterprise and/or will not vary according to changes in the scale of the enterprise.

Regular Labour

The cost of labour involved in harvesting and securing the silage crop, based on recorded hours of work and actual wage-rates, including overtime, was charged directly to silage. Hours worked by the farmer or his family were charged at the appropriate standard hourly rates for enterprise costs, as agreed by the Scottish Conference of Agricultural Economists, i.e. Farmer - 6s. 10d. per hour
Youth - 4s. 11d. per hour

Tractor Work

The recorded hours for which tractors were in operation in harvesting and securing the silage crop were charged at 4s. 9d. per tractor per hour as laid down by the Scottish Conference of Agricultural Economists.

Depreciation and Repairs of Specialised Machinery

Depreciation on a straight-line basis was calculated at the following rates:

Forage Harvesters, Trailer Silage Sides and Flail Mowers	20%
Reciprocating Mowers and Buckrakes	10%

Where machines were used for further work beyond that involved with the silage costed, the depreciation cost was shared as appropriate. Trailers were not included as specialised machinery, since they would be included under overhead costs as part of the general farm equipment. The cost of special high silage-sides was included.

The actual cost of repairs and parts for specialised machinery was charged for each farm.

Silo Depreciation

The total cost net of grant, less a proportion of the cost of roofing where used for storing hay or straw, was depreciated on a straight line basis at the rate of 10 per cent. Where polythene, butyl or rubber sheeting

was used to seal the silage it was depreciated at an appropriate rate from 20 per cent to 50 per cent according to the strength of material used.

Labour and Tractor Costs for Spreading Fertiliser

A standard cost of 10s., per acre per application of fertiliser was charged to cover the labour and tractor work in spreading.

Labour and Tractor Costs for Establishment of Ley

Standard costs of £1 per acre where undersown and £4 per acre where direct sown were used to cover the labour and tractor work involved in establishing the grass ley, a share of this being charged according to the intended length of ley.

Rent

A share of the actual rent per acre was charged in the case of tenants and for owner occupiers a share of the estimated rental value per acre (based on the rents paid on similar farms in the area).

Overhead Costs

This item is an estimated share of general farm expenses which cannot be allocated between the different enterprises. It was calculated in the way laid down by the Scottish Conference of Agricultural Economists on the basis of the following charges:

	Dairy Farms	Other Farms
Per £ Direct Man Labour	9s. 9d.	8s. 9d.
Per Tractor Hour	10s. 9d.	6s. 6d.
Per Acre	16s. 9d.	10s. 9d.

The 'per acre' charge was shared between the silage and grazing.

General Data and Efficiency Factors

Tons of Silage Costed

The quantity of made silage was determined by measuring the volume of settled silage in each pit and deducting the estimated wastage. The tonnage was calculated on the basis of 45-50 cubic feet per ton according to silage dry matter and degree of chopping.

Total Tons of Silage Made

In some cases the whole of the silage made was not costed. Also some farmers shared their silage machinery with a neighbour. An estimate of the total quantity of silage harvested with the silage machinery was

therefore made to give a more accurate idea of the scale of the silage-making operation.

Acres Costed

The number of acres of grass from which the costed silage was obtained.

Costed Acreage Cut Over

The acreage cut over to obtain the costed silage - i.e. where a field was cut twice, double the acreage was counted.

Labour and Tractor Hours

The recorded hours of labour and tractor work involved in harvesting and securing the silage crop, including contract and casual work.

APPENDIX B

RESULTS OF CORRELATION AND REGRESSION ANALYSIS

Independent Variable - Units of Nitrogenous Fertiliser Applied per Acre per Cut

Dependent Variable	Size of Sample* (Number of Farms)	Response per 10 Units Nitrogen (Regression Coefficient)	Significance	Correlation Coefficient	Explained Variation %
Yield of Dry Matter per Acre per Cut (cwt.)	38 33	0.61 1.65	- 0.02	0.231 0.421	5 18
Yield of Starch Equivalent per Acre per Cut (cwt.)	38 33	0.72 1.41	0.001 0.001	0.618 0.831	38 69
% Starch Equivalent in Silage	38 33	0.14 0.34	- -	0.148 0.238	2 6
% Digestible Crude Protein in Silage	38 33	0.05 0.08	- -	0.132 0.129	2 2

*Results were calculated for a reduced sample of 33 farms, omitting those farms where over 80 units of nitrogen were applied per acre per cut, because it appeared that above this level the stage of diminishing returns may have been reached.