Silage

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THE IMPACT OF TOWER SILOS ON GRASS CONSERVATION AND GRAIN STORAGE

With Particular Reference to the Exeter Province

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Department of Agricultural Economics

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(with particular reference to the Exeter Province)

by

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C O N T E N T S

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CHAPTER I.

INTRODUCTION

In recent years the word "productivity" has been belaboured more than most others and reference has been made repeatedly to the need for higher productivity in the United Kingdom as the means of solving many of our economic problems. Sector productivity estimates are being widely used to highlight relative performances and farming is always included in these exercises. The data for the farming industry show a proud record of improvement in the post-war period, and achievements in the 60's have been the envy of most other industries. It is tempting for farmers to claim for themselves full credit for these worthy performances, but it must be appreciated that the improved productivity is attributable not only to their own better work methods but also to more and better use of services and of most farm resources. Improved varieties of seeds, the greater use of more effective fertilisers, higher yielding livestock, better appreciation of nutritional needs, as well as a whole array of chemicals and antibiotics have made a tremendous impact on crop and livestock production. In addition, with the appearance of a host of labour saving devices including the modern tractor and its allied equipment, farmers have been able to cope with the exodus of labour to other industries without sacrificing production. As far as labour productivity is concerned the trend with crops has been particularly impressive, but livestock production has not exhibited the same degree of improvement. It is true that improved milking facilities have resulted in considerably reduced labour requirements in dairying, but the feeding of livestock has proved a most intractable problem, and has claimed far too much expensive hand labour. Self-feeding of silage does, of course, represent a step in the right direction but silage itself is not accepted by all farmers.

To date then, the feeding of livestock in the U.K. is, by and large, an arduous task making heavy demands on manual labour. This still is so despite the repeated reminders that farmers in the United States have largely solved the problem and are able to feed large numbers of livestock with the minimum use of labour. But the constant reminders have not gone unheeded and growing numbers of British farmers are introducing equipment which will not only make labour far more productive in feeding stock but also, they hope, help to improve the quality of the final product. As with most innovations, technical difficulties are being encountered and the quest for perfection continues, but there is a real danger that imperfections, coupled with the high costs of some of the new equipment, may dissuade many from even considering the investment of capital. Reticent attitudes to capital innovations are also conditioned by the long era of a relatively cheap and abundant supply of labour in the United Kingdom. This era is now past and serious consideration must be given to the possibilities of substituting capital for labour. In recent years more and more farmers are recognising the importance of capital investment of a labour saving type. In this connection it should be emphasised that any plans involving a change in resources should always be preceded by an examination of the relative costs of the various inputs and of their effect on output. It has taken a long time for this elementary precaution to be appreciated generally in industry, and farming has been no exception.

The Investigation

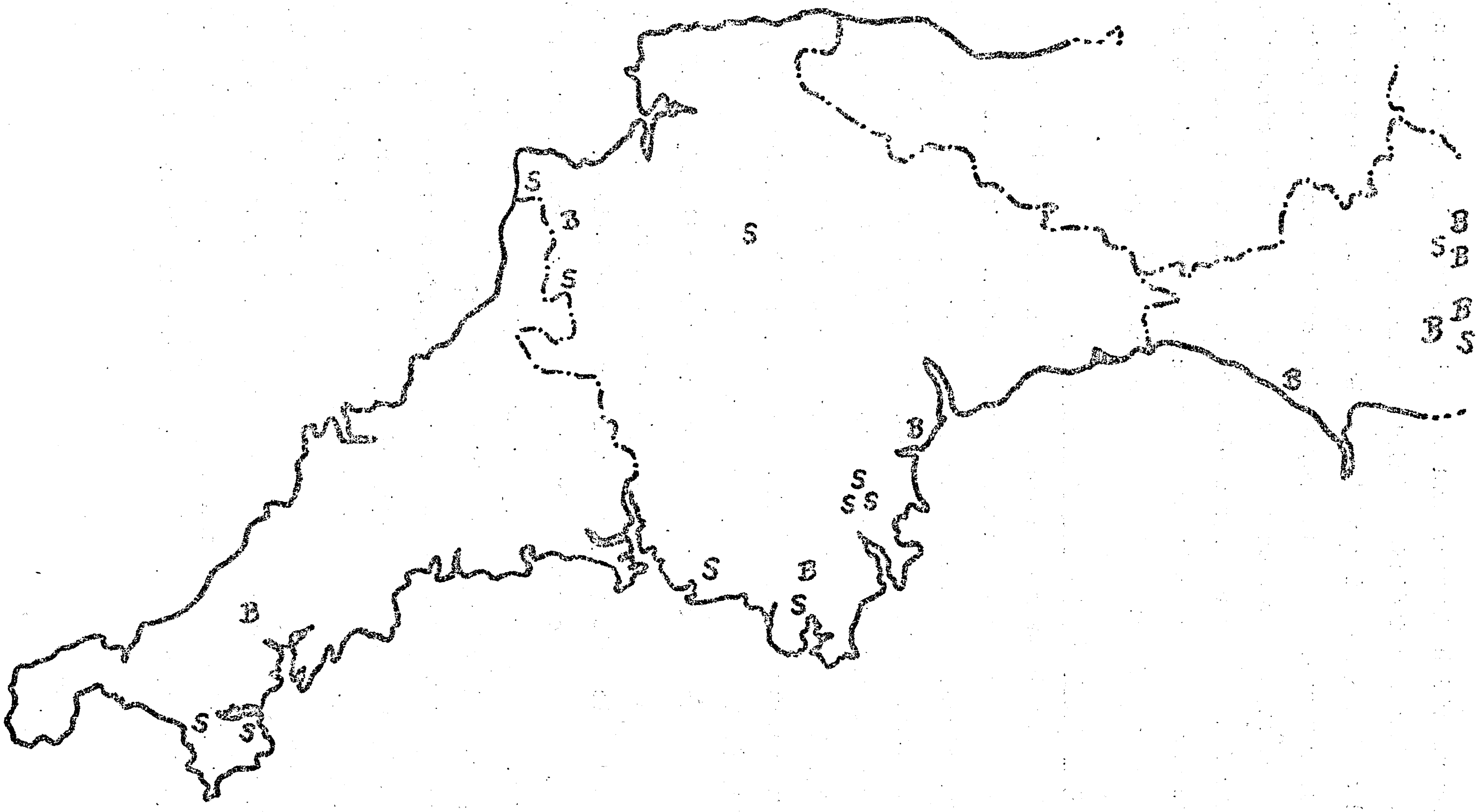
The appearance of growing numbers of tower silos on the landscape of this country is a manifestation of the use of increasing quantities of capital in the farming industry. The claims made for products stored therein, be they cereals or conserved grass products, together with the heavy capital commitments involved, have aroused the interest of the Department of Agricultural Economics. In view of these considerations, an investigation into the impact of this new development was commenced in the autumn of 1965 and was recently completed. The report on this investigation examines the characteristics of both farmers and farms and sets out the costs incurred on the towers and ancillary equipment. The implications of both high dry matter silage and moist grain storage are then considered. It must be emphasised, however, that the budgets which are presented in this report are primarily designed to highlight the factors which farmers must consider in deciding whether to introduce tower silos. They may indicate fairly accurately the results which would be obtained on the generality of farms, but they are not presented here primarily for this purpose. In the preparation of budgets, prospective buyers of capital equipment must consider their own particular circumstances and how the introduction of tower silos would affect their use of resources and the level of farm output. By doing so they can minimise the risk of introducing unnecessary, unsuitable and unrewarding capital equipment.

The Technique of Storage in Tower Silos

The introduction of a tower silo makes it possible to control the circulation of air through grass and undried grain. With the usual systems of storage, air circulates fairly freely, particularly during the initial stages. For the storage of high dry matter silage and moist grain this would induce heating and result in nutrient losses. Air circulation in grain would also encourage increased activity of moulds and insects leading to further deterioration in quality. Tower silos are designed to provide relatively air-tight conditions, thereby limiting the supply of air. Grass continues to respire in the presence of oxygen and produces carbon dioxide. If no more oxygen is allowed to enter the tower, respiration ceases, and the appropriate bacteria produce lactic acid to give a well-preserved silage. The tower silo, it is claimed, enables young, leafy grass to be conserved successfully at a high dry matter content (a range in practice of 30% to 60%), thereby reducing the total tonnage carted and conserved in comparison with traditional techniques. Similarly, with moist grain storage, organisms associated with cereals respire and thereby use up the supply of oxygen in the tower. In doing so their activity is inhibited before the grain is damaged, and the crop is stored in an atmosphere of carbon dioxide created by respiration and fermentation. The object of the exercise is, therefore, to restrict the entry of air. Having established air-tight storage conditions the problem then becomes one of unloading the towers without allowing too much air to enter. The ease with

LOCATION OF FARMS WITH TOWER SILOS FOR (S) HIGH DRY MATTER SILAGE AND (B) MOIST BARLEY STORAGE

(21 FARMS, CORNWALL, DEVON and DORSET, 1966)



Scale: 1 inch = 19 miles

which this is achieved depends on the type of tower silo and the unloading equipment used. Wastage could occur when there is too long an interval between the unloading of small quantities. These, in simple terms, are the principles involved in tower storage.

The Sample

The number of tower silos in the South-West, particularly those for barley storage, have been steadily growing, but inevitably the assessment of this new development must be based, in the initial stages, on a small sample of farms.

Table 1. Characteristics of Farmers in the Sample - Exeter Province 1965/66

Characteristics	Tower Silage Sample	High Moisture Grain Sample	All Farms
	Number of farmers		
Background:-			
Farm	8	7	15
Rural	2	2	4
Urban	2	-	2
Total	12	9	21
Education:-			
Up to school leaving age	3	4	7
Higher school work	3	-	3
Farm Institute	1	1	2
College	3	3	6
University	2	1	3
Total	12	9	21
Age Distribution:-			
30 - 34	1	1	2
35 - 39	3	2	5
40 - 44	3	4	7
45 - 49	3	1	4
50 - 54	1	1	2
55 - 59	-	-	-
60 - 64	-	-	-
65 and over	1	-	1
Total	12	9	21

As shown in Table 1, a total of 21 farmers co-operated in the survey. Of these, nine had invested in grain towers and 12 in silage towers (of the 12, three also had a grain tower). The location of the farms is illustrated on the map, which shows that three were in Cornwall, 11 in Devon and seven in Dorset.

The background, education and age distribution of the farmers are also set out in Table 1. A close scrutiny of the data failed to show any significant characteristics. It was found that, contrary to popular belief, the majority of these towers were owned by farmers who came from a farm background, and only in two out of 21 cases were the owners newcomers to the countryside. In addition, the educational background of the co-operators in this investigation varied quite widely. Table 1 also shows the age distribution of the farmers. It would be tempting to claim that the more enterprising group of young to middle-aged farmers were predominant here, but the sample is small and a Chi-square test applied to this and the age distribution of a representative sample of farmers in Devon, set out in Table 2, failed to reveal any significant differences.

Table 2. Age Distribution of the Farmers - Exeter Province 1965/66

Age Group Years	Expected Distribution*	Actual Distribution of Sample
	per cent	
20 - 24	2·6	-
25 - 29	4·9	-
30 - 34	8·4	9·5
35 - 39	12·4	23·8
40 - 44	15·9	33·3
45 - 49	15·2	19·1
50 - 54	12·6	9·5
55 - 59	11·2	-
60 - 64	9·9	-
65 and over	6·9	4·8
	100·0	100·0

* Data from the Devon Farm Survey 1965, Exeter University Agricultural Economics Dept., as yet unpublished.

The details of the farms in the sample are set out in Table 3. All the tower silos were on fairly large farms - this applied in particular to towers used for moist grain storage. The farms were in the main owned rather than

Table 3. Details of Farms in the Sample - Exeter Province 1965/66

Details	Tower Silage Sample (Average 12 farms)		High Moisture Grain Sample (Average 9 farms)	
	Per farm, acres	%	Per farm, acres	%
Tenure:-				
Owned	269	94	434	88
Tenanted	17	6	61	12
Total	286	100	495	100
Cropping:-				
Cereals	73	26	198	40
Grass	197	69	261	53
Other	16	5	36	7
Range in farm size (acres)	117 - 680		219 - 846	
	No.	Range	No.	Range
Stocking:-				
Dairy cows	70	0 - 120	76	12 - 115
Other cattle	68	20 - 145	148	40 - 287
Breeding ewes	15	0 - 175	97	0 - 310
Pigs	85	0 - 650	219	0 - 1700
Poultry	135	0 - 770	68	0 - 300

tenanted. Grass was the predominant crop in all cases but obviously cereals figured prominently in the high moisture grain sample. The dairy enterprise was important on all but two of the farms.

Reasons for Introducing Tower Silos

All the farmers co-operating in this investigation were asked why they purchased tower silos and their answers are summarised in Table 4.

Table 4. Reasons for Adopting Tower Silos - Exeter Province 1965/66

Type of Tower Silo	No. of farmers in the sample	Reasons for adoption	No. of farmers stating each reason
Silage Tower Silos	12	Eliminate Waste	9
		Improve Quality	7
		Save Labour	11
High Moisture Grain Tower Silos	9	Provide Storage	8
		Eliminate Drying	8
		Save Labour	5

Some farmers gave more than one reason for adopting these new techniques, but priorities could not be clearly defined in the three main categories given for each type of tower. However, the most dominant first reason given for investing in a silage tower was the prospect of reducing the waste which is such a prominent feature of traditional conservation methods. The possibility of producing a better quality product, even if only by minimising the influence of the weather, was in total an important attraction. The saving in labour which the system seemed to make possible was given more often than the other two as a major reason for buying a tower silo. This reason has a wide interpretation and in fact ranged from the expected saving in manual work associated with mechanised feeding and, possibly, a modernised building and yard layout, to expanding the business without employing an extra man and actually reducing the labour force in some instances.

The reasons given for buying tower silos for moist grain storage were the saving of labour, the provision of storage and the elimination of drying. Where the objective was to roll barley and feed it to stock there seemed little point in drying it first and, indeed, in possibly having to steam it afterwards prior to feeding. Therefore, storing undried barley for eventual feeding had obvious advantages. These included ease of milling, reduction in the incidence of digestive and respiratory troubles and possibly improvement in feeding value over dry barley. Saving in labour was associated with the speed up in harvesting and storing operations due to elimination of bottlenecks at the drier and earlier combining both in the season and each day. The installation of a tower silo associated with a modernised layout was also conducive to further labour economies. Other advantages claimed were the reduction of waste in the field, due to earlier combining, and the elimination of vermin and other damage in the sealed store.

Types of Towers

An examination in Table 5 of the types of towers used shows that on the

Table 5. Types of Tower Silos Used - Exeter Province 1965/66

Type of Tower	No. of Silage Tower Silos	No. of Moist Grain Tower Silos	Total
Galvanised	4	6 + 2	12
Concrete Stave	3	-	3
Vitreous Enamel*:-			
(a) top unloading	2	-	2
(b) bottom unloading	4	3 + 1	8
Total	13	12	25

* This category includes tower silos referred to as glass fused to steel, glass lined as well as vitreous enamel.

21 farms there were 25 silos. One farm had two galvanised silage towers and on three other "silage tower" farms a moist barley tower silo had also been erected. The galvanised type was the most popular for moist grain storage, and the vitreous enamel type was prominent for high dry matter silage. Only three of the towers used for grass were of the concrete stave type.

Obviously the decision to introduce one or other of the different types of tower silos is tied up with a number of factors. These include the cost of the towers themselves as well as the cost of the allied equipment, the expected life of the tower, maintenance costs and the effect on wastage and on the quality of the product. The impact of some of these factors cannot be assessed with any degree of confidence beforehand so that the influence of sales pressures must also be considered. The local agencies for each particular type of tower will obviously influence the decisions of farmers in their area quite considerably. Undoubtedly salesmanship has been a dominant feature to date, because reliable data on products stored in different types of towers are restricted to a few farms and may not necessarily be indicative of what can be achieved on average. The next two chapters are devoted to an examination of the capital and other costs of operating tower silos for grass conservation and moist grain storage, and budgets are presented to show the impact on margins over concentrates and returns on capital invested.

CHAPTER II.

HIGH DRY MATTER SILAGE TOWERS

Costs of Towers and Equipment

The silage towers in this study were purchased between 1962 and 1965. They included top and bottom unloading vitreous enamel types as well as the galvanised and concrete stave types. Comprehensive data on the costs of the entire tower silage system were collected. These included the prices paid for the towers and the associated loading and unloading* equipment as well as the cost of preparing the concrete base and installing the towers. This information, together with other relevant details, are set out in Table 6.

Table 6. Average Capital Costs+ of Silage Towers and Allied Equipment - Exeter Province 1965/66

Details \ Type of Tower	Galvanised	Concrete Stave	Vitreous Enamel	
			Top Unloading	Bottom Unloading
Average Capacity cu.ft.	15,310	18,240	28,290	17,040
Capital Cost, £:-				
Tower Silo (incl. installation)	2,348	2,558	3,896	4,440
Loading & Unloading equipment	1,340	1,930	1,952	1,705
Total	3,688	4,488	5,848	6,145
Cost per 1000 cu.ft. capacity:-				
Tower only	153	140	138	261
Tower & Allied equipment	241	246	207	361

+ Tower Silos purchased from 1962 - 1965. Harvesting equipment costs are excluded.

Since the average capacity of the towers showed a wide range, the costs

* The unloading equipment incorporates the unloader and feed auger or conveyor.

per 1,000 cubic feet capacity have been calculated and these are set out for the towers themselves as well as for the towers and allied equipment.

The table shows the heavy capital cost of the vitreous enamel bottom unloading towers at £261 per 1,000 cubic feet compared with £140 for the concrete stave type. It also illustrates the importance of looking at the capital costs of the whole system rather than confining attention to the main and more obvious piece of equipment. This is doubly important with towers because the essential loading and unloading equipment does account for a substantial portion of the total investment.

Performance from High Dry Matter Silage

There is no denying the fact that a tower silo system can involve farmers in very heavy capital investment and, therefore, the full implications of introducing it should be investigated before capital is committed. Such an exercise involves determining the effect of the system on output and on costs, and this has been attempted in this study. As part of the exercise, feeding records for the dairy cows have been collected, and these have been related to the theoretical nutrient requirements of the animals for both maintenance and production. The preparation of data of this nature is not easy because there are so many variable factors for which estimates have to be used. For instance accurate measures of the quantity of home-grown foods used are not always available and the estimates of the farmer, which may contain substantial errors, have had to be used. Nevertheless, this exercise has been undertaken in the belief that it is unlikely that all estimates would be biased in the same direction.

Analyses of the nutritional value of 22 samples of tower silage have been used in compiling the data in Table 7. The table suggests that most farmers tend to overfeed their dairy cows, particularly with protein. Compared with theoretical requirements, five readings for energy showed overfeeding of between 50% and 100%, and five readings for protein overfeeding in excess of 100%.

There are, therefore, some indications that marked economies can be made, particularly in the protein fed to the dairy cows in the sample. It is realised, of

Table 7. Relationship of Nutrients fed to Theoretical Requirement for Cows in Milk - Exeter Province 1965/66

Relationship of nutrients fed to theoretical requirements	S.E.	P.E.
	Number of readings	
Over 200%	0	5
150 - 200	5	7
125 - 150	7	6
100 - 125	7	1
Less than 100	3	3
Total	22	22

course, that the sample is small and generalisation somewhat dangerous but these shortcomings are unavoidable in the primary stages of any development.

An assessment of the levels of production (in addition to maintenance) obtained from high dry matter silage was made for each reading taken on the 11 dairy farms in the sample. This enabled a grouping of these readings according to the estimated gallonage obtained from the product. The results are set out in Table 8.

Three groupings emerged, the first with tower silage making virtually no contribution to production, the second with readings of between 0·1 and 0·9 gallons per cow per day, and the third group with readings in excess of 0·9 gallons. The basis of the three groups was production according to starch equivalent requirements, but the production from the protein contained in tower silage is also set out. For instance in Group 1, cows produced no gallons from the energy content of the silage, but managed to yield 0·3 gallons per cow per day from the protein. Group 3 contained the readings with the highest levels

Table 8. Comparison of Tower Silage Analyses and Milk Production Results - Exeter Province 1965/66

Details	Group* I		Group II		Group III		All Farms +	
No. of Farms	5		5		4		11	
No. of Readings	6		8		8		22	
Analysis:-								
% D.M.	45·1		47·2		46·4		46·3	
pH	5·2		4·4		4·8		4·7	
% Crude protein in D.M.	13·9		14·0		15·5		14·5	
% Crude fibre in D.M.	30·5		31·7		29·3		30·5	
Estimated % S.E.	22·7		22·2		22·2		22·3	
Estimated % P.E.	4·2		3·9		4·4		4·1	
Milk Production Results:-								
No. of cows in herd	64		59		82		69	
% dry	25		10		15		16	
Daily yield/cow in herd (galls)	2·2		2·2		2·2		2·2	
Concentrates fed (incl. steaming up) lb./gall.	4·2		3·6		2·1		3·2	
Daily yield/cow in milk (galls) from:-	S.E.	P.E.	S.E.	P.E.	S.E.	P.E.	S.E.	P.E.
Tower silage	nil	0·3	0·3	0·4	1·2	1·2	0·6	0·7
Concentrates and other	2·9	2·6	2·1	2·0	1·3	1·3	2·0	1·9
Total	2·9		2·4		2·5		2·6	
Tower Silage fed:-								
lb./cow/day	43		59		52		52	
lb. D.M./cow/day	18·8		27·3		24		23·8	

* Group I. on S.E. basis NIL production from tower silage
Group II. on S.E. basis 0·1 - 0·9 gallons/cow in milk from tower silage
Group III. on S.E. basis more than 0·9 gallons/cow in milk from tower silage

+ Two of the 11 farms are represented in more than one group.

of production from tower silage - 1·2 gallons from both starch and protein.

The contribution of tower silage to milk production is, of course, dependent on such factors as the daily yield of the cows, constituents of the ration, the quantity of silage and other foods fed as well as on the analyses of the different foodstuffs. The herd variation in daily yield per cow in milk was not great, the average being 2·6 gallons. All farmers relied heavily on tower silage and concentrates while hay made only a minor contribution. The analyses disclosed very few obvious differences in the three groups which would account for the difference in production obtained from tower silage. There was a fairly wide range in quantities fed measured on the basis of both green matter and dry matter, but the group with the highest production did not show the greatest quantity fed and the quality in this group was little better than in the other two. It does seem, therefore, that the superior performance recorded in this group is the result of a more meticulous system of rationing the dairy cows involving the adjustment of concentrate feeding according to the quality of forage available. The average picture shows a production of about half a gallon in addition to maintenance from 52 lb. of tower silage with 46·3% dry matter. In theory the quality and quantities of tower silage fed in each group were adequate for more production than was in fact achieved and these points are noted in the budgets presented later.

Budgeting the Effect of Tower Silos for Grass

In budgeting the effect of introducing tower silo systems, it has been assumed that 50 lb. of silage with 46·3% dry matter were fed daily to each cow. It was further assumed that the S.E. and P.E. of the silage were 22·3 and 4·1 respectively - the average analysis in the sample. The starch equivalent of 50 lb. of such silage would, therefore, seem to be adequate to meet the daily maintenance requirements of a Friesian cow and the production of 1½ gallons of milk. There would still be a surplus of protein available. This should be adequate to balance a carbohydrate rich food such as barley. Indeed it has been further assumed that barley fed at 3½ lb. per gallon was sufficient for the next two gallons, (see Appendix I).

These assumptions have been used for the preparation of budgets depicting four different situations, which are:-

(a) Traditional methods of conserving grass with the silage making no contribution to production. This situation would involve the feeding of concentrates for all production during the six winter months.

(b) The introduction of the tower silo system with high dry matter silage producing $\frac{1}{2}$ gallon of milk per cow per day - the average situation discovered in this sample of farms - with balanced concentrates used thereafter.

(c) High dry matter silage providing for maintenance and the production of $1\frac{1}{2}$ gallons of milk per cow per day - the situation in the group with the best readings - again with balanced concentrates thereafter, and

(d) The situation where the full theoretical potential of the tower silage is exploited. This involves getting maintenance and the production of the first $1\frac{1}{2}$ gallons from tower silage, barley fed at $3\frac{1}{2}$ lb. per gallon for the next two gallons and balanced concentrates resorted to above this level of production.

The impact of the tower silo system on stocking rate needs to be clarified. Grazing requirements may well remain the same, but the elimination of part of the previous wastage can result in a greater quantity of conserved product or reduce the acreage set aside for conservation. In this study it has been assumed that the introduction of a tower silo system makes it possible to reduce the acreage conserved per animal and thereby allow more cows to be kept. The example set out in Appendix II illustrates this situation and emphasises the importance of considering not only the conserved acreage, but also the grazing requirements of the animals. Obviously improvement of this nature takes some time and co-operators in this study have not been using the tower system long enough to exhaust all the possibilities. Nevertheless the data showed that the farms were more heavily stocked than average, and it was assumed that stocking rate could be improved by some 5%. In view of this marginal change in the size of herd, building charges have been omitted altogether.

Up-to-date capital costs for different towers with a capacity of approximately 17,000 cubic feet,* together with as far as possible standardised loading, unloading and harvesting equipment are set out in Table 9. These are used in subsequent budgets. The equipment decided on for this exercise consisted of a dump box and blower (loading), an unloader, an open type auger and

Table 9 Capital Costs of Silage Towers and Allied Equipment, 1966
Capacity of approximately 17,000 cubic feet

Capital Costs \ Type of Tower	Galvanised	Concrete Stave	Vitreous Enamel	
			Top Unloading	Bottom Unloading
	£	£	£	£
Tower Silo incl. delivery and erection	2,500	2,220	3,140	4,250
Silo base and electrical installation	250	250	250	250
Total	2,750	2,470	3,390	4,500
Loading equipment	1,100	1,100	1,100	1,100
Unloading equipment	1,070	1,000	1,000	1,370
Harvesting equipment	1,900	1,900	1,900	1,900
Total Capital Costs	6,820	6,470	7,390	8,870

manger (unloading) and for harvesting - a flail mower, full chop harvester and two tipping trailers. The capacity chosen is considered adequate to meet

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* 17,000 cubic feet is approximately the capacity of the average tower encountered in the survey.

the requirements of an 80 cow herd fed 50 lb. per cow per day during a winter period of up to 180 days.

The foregoing assumptions on quantity and quality of product, reduction of waste and its effect on stocking rate, as well as the varying performance from high dry matter silage, have been included in the budgets which follow. The first stage estimates the effect of the tower silo system on margin over concentrates in milk production for the four different situations depicted above. No conclusive evidence is available on the possible influence of type of tower on the quality of the final product or on wastage. In the absence of such detail and more particularly in view of the fact that the variation in the quality of tower silage between farms having the same type of tower was as great as that between farms of different types, it has been assumed that the quality and wastage rates are the same for all types of tower. Similarly, it has been assumed that running and maintenance costs are the same for all towers although it is realised that there may be some differences.

In calculating the scope which exists for the replacement of concentrates it was necessary to estimate the gallons produced during the winter months in the different quantity categories. This involved the use of average lactation curves, and estimates from these of the number of gallons produced during the winter period in each of the following categories:-

(i) over $3\frac{1}{2}$ gallons per cow per day

(ii) gallons between $1\frac{1}{2}$ and $3\frac{1}{2}$ per cow per day

(iii) gallons between $\frac{1}{2}$ and $1\frac{1}{2}$ per cow per day

and (iv) gallons up to $\frac{1}{2}$ gallon per cow per day

These data were calculated for herds calving all the year round and averaging 850 and 1,000 gallons per annum and for herds calving in October and November (to represent the extreme in autumn calving for winter milk) also averaging 850 and 1,000 gallons. In this exercise it has been assumed that the level of concentrate feeding in the summer months was the same irrespective of the calving pattern. This is obviously not so, but this has been done here in order to make meaningful estimates of the effect of tower silos on the profitability of herds with different calving patterns and levels of milk yield. The data should not, therefore, be used to compare the profitability of summer and winter milk production. Very many permutations can be depicted in an exercise of this nature but only the very minimum are presented here and summaries are included for these in Table 10. The detailed budgets for the four

Table 10. Margins over Concentrates for Different Situations and Assumptions

Assumptions \ Situation	A 76 cows	B 80 cows	C 80 cows	D 80 cows
	£	£	£	£
I. 850 gallon herd calving all the year round				
Margins	7248·1	7924·8	8619·2	8992·8
Additional Margins over A	-	676·7	1371·1	1744·7
II. 850 gallon herd calving October - November				
Margins	6984·4	7686·7	8511·7	9175·6
Additional Margins over A	-	702·3	1527·3	2191·2
III. 1000 gallon herd calving all the year round				
Margins	8491·2	9237·3	9952·7	10394·1
Additional Margins over A	-	746·1	1461·5	1902·9
IV. 1000 gallon herd calving October - November				
Margins	8183·0	8949·8	9774·4	10507·3
Additional Margins over A	-	766·8	1591·4	2324·3

Situation A. Before introduction of Tower Silo - concentrates fed for all winter milk at 4 lb. per gallon.
Situation B. Increased stocking and concentrates replaced for the first ½ gallon during winter.
Situation C. Increased stocking and concentrates replaced for the first 1½ gallons during winter.
Situation D. Increased stocking and concentrates replaced for the first 1½ gallons and barley fed for the next 2 gallons during winter.

situations for the 850 gallon herd calving all the year round are presented in Appendix III. In this exercise it is assumed that the costs of producing grass remain the same and the budgets are then concerned purely with the effect of tower silos on concentrate substitution and stocking rates.

It follows, therefore, that success in replacing concentrates with better quality conserved grass normally results in better margins (value of output less cost of concentrates). This is depicted in Table 10 which shows herds obtaining 3½ gallons from high dry matter silage and 7 lb. barley getting the highest margins. It is worth noting that the higher price received for milk from October/November calvers failed to overcome the disadvantage of heavier winter feeding except again where 3½ gallons were obtained from silage and barley. The actual margins realised are influenced by patterns and levels of monthly prices as well as concentrate feeding. However, this report is only concerned with additional margins which tower silo systems might confer. These have been calculated at different yield levels and for different milk production patterns. This is the only way of isolating the effect of tower silos and determining whether the investment is justified.

Only the detailed budget for one type of tower is included in the main body of the report. This is set out in Table 11, but a summary of the budget results for all others is also given later. For each type of tower, the tower itself and all the allied equipment have been written off over 10 years. Whilst some types will undoubtedly have a longer life, the possibility of obsolesence cannot be ignored.

The budget for the vitreous enamel bottom unloading tower has been used. It has been assumed that a 30% grant* will be available. The additional margins available to meet the interest charges, repayment of capital and tax liability and to provide the farmer with a return for all his enterprise,

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* This is made up of the proposed 25% Farm Improvement Scheme grant and a further 5%. No provision has been made for grants on loading and unloading equipment, although it seems probable that these will be available shortly.

have been calculated. In this budget it has been assumed that prior to the introduction of the tower system the conserved grass product made no contribution to production. Obviously on many farms hay and silage do contribute to production and in such cases an appropriate adjustment to the figures has to be made.

In the four situations investigated it is obvious that a vitreous enamel bottom unloading tower system cannot be justified with only the concentrates for half a gallon being saved. The highest return on investment is nearly 56%. This is obtained for IV D. In this particular instance tax liability accounts for nearly 10% of the additional profit, but about 21% is still left for the farmer himself.

A summary of returns on investment available to the farmer and derived from the budgets for four different tower systems and four different herd situations, with and without a grant for the tower, is set out in Table 12. The concrete stave type gives the best return but it should be emphasised that in the absence of data on this point no allowance has been made for possible improvements in quality and reduction in wastage as a result of using the more expensive towers.

Some allowance has been made in the foregoing for a reduction in the considerable wastage which is customary with traditional methods of conserving grass, and for possible changes in the stocking rate. Furthermore, the analyses of the different silages should reflect higher quality. After all, it is claimed that with the tower system grass can be cut at an earlier stage and that with appropriate handling methods, drying could be effectively and rapidly done to the appropriate dry matter content. The elimination of a day or two in field operations reduces the risk of damage because of bad weather. The combination of earlier cutting and less rain damage should result in a product of superior quality, and one which should make a significant contribution to the production ration of cattle, thereby replacing relatively expensive concentrate feed. Stocking rate changes and the effect of a superior quality

Table 11. Calculation of the Returns on Capital Invested in a Vitreous

Capital Invested	£
Vitreous Enamel Tower Silo	4,500
Allied Equipment	4,370
	8,870
Less F.I. Cash Grant 30% of tower	1,350
Net Investment	7,520
Average Investment+ - tower and equipment	3,760
+ 4 cows @ £100 each	400
Total Average Investment	4,160

Returns on capital £:-	IB	IC	ID
Additional Margins (return on investment)	676·7	1,371·1	1,744·7
Interest charges ∅	291·2	291·2	291·2
	385·5	1,079·9	1,453·5
Annual Allowance on Net Investment over 10 years	752·0	752·0	752·0
Taxable profit	nil	327·9	701·5
Tax @ 8/3d.*	nil	105·2	225·1
Available to farmer	nil	222·7	476·4
Allocation of Returns on capital %:-			
Interest charges	7·0	7·0	7·0
Repayment of capital	max. 9·3	18·1	18·1
Tax commitments	nil	2·5	5·4
Available to farmer	nil	5·4	11·4
Total Returns on Capital	16·3	33·0	41·9

+ The average annual investment is assumed to be half the original capital invested.

∅ 7% on half tower and equipment £263·2
7% on 4 additional cows £ 28·0
£291·2

* The tax @ 8/3 relates to 7/9ths of the taxable profit, thus allowing 2/9ths for Earned Income Relief.

Enamel, bottom unloading Tower Silo for Grass

IIB	IIC	IID	IIIB	IIIC	IIID	IVB	IVC	IVD
702.3	1,527·3	2,191·2	746·1	1,461.5	1,902·9	766.8	1,591·4	2,324·3
291·2	291·2	291·2	291·2	291·2	291·2	291·2	291·2	291·2
411·1	1,236·1	1,900·0	454·9	1,170·3	1,611·7	475·6	1,300·2	2,033·1
752·0	752·0	752·0	752·0	752·0	752·0	752·0	752·0	752·0
nil	484·1	1,148·0	nil	418·3	859·7	nil	548·2	1,281·1
nil	155·3	368·3	nil	134·2	275·8	nil	175·9	411·0
nil	328·8	779·7	nil	284·1	583·9	nil	372·3	870·1
7·0	7·0	7·0	7·0	7·0	7·0	7·0	7·0	7·0
max. 9·9	18·1	18·1	max. 10·9	18·1	18·1	max. 11·4	18·1	18·1
nil	3·7	8·9	nil	3·2	6·6	nil	4·2	9·9
nil	7·9	18·7	nil	6·8	14·0	nil	9·0	20·9
16·9	36·7	52·7	17·9	35·1	45·7	18·4	38·3	55·9

product have been allowed for as far as possible, but no adjustment has been made for reductions, if any, in the time spent in feeding cattle.

Table 12. Summary of % Returns Available to Farmers on Investments in Tower Silos for Grass

Situations / Av. Annual Yield	Tower Grant	Vitreous Enamel Bottom Unloading			Vitreous Enamel Top Unloading			Concrete Stave			Galvanised		
		B	C	D	B	C	D	B	C	D	B	C	D
		per cent											
I. 850 galls with cows calving all the year round	nil	nil	2·1	7·3	nil	5·7	11·9	nil	8·8	15·8	nil	7·5	14·2
	30%	nil	5·4	11·4	nil	9·1	16·2	nil	11·9	19·6	nil	10·7	18·1
II. 850 galls with cows calving Oct/Nov.	nil	nil	4·3	13·6	nil	8·3	19·3	nil	11·7	24·1	nil	10·3	22·1
	30%	nil	7·9	18·7	nil	12·1	24·7	nil	15·1	28·9	nil	13·8	27·1
III. 1000 galls with cows calving all the year round	nil	nil	3·3	9·5	nil	7·2	14·5	nil	10·5	18·7	nil	9·1	17·0
	30%	nil	6·8	14·0	nil	10·8	19·2	nil	13·7	22·9	nil	12·5	21·3
IV. 1000 galls with cows calving Oct/Nov.	nil	nil	5·2	15·5	nil	9·4	21·5	nil	12·9	26·6	nil	11·5	24·5
	30%	nil	9·0	20·9	nil	13·3	27·2	nil	16·4	31·7	nil	15·1	29·7

Self-feeding methods have long removed much of the drudgery involved in feeding livestock, but the usual methods in practice still involve cleaning up the feeding face. Modifications to these methods can be introduced so that some rough and ready rationing of the livestock results, but precise rationing is almost impossible. Tower silos, however, can be completely automatic and can be regulated so that accurate quantities of conserved grass, suitably balanced with other feeds, can be provided. It is, however, extremely difficult to put a precise value on these advantages since they vary from one farm to another and in some particular instances there may be no labour economies. These are points which the individual farmer with precise data must incorporate in his budgeting exercises. He should also explore the possibilities of restricting not only the high dry matter silage to the most productive cows but also the daily intake. Both would enable more cows to be kept without further investment in storage capacity. Furthermore, he should also appreciate that the introduction of additional towers would not necessarily involve further investment in harvesting, loading and unloading equipment. Consequently the total investment in equipment per ton capacity would tend to fall as further towers are added.

CHAPTER III.

MOIST GRAIN TOWERS

It is interesting to note from Table 13 that on the farms with moist grain storage facilities, barley formed a major part of the concentrate ration of the dairy cows, amounting on average to 68% by weight and varying in individual cases from 46% to as much as 89%.

Table 13. Place of Barley in the Feeding of Dairy Herds - Moist Grain Tower Sample Exeter Province 1965/66.

Code No.	Barley as % of total concentrates
1	67
2	55
3	89
4	50
5	46
6	80
7	70
8	70
9	85
Average all Farms	68

Costs of Towers and Equipment for Grain Storage

The capital invested in moist grain towers and allied equipment is given in Table 14. These were purchased between 1963 and 1965 and include towers of different types. On average the vitreous enamel tower is much more expensive per ton capacity than the galvanised type, but the differences in the average capacity of the two groups are partly responsible for this because the vitreous enamel towers investigated were smaller.

To overcome the difficulty involved in comparing towers of different sizes, up-to-date capital costs for towers and allied equipment for storing approximately 100 tons and 200 tons are shown in Table 15. The loading equipment includes a blower and pipes, and the unloading, a sealed auger for use with a trident outlet, which is included in the cost of the tower. An

Table 14. Average Capital Costs of High Moisture Grain Towers and Allied Equipment - Exeter Province 1965/66

Details \ Type of Tower	Galvanised	Vitreous Enamel
Average Capacity (tons)	175	110
Capital Costs:-	£	£
Tower Silo (incl. installation)	1385	1296
Loading and unloading equipment	275	227
Total	1660	1523
Cost per ton capacity:-		
Tower Silo	7·9	11·8
Tower and allied equipment	9·5	13·9

auger was not included for filling the tower because of the height of the filling hatch in each case. The data show that with similar capacity towers

Table 15. Capital Costs of High Moisture Grain Towers and Allied Equipment, 1966 Capacity approximately 100 & 200 tons

Capital Costs \ Type of Tower	Galvanised		Vitreous enamel	
	100 tons	200 tons	100 tons	200 tons
	£	£	£	£
Tower Silo incl. delivery & erection	890	1350	1130	1700
Silo Base and electrical installation	160	240	160	240
Total	1050	1590	1290	1940
Loading equipment	280	300	280	300
Unloading equipment	60	70	60	70
Total Capital Costs	1390	1960	1630	2310

the vitreous enamel types are more expensive. However, the deduction of

Farm Improvement Scheme Grants of 30% and averaging the investments*, narrows the differences. These figures have been used later to estimate the effect of moist grain towers on margins.

Budgeting the Effect of Grain Tower Storage

The introduction of moist grain towers involves farmers in substantial capital investment which can only be justified if the additional returns, together with costs saved, are large enough to meet the costs of running the towers and allow an adequate margin to meet interest charges, depreciation and leave a profit to reward the farmer for his effort and enterprise. Additional margins estimated for silos with approximately 100 and 200 tons capacity have been set out in Tables 16 and 17. All calculations are made on the basis of a standard 16% moisture content. Again the number of permutations which could be presented are infinite. In this exercise the number of situations depicted have been severely restricted, mainly because the objective is to present the considerations involved in moist grain storage rather than to try and answer with precision the likely impact on all producers of storing grain rather than selling at harvest time.

The additional returns farmers are likely to realise will come from (a) increased yields because of the possibility of harvesting before too much grain is shed and (b) reduced storage losses through elimination of heating and damage by vermin, insects and other organisms. No information on the extent to which yields increase or losses decrease was available from this investigation and in the absence of any reliable information, 1¼% has been assumed in each instance giving a total additional effective yield of 2½%.

Reference has already been made in Chapter 1 to the reasons given for introducing grain towers. Previously there were no drying facilities on four of the farms investigated and on these and on three other farms, the farmers relied heavily on sacks as a method of storing grain. The tower silos in

* The average annual investment is assumed to be half the capital invested.

Table 16. Calculation of Additional Margins on Investment in a Moist Grain Tower (approx. capacity 100 tons)

	(1) £	s.	d.	(2) £	s.	d.		(1) £	s.	d.	(2) £	s.	d.
Additional Returns													
Increased Yield say $1\frac{1}{4}\%$ Decreased Storage Losses $1\frac{1}{4}\%$ = $2\frac{1}{2}$ tons @ £25. 6s. 8d. per ton	63	6	8	63	6	8	Running Costs and Mtce of Tower and Equipment	20	0	0	20	0	0
Costs Saved													
Drying Costs for 5% moisture reduction (1) of 10% crop i.e. 10 tons @ 45/- per ton	22	10	0										
(2) of 20% crop i.e. 20 tons @ 45/- per ton				45	0	0							
Transport Costs:- (1) 10% crop i.e. 10 tons @ 20/- per ton	10	0	0										
(2) 20% crop i.e. 20 tons @ 20/- per ton				20	0	0	Add'l Margin (1) (2)	200	16	8	233	6	8
Sack Hire for 100 tons storage @ 25/- per ton for 20 weeks	125	0	0	125	0	0							
	220	16	8	253	6	8		220	16	8	253	6	8

Table 17. Calculation of Additional Margins on Investment in a Moist Grain Tower (approx. capacity 200 tons)

	(1) £	s.	d.	(2) £	s.	d.		(1) £	s.	d.	(2) £	s.	d.
Additional Returns													
Increased Yield say 1¼% Decreased Storage Losses 1¼% = 5 tons @ £25. 6s. 8d. per ton	126	13	4	126	13	4	Running Costs and Mtce. of Tower and Equipment	20	0	0	20	0	0
Costs Saved													
Drying Costs for 5% moisture reduction													
(1) of 10% crop i.e. 20 tons @ 45/- per ton	45	0	0										
(2) of 20% crop i.e. 40 tons @ 45/- per ton				90	0	0							
Transport Costs:-													
(1) 10% crop i.e. 20 tons @ 20/- per ton	20	0	0										
(2) 20% crop i.e. 40 tons @ 20/- per ton				40	0	0	Add'l Margin (1) (2)	421	13	4	486	13	4
Sack Hire for 200 tons storage @ 25/- per ton for 20 weeks	250	0	0	250	0	0							
	441	13	4	506	13	4		441	13	4	506	13	4

most cases were introduced to fit into an existing system of grain storage and handling and, therefore, the costs saved would vary enormously from one farm to another. For the purposes of this exercise, however, it has been assumed that the costs saved include drying costs, transport to and from driers as well as the sack hire costs. It could also be claimed that a rental charge for the building used for storage is also saved. Again, the extent to which these costs are saved varies enormously from year to year and from farm to farm and in this study for purposes of illustration it has been assumed that on average annual drying costs and transport for a 5% moisture reduction on 10% and on 20% of the crop are saved. For simplicity, contract drying and transport charges have been assumed here as well as sack hire for the entire crop for a 20 week period.

On the basis of these assumptions on additional returns and costs saved it seems that additional margins of £201 and £233 are available in the case of the 100 ton silo for situations where 10% and 20% of the crop is dried. For the 200 ton silo the additional margins are £422 and £487 respectively. These additional margins have to be set against depreciation and interest charges and provision must be made to meet tax liability and to provide a return to the farmer. This has been done in Table 18 for the galvanised and vitreous enamel towers net of farm improvement grant. (The situation without a grant and the calculation of the investment net of grant are depicted in Appendices IV and V).

The data depict the average situation which farmers are likely to encounter if the assumptions made in this study are applicable. It is realised that the situation will vary according to the life of the investment and interest charges will be at their highest in the initial years. Obviously, therefore, individual farmers contemplating an investment would be well advised to calculate their commitments each year. In this way they could also estimate the number of years necessary to repay the entire capital involved assuming that any margin available to them was used each year for this purpose.

Table 18. Calculation of the Returns on Net Capital Invested in Moist Grain Towers

Details	Approximate Capacity of Towers							
	100 tons				200 tons			
	Galvanised		Vitreous Enamel		Galvanised		Vitreous Enamel	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
Returns on capital £:-								
Additional margin (returns on investment)	200·8	233·3	200·8	233·3	421·7	486·7	421·7	486·7
Interest charges ∅	37·7	37·7	43·5	43·5	51·9	51·9	60·5	60·5
	163·1	195·6	157·3	189·8	369·8	434·8	361·2	426·2
Annual allowances over 10 years on tower and equipment	107·5	107·5	124·3	124·3	148·3	148·3	172·8	172·8
Taxable profit	55·6	88·1	33·0	65·5	221·5	286·5	188·4	253·4
Tax @ 8/3d.*	17·8	28·3	10·6	21·0	71·1	91·9	60·4	81·3
Available to farmer	37·8	59·8	22·4	44·5	150·4	194·6	128·0	172·1
Average investment+	538·0	538·0	622·0	622·0	742·0	742·0	864·0	864·0
Allocation of Returns on Capital %								
Interest charges	7·0	7·0	7·0	7·0	7·0	7·0	7·0	7·0
Repayment of capital	20·0	20·0	20·0	20·0	20·0	20·0	20·0	20·0
Tax commitments	3·3	5·3	1·7	3·4	9·6	12·4	7·0	9·4
Available to farmer	7·0	11·1	3·6	7·1	20·2	26·2	14·8	19·9
Total Returns on Capital	37·3	43·4	32·3	37·5	56·8	65·6	48·8	56·3

∅ 7% on half tower and equipment

* The tax @ 8/3d. relates to 7/9ths of the taxable profit, thus allowing 2/9ths for Earned Income Relief.

\+ The average annual investment is assumed to be half the original capital invested.

The data show that on average fairly attractive gross returns on investment net of grant are forthcoming. These range from about 32% in the case of the 100 ton vitreous enamel towers to as much as 66% for the 200 ton galvanised towers. In some cases the returns were inadequate to meet all commitments and at the same time to provide the farmer with a return for his efforts. This was the case for 100 ton vitreous enamel towers with no grant and only 10% of the crop having to be dried, (see Appendix IV). It should be pointed out that this study did not reveal advantages for the vitreous enamel over the galvanised tower but it is not claimed that this is so. Indeed, far more evidence is needed before confident pronouncements can be made on the relative efficiencies of towers of different types.

CHAPTER IV.

SUMMARY

It has already been emphasised that the present study is concerned more with the factors which should be considered in deciding whether to invest capital in tower silos rather than with the prediction in specific terms of the impact of such capital investment on farm profits. In the course of the investigation several significant points concerning both high dry matter silage and moist grain storage have emerged.

TOWER SILAGE

Individual farmers in the sample have between them experienced a host of difficulties in the process of conserving grass in tower silos. These are set out below.

Technical difficulties

Different participants encountered snags in the process of harvesting, loading and unloading grass and it seems that adaptations and modifications of existing equipment will have to continue before a completely reliable and easily manageable system is evolved.

At the moment there is a variation in the attitude of farmers towards the use of the flail mower. It is claimed on the one hand that it will speed up the cutting operation and with ideal conditions wilting takes place rapidly. On the other, it does tend to mix up the grass. This might make the subsequent chopping operation rather inefficient because it could result in wide variation in the length of material which is blown into the tower. In this respect the importance of sharp well-set knives on the forage harvester cannot be over emphasised. In addition to inefficient chopping, grass which is either too wet or too dry, as well as operational bottlenecks can lead to delays at the blower, and may slow up the rate of filling. A slow rate of filling could be serious in the case of large diameter towers because of the risk of overheating.

The loading of the towers has a profound impact on subsequent unloading and co-operators emphasised the importance of an even spread of the crop in the silo. Manufacturers are acutely aware of this factor and various pieces of equipment have been used to deflect and distribute the grass in an attempt to obviate the need for spreading by hand. Success in this quest has been variable and it still seems that the complete answer has so far eluded the industry.

Perhaps the task of unloading tower silos has created the biggest problem but there is growing confidence at the moment that the features conducive to success have at least been recognised. Most farmers would agree that even spreading of a uniform, finely chopped material having a dry matter content of between 40% and 45% are features which go a long way towards ensuring rapid rates of unloading. Lastly, it seems that the correct adjustment and servicing of unloaders is of vital importance in ensuring a steady flow of material.

It seems then that scrupulous attention to detail is essential to the successful operation of the equipment at present available. Furthermore, the equipment does not allow very much latitude in the condition of the crop and both moisture content and fineness of chop must be within narrow limits to assure success. It is worth noting that lack of care at this stage only delays operations such as auger feeding and may involve considerable time in supervising a long drawn out operation of unloading.

Labour economy

The use of tower silos and mechanised feeding systems rarely result in fewer men being employed although this is not impossible on the larger farms. However, labour economies do occur on most farms but any labour saved is usually taken up in expanding the size of business. On the present sample it was found that valuable time was devoted by the farmer himself or by a paid manager to the supervision of all operations and to the maintenance of all equipment in working order. The position, therefore, is one of replacing the cheaper general farm worker by a more expensive supervisor. This may be a temporary phase during which farmers acquire more knowledge, farm staff are trained and manufacturers improve their designs, and it is hoped that the system eventually becomes reliably automatic.

Performances from Tower Silage

There is no denying the fact that the performances from tower silage have been very disappointing to date. There are, of course, a few records of success but in the majority of cases the story is one of over-feeding of concentrates and the under-estimation or failure to take advantage of silage quality, particularly with regard to protein content. However, it should be stressed that the farmer usually has to rely on experience to indicate the precise feeding value of the tower silage because chemical analyses often, and perhaps inevitably, fail to match the current feed being unloaded. The farmer faced with this situation tends to resort to generous supplementary feeding in order to guard against any adverse change in quality. In doing so there is a grave risk of using high quality silage wastefully.

It is possible that farmers should restrict the use of high quality tower silage to high yielding cows. At the moment most farmers feed the entire herd together so that dry cows and low yielders might be consuming far more than they actually need to meet their maintenance and production requirements. With a strict rationing system and splitting the herd according to nutrient requirements, over-feeding is avoided and the silage would then be adequate for more cows. The combined effect of minimising wastage in conservation and of rationing the product carefully would allow stocking rates to be increased.

The study covered a range of equipment which varied in price, but there was no indication from this survey that the more expensive equipment was more efficient. This may be the case because most farmers are now aware of the importance of covering the grass in the "top unloading" towers with some form of plastic sheeting after each filling. In this way the wastage associated with heating and surface decomposition can be considerably reduced.

Management

A high standard of management is essential if success is to be assured with a tower silage system. In this respect the importance of experience in the developmental stage cannot be overstressed, because most farmers do become aware of the factors involved in the successful operation of the system, and some claim considerable improvement from year to year. As with all grassland systems, complete success is not possible unless every aspect of the process of growing grass in the field to its final utilisation in livestock production is carefully scrutinised. (Although this study concerns itself with dairy cows, its impact on the feeding of other livestock should not be overlooked.) In this respect the use of the expensive tower system demands a change in grassland management and a succession of young, highly digestible swards for conservation is vital. Subsequently a conservation technique with a smooth team operation must be evolved in order to ensure the rapid filling of the tower with a uniform quality, short chopped and evenly spread product falling within a narrow range of dry matter content. In the entire process from growing grass to feeding stock it has been found that the technical ability of the farmer to supervise, adjust and maintain the equipment is of paramount importance. The impact of the tower silo system thus precipitates the need to make policy decisions on the entire farm organisation such as changes in stocking and cropping, in feeding methods and in labour use. Adjustments of this nature are vital and farmers should be warned of the consequences of using towers merely as a substitute for their existing conservation methods.

At the moment farmers are experiencing difficulty in wilting early cut, highly digestible grass to a product having 40%-45% dry matter. This is primarily due to the absence of suitable weather conditions - it is a known fact that the number of consecutive days during which wilting can be practised in the South-West are relatively few. This is a major drawback in the production of a high quality grass silage, and farmers must be prepared to experiment with other crops which do not require wilting and which are, therefore, largely independent of weather conditions. The use of whole crop barley, maize and forage mixtures such as dredge corn and tic beans may hold the key to success in the future, both as regards improved conservation techniques and more uniform nutritional values in the final product.

Prospects

The appearance of tower silos and allied equipment is of comparatively recent origin and at the moment many interesting and promising developments and adaptations are taking place. For instance, glass fibre, stainless steel and aluminium alloy towers have recently been put on the market. The wide range of equipment being offered by a number of manufacturers ensures a highly competitive market and as the report is being prepared price reductions are announced by at least one tower silo manufacturer. Quite apart from the significance of new technology on the reliability and efficiency of harvesting, loading and unloading equipment for tower silos, and the feeding operation, a number of extremely important factors are likely to influence the position. The effect on cereal and other product prices of membership of the European Economic Community, the prospect of cheap sources of energy and its implication for drying grass, the possibility of dairy herds getting much bigger and improvements in existing conservation methods and feeding arrangements, all these have to be carefully considered before embarking on an alternative system of conservation. In the welter of choices available already and the technology which will become available over the next few years, decision making becomes difficult, and it is very unlikely that farmers will always be satisfied in retrospect that they have made the right decisions. However, they should try to establish whether particular capital investments are justified. It is hoped that this report will be of some assistance to prospective buyers in highlighting the host of factors which need to be considered. The fact that at certain indifferent levels of performance from tower silage the capital investment is not justified, illustrates the importance of the budgeting exercise.

MOIST GRAIN STORAGE

In this study it was not possible to assess the relative performance of "moist" and "dry" barley - the majority of farmers in this sample having mixed their own concentrates using either product according to availability. However, the data did show that farmers relying heavily on home-produced concentrates tended to feed their livestock rather lavishly - this is in line with evidence from another part of the country.(1)

All the co-operators in this investigation used towers for the storage of barley. They were all agreed that moist barley had certain advantages over the "dry" product. For instance, it was claimed that moist barley was easier to roll, that its use reduced the incidence of respiratory and digestive troubles quite often associated with the dust in the dry grain, and that the fermentation which takes place results in a very palatable product which might induce stock to consume greater quantities.

For the 1965 harvest the moisture content of the barley stored in the tower silos varied from 16% to 28%. Obviously at 16% the keeping time of the product was indefinite. At the other extreme of 28% the "shelf" life or keeping time would only be a matter of a few days. Apart from its influence on this factor, the moisture content also determines the ease with which the grain can be blown, augered and processed. Due to improved technology, particularly in the unloading of moist grain from tower silos, very little difficulty was experienced in handling the product on the present sample of farms.

In the decision to invest in a tower silo for grain storage, the possibility of improved feeding value was very much a secondary consideration. The elimination of drying was a far more important factor on these farms where barley was already being rolled and fed to stock. Furthermore, the towers were generally erected to fit in with existing facilities, thereby replacing sack storage, and increasing storage capacity, and in the process removing

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(1) The costs of inaccuracy in dispensing concentrates to dairy cows. R.S. Cook, Miscellaneous Studies No. 28, University of Reading.

any bottlenecks which may have occurred previously between field and storage.

It must be realised that the investment in tower silos for grain storage is rather inflexible. Indeed, apart from providing storage for dry grain, the silos have no other economic use so that if livestock enterprises were terminated it would be difficult to find a market for the moist products, although in fact four farmers in the survey did sell a small tonnage of the barley for stock feeding. The limited market which exists for the moist grain must, therefore, be borne in mind when deciding whether to invest in these facilities, and at the same time all the other financial implications must be carefully budgeted. Again, it is hoped that this study has helped farmers in some small measure to make the correct decision regarding investment in tower silos for grain storage.

A P P E N D I C E S

APPENDIX I.

Potential Contribution* of Tower Silage to Milk Production

	S.E.	P.E.
50 lb. Tower Silage @ 46·3% D.M. provides	11·15	2·05
Maintenance Friesian Cow	7·00	0·70
For production	4·15	1·35
1st gallon	2·50	0·50
	1·65	0·85
½ gallon	1·25	0·25
	0·40	0·60
3½ lb. Barley	2·50	0·23
	2·90	0·83
1 gallon	2·50	0·50
	0·40	0·33
3½ lb. Barley	2·50	0·23
	2·90	0·56
1 gallon	2·50	0·50
	0·40	0·06

* 1½ gallons from Tower Silage and next 2 gallons from Barley.

APPENDIX II.

Effect of Conservation Method on Density of Stocking

Assumed Requirements	Traditional Silage	Tower Silage
	acres per cow	
Grazing	1·20	1·20
Conservation	0·45*	0·37*
Total	1·65	1·57
	number	
Cows per 100 acres	61	64
Increase in stocking rate	-	5%

* Based on difference in total wastage rate of 15% of the original dry matter.

APPENDIX III. Effect of Tower Silo System on Margin over Concentrates in Milk Production

(all year round calving pattern)

IA. Situation before Introduction of Tower Silo:-

76 Cow Herd averaging 850 gallons at 3/- per gallon and fed on Silage and Concentrates

Output	£	Costs	£
Milk sold £127·5 x 76 cows	9,690·0	Concentrates:-	
90% calving rate x £14	957·6	397 Winter gallons @ 4 lb/gall = 14·18 cwt. @ 35/- x 76 cows	1,886·3
	10,647·6		
Depreciation £10/cow	760·0	453 Summer gallons @ $1\frac{3}{4}$ lb/gall = 7·08 cwt. @ 28/- x 76 cows	753·2
			2,639·5
		Margin over Concentrates	7,248·1
	9,887·6		9,887·6

IB. Increased Stocking Rate and Replacing Concentrates for $\frac{1}{2}$ gallon during Winter

Output	£	Costs	£
Milk sold - 76 cows	9,690·0	Concentrates:-	
- 4 cows	510·0		
90% calving rate x £14	1,008·0	322 Winter gallons @ 4 lb/gall = 11·5 cwt. @ 35/- x 80 cows	1,610·4
	11,208·0	453 Summer gallons @ $1\frac{3}{4}$ lb/gall	
Depreciation £10/cow	800·0	= 7·08 cwt. @ 28/- x 80 cows	792·8
			2,403·2
		Tower - running costs only (£)	
		fuel & electricity 30	
		other 50	80·0
			2,483·2
		Margin over Concentrates	7,924·8
	10,408·0		10,408·0

IC. Increased Stocking Rate and Replacing Concentrates for $1\frac{1}{2}$ gallons during Winter

Output	£	Costs	£
		Concentrates	
Milk sold - 76 cows	9,690·0	183 Winter gallons @ 4 lb/gall = 6·54 cwt. @ 35/- x 80 cows	916·0
- 4 cows	510·0	453 Summer gallons @ $1\frac{3}{4}$ lb/gall = 7·08 cwt. @ 28/- x 80 cows	792·8
90% calving rate x £14	1,008·0		1,708·8
	11,208·0	Tower - running costs only (£)	
Depreciation £10/cow	800·0	fuel & electricity 30	
		other 50	80·0
			1,788·8
		Margin over Concentrates	8,619·2
	10,408·0		10,408·0

ID. Increased Stocking Rate, Replacing Concentrates for $1\frac{1}{2}$ gallons and Using Barley for the next 2 gallons during Winter

Output	£	Costs	£
		Concentrates	
Milk sold - 76 cows	9,690·0	17 Winter gallons @ 4 lb/gall = 0·61 cwt. @ 35/- x 80 cows	85·6
- 4 cows	510·0	166 Winter gallons @ $3\frac{1}{2}$ lb/gall = 5·19 cwt. @ 22/- x 80 cows	456·8
90% calving rate x £14	1,008·0	453 Summer gallons @ $1\frac{3}{4}$ lb/gall = 7·08 cwt. @ 28/- x 80 cows	792·8
	11,208·0		1,335·2
Depreciation £10/cow	800·0	Tower - running costs only (£)	
		fuel & electricity 30	
		other 50	80·0
			1,415·2
		Margin over Concentrates	8,992·8
	10,408·0		10,408·0

APPENDIX IV. Calculation of the Returns on Capital Invested in Moist Grain Towers
(no grant allowed)

Details	Approximate Capacity of Towers							
	100 tons				200 tons			
	Galvanised		Vitreous Enamel		Galvanised		Vitreous Enamel	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
Returns on capital £:-								
Additional margin (return on investment)	200·8	233·3	200·8	233·3	421·7	486·7	421·7	486·7
Interest charges ø	48·7	48·7	57·1	57·1	68·6	68·6	80·9	80·9
	152·1	184·6	143·7	176·2	353·1	418·1	340·8	405·8
Annual allowances over 10 years on tower and equipment	139·0	139·0	163·0	163·0	196·0	196·0	231·0	231·0
Taxable profit	13·1	45·6	nil	13·2	157·1	222·1	109·8	174·8
Tax @ 8/3d.*	4·2	14·6	nil	4·2	50·4	71·2	35·2	56·1
Available to farmer	8·9	31·0	nil	9·0	106·7	150·9	74·6	118·7
Average investment+	695·0	695·0	815·0	815·0	980·0	980·0	1155·0	1155·0
Allocation of Returns on Capital %								
Interest charges	7·0	7·0	7·0	7·0	7·0	7·0	7·0	7·0
Repayment of capital	20·0	20·0	17·6⁑	20·0	20·0	20·0	20·0	20·0
Tax commitments	0·6	2·1	nil	0·5	5·1	7·3	3·0	4·8
Available to farmer	1·3	4·5	nil	1·1	10·9	15·4	6·5	10·3
Total Return on Capital	28·9	33·6	24·6	28·6	43·0	49·7	36·5	42·1

ø 7% on half tower and equipment.
* This tax at 8/3d. relates to 7/9ths of the taxable profit, thus allowing 2/9ths for Earned Income Relief.
+ The average annual investment is assumed to be half the original capital invested.
⁑ maximum.

APPENDIX V.

Calculation of Net Capital Invested in Moist Grain Towers

Approximate capacity 100 tons

	Galvanised £	Vitreous Enamel £
Tower Silo (incl. installation)	1050	1290
Loading and unloading equipment	340	340
Total Capital Cost	1390	1630
Less F.I.S. 30% Cash Grant on Tower	315	387
Net Capital Cost	1075	1243
Average Investment	538	622

Approximate capacity 200 tons

	Galvanised £	Vitreous Enamel £
Tower Silo (incl. installation)	1590	1940
Loading and unloading equipment	370	370
Total Capital Cost	1960	2310
Less F.I.S. 30% Cash Grant on Tower	477	582
Net Capital Cost	1483	1728
Average Investment	742	864