AGRICULTURAL ECONOMICS RESEARCH UNIT
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TOWER SILO FARMING IN NEW ZEALAND

PART 1
A REVIEW

by

D. McCLATCHY

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Research Report No. 56
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THE AGRICULTURAL ECONOMICS RESEARCH UNIT

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TOWER SILOS IN NEW ZEALAND

PART I : A REVIEW

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Agricultural Economics Research Unit Research Report No. 56

PREFACE

The introduction of fully mechanised fodder conservation in New Zealand and its consequent implications for a possible zero grazing system of pasture utilisation, has aroused a great deal of interest and controversy in recent years.

A system of fodder conservation which aims at more efficient utilisation of pastures and fodder crops, would, on the face of it, seem to have an important place in the New Zealand livestock industry. Such a proposition obviously requires some preliminary investigation before it can be officially recommended. Does tower storage offer an efficient means of fodder conservation?

A second major question is inspired by the suggestions of the zero-grazing advocates. That is, can a system of animal production based on the mechanical feeding of high-yielding non-grazable crops, harvested mechanically and stored in towers, be more profitable than the traditional pasture grazing system in any particular New Zealand environment?

The potential offered by Silo farming - as it is sometimes known - must be investigated,and it is in this spirit that the research underlying the following report was initiated and carried out. At the suggestion of the New Zealand Silo Society, supported by a research grant, we set out simply to establish the facts about the present extent of silo use in New Zealand, and the advantages claimed by the operators - and to follow it up with an investigation of the economics of various tower silo systems.

This report gives the results of this initial survey. The first few pages make clear that the essential characteristic of the new system is the use of tower silos for storage with or without mechanical feeding systems and indoor housing. Mr McClatchy brings out the essential advantages and disadvantages of tower silos in use in New Zealand today and relates these to overseas performance and experience as reported in the literature.

A second report will deal with the anticipated profits which can be expected from these new systems of fodder conservation.

The Agricultural Economics Research Unit is happy to be associated with the University of Waikato in organising and carrying out this investigation and in joint publication of the reports. Acknowledgment must also be made to the New Zealand Silo Society for their generous research grant which allowed the project to be carried out.

B. P. Philpott

Lincoln College,
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I N D E X

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TOWER SILOS IN NEW ZEALAND
PART I : A REVIEW

INTRODUCTION

Outline of the Study

This bulletin presents the results of the first stage of a study of the present and potential place in New Zealand agriculture of tower silos for forage conservation. The aim of the study is to present information which will aid policy-makers and farm management extension workers in deciding if and when investment by farmers in tower silo systems should be encouraged on economic grounds.

This first stage report seeks to describe the present usage of tower silos in this country, the main implications for management on the farms concerned, and the attitudes of the existing operators. Information was obtained by means of a survey conducted by the author in the latter part of 1968.

There is no concern in the present instance with attempting an evaluation of the worthwhileness, on economic or any other grounds, of any particular type of tower silo system. A second bulletin will present some profitability studies of tower silo enterprises on hypothetical case farms. The choice of a normative[1] method of profitability analysis stems from the present lack of sufficient historical

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[1] i.e. based on 'what could or should be' rather than 'what has been' achieved.

real-farm technical data, and the claim by most present operators that their performances to date with towers, due to initial lack of experience and advice, are not representative of what they will be able to achieve in the future.

Tower silos in New Zealand and overseas

Cylindrical towers have been used for many years in some countries, particularly the United States, for the storage of silage. Their use in New Zealand, except for the odd isolated instance, is a relatively recent innovation, which has not yet been adopted to the extent of the more traditional methods of silage storage, or of the other notable recent development in this field, the vacuum packing of silage. There would appear to be a fairly widespread belief at present among New Zealand farmers and farm advisers that the relatively high capital cost of tower silos and associated equipment makes them an unprofitable investment. However, to the author's knowledge at least, no thorough economic analysis has yet been carried out to test this proposition under any particular set of conditions in this country, let alone under all conditions.

In Britain the profitability of tower silos on dairy farms is under considerable debate amongst agricultural economists at the present time. Most appear to agree that considerable economies of scale are associated with these structures and associated feeding systems, and that on the largest farms (e.g. over 100 cows - not necessarily large by New Zealand standards) they are economically justified. The disagreement appears to centre mainly on where the 'break-even' herd size lies.

In the United States most silage is stored in towers. In

1963 there were 682,000 upright silos, 251,000 trench, bunker and pit silos, and 70,000 temporary structures including stacks.[1] As a proportion of the total, the numbers of upright silos varied by State from 10 per cent in Texas to 95 per cent in Wisconsin. The Illinois Forage Handbook[2] states (p. 9), - "For feeding more than 450 tons of silage a year, the upright silo, equipped with a silage unloader and conveyor, is the most economical system (of storage)".

Naturally the same conclusions need not necessarily apply for the New Zealand farmer, facing, as he does, a different farm costs structure and different climatic and growth conditions. Nevertheless, in view of the widespread use of these structures in some other countries, it seems surprising that their potential place in New Zealand agriculture has not been investigated more thoroughly in the past.

The association of tower storage and mechanised feeding of silage

It is not necessary that silage be fed mechanically from tower silos, but it is probably true that this method of storage is much better adapted to mechanised feeding than other alternatives. This in turn probably explains largely why the use of towers is more common in countries where the housing of stock for at least part of the year is a normal practice, and/or where labour costs are relatively higher.

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[1] See U.S. Department of Agriculture (1968).

[2] See University of Illinois (1964).

Some farmers are known to have their own successful improvised systems of mechanical handling of pit, clamp, or stack silage, and of hay. In general, however, it appears that commercially available mechanised handling systems for these forages are still very much in the developmental stage, considering the range of equipment already available for handling tower silage. It may therefore be concluded that, for the ordinary farmer, tower silos are a necessary prerequisite for fully mechanised forage feeding at the present level of machinery availability.

If mechanised forage feeding is considered a desirable adjunct to housing livestock, then tower silos may also be regarded as a prerequisite for a stock housing system.

The association of tower storage and the conservation of low moisture silage

The use of towers as a method of silage storage has also received a boost in recent years with the increased popularity of wilted ('high dry matter' or 'low moisture') silage. This technique provides a more palatable end-product, which can be consumed in greater quantities by the animal fed, and which therefore has the advantage over unwilted (high moisture) silage in that it can be used as the main basis of an above maintenance diet. Wilted silage, however, is much more prone to aeration damage than unwilted silage and thus its storage under air-tight conditions is far more critical. Such conditions have so far only been satisfactorily achieved in towers and in vacuum-packed plastic envelopes and are probably more easily and consistently obtained under farm conditions with the former technique, particularly where the towers are designed to be air-tight. Deterioration once feeding commences is likely to be considerably less in towers, with a relatively small (in relation to

total silage volume) air interface. Some towers are designed so that no exposure to the atmosphere occurs even during unloading. With the vacuum-packing technique, risk of puncture, subsequent air-leakage, and consequential heavy damage to the silage, is fairly high under farm conditions. Objective measurement of the degree of this risk is needed. At present, however, a practical conclusion would appear to be that tower silos are desirable for low moisture silage making.

REVIEW OF SURVEY RESULTS

In June 1968, when this survey was commenced, there were 30 known tower silo operators in New Zealand. Information about their farm organisation and management, with particular reference to their tower silo operations, was gathered from 18 of these by means of a postal questionnaire (most) and by personal visit (some).

Most farmers contacted had had only limited experience with tower silos, and were not satisfied that they had arrived at the most satisfactory or efficient method of utilisation of their structures. The average time of involvement with such a system was 2-2$\frac{1}{2}$ years, the longest, 8 years. This lack of experience in many cases seriously limited the ability of the farmer to answer many of the questions asked.

There proved to be considerable variation between these 18 farms in -

a. the type of farming practised in terms of products;

b. the types and sizes of tower silo(s) owned;

c. the types of material stored in the silo(s);

d. the methods of feeding of this material;

e. the place and importance of tower silage in the overall livestock feeding program throughout the year;

f. the extent to which the tower silo feeding system was associated with a livestock housing system; and

g. the attitudes of the operators, particularly with reference to the assessed advantages and disadvantages of their tower silo system, both at the time of the initial investment and at present.

These points will be considered in turn in the sections which follow. A subsequent section attempts to classify the roles which tower silo systems can be made to play in the total farm feeding program, and to outline the possible advantages and disadvantages of such systems in relation to alternatives for each main type of role. A further section looks critically at some of the main arguments for tower silo systems, and the final section summarises the findings to this stage.

TYPES OF FARMING PRACTISED BY TOWER SILO OPERATORS

A wide range of farm types are represented by those farms on which tower silos are already in operation in New Zealand. These include

1. Intensive beef fattening units.
2. Store beef and beef breeding units.
3. Traditional sheep/beef 'fat lamb' farms.
4. Mixed cropping farms.
5. Town supply dairy farms.
6. Seasonal supply dairy farms.

Roughly one half of the farms surveyed are dairy farms principally (i.e. in categories 5. and 6. above), though many of these have associated beef enterprises (mainly dairy beef). On all types the feeding of tower silage is confined largely to cattle (both beef and dairy types), though in one case it is being used as a supplementary sheep fodder.

Approximately one third of present 'tower silo farmers' run pedigree livestock. This is probably considerably greater than the proportion of 'all farmers' who are registered stud breeders.

VARIATIONS IN STRUCTURE OF TOWER SILOS

1. Numbers owned

Three farmers owned three tower silos, three owned two, and the rest one. In addition two men each owned a smaller tower-type grain silo.

2. Capacities

The capacity of a tower silo is best expressed in tons of plant dry matter (D.M.), because although the capacity in terms of total weight is much higher for higher moisture material, consolidation is such that the weight of D.M. to fill a tower silo tends to be fairly constant with varying moisture content of the stored crop.

Capacities of silos owned varied from 90 up to 200 short tons of D.M. Total tower silo storage capacity per farm varied from 90 up to 490 short tons of D.M. This latter figure may be expressed as the total annual production from 70 acres at 14,000 lbs. D.M. per acre.

3. Types

The tower silos at present in use in New Zealand on the farms surveyed cover a wide range of construction materials. These structures are frequently classified into two groups, depending on whether or not they are designed to be sealed against the atmosphere. Those which are, are in general more expensive to buy. The makes in use include both a bottom-unloading and a top-unloading type made from steel which is coated with vitreous enamel or glass to prevent corrosion, and a top-unloading fibreglass type. About 75 per cent of the respondents had towers of the air-sealed type.

Non-sealed (at top) types in use are made from monolithic concrete, concrete blocks, plywood, or wooden staves. A concrete

stave type tower silo is also advertised as available and made in New Zealand. These are usually well sealed on the inside walls with various combinations of paint and plastic or other sealing compounds. American trials have shown that the D.M. wastage rates can be very much lower in tower silos which are air-sealed, but that effective air-tight conditions can be achieved in unsealed types with careful consolidation and the use of plastic covering sheeting. On the other hand, some of the 'air-sealed' types have been found to be not always completely air-tight, particularly once unloading has commenced.

Air-sealed types appear to have definite advantages where loading is to be on an interrupted basis, e.g. where several cuts are taken from one crop at intervals. The bottom-unloading model, while difficulties of unloader maintenance appear to be greater, has considerable advantages when loading and unloading are desired to proceed simultaneously. This latter situation may arise with a smaller farm, with perhaps only one silo, and where the policy is to feed supplementary tower silage all the year round.

CROPS ENSILED IN TOWERS AT PRESENT

Three farmers of those surveyed grew corn which they harvested at a fairly mature stage ('dent' stage - cob formed and grain beginning to show indentation). This material is chopped and stored directly, without any form of drying, at a moisture level of roughly 70%. In addition one farmer ensiled corn waste material, which he obtained at very low cost as a residue after harvest of sweet corn for canning. A few farmers not yet growing corn indicated their intention to do so ultimately or in the near future. One farmer ensiled an oat crop at a similarly mature stage.

All other types of material were mown and wilted in the windrow (sometimes with the aid of conditioning or crimping) before being fine-chopped and stored at 50-60% moisture or less. All except two of the respondents stored in towers at least some such low moisture silage which they had made from normal grass/clover pasture. Such 'haylage' constitutes at present by far the greatest bulk of the material stored in towers in New Zealand.[1]

There may be some need at this stage to underline a distinction between two main classes of material stored as tower silage, each of which has rather different feed value characteristics from the other. These two types will be called here 'Grain-silage' and 'Leaf-silage', and are discussed in turn below:

a. Grain-silage. If a plant of the grass family is cut for silage when the grain is mature (though not fully ripe), then the protein level in the resultant silage D.M. will be lower, and the total carbohydrate higher, than if the crop had been cut at a physiologically less mature stage. For any one plant species the non-digestible carbohydrate fraction (largely fibre) will be higher the more mature the crop, so that digestible carbohydrate (D.M. basis) may not be higher, and total digestible nutrients will probably be lower, at this stage. However, corn (maize) has a relatively low fibre content, and a correspondingly high relative digestibility, even at such a mature stage when its per acre D.M. yield is at a maximum. It is relatively

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[1] c.f. The United States, where, in 1963, 76 per cent of all silage came from the corn plant, and pasture grasses and legumes accounted for less than 13 per cent (U.S.D.A. op. cit.).

low in protein, on the other hand,and should therefore be regarded as a high-energy, low-protein feed. Because of its high yield and high digestibility characteristics, corn is the predominant crop to be used for ensiling at the mature stage, both in New Zealand and overseas. Grain sorghum, oats, and other cereals, are sometimes used.

b. Leaf-silage. In contrast to the position in the U.S.A., this type of silage is still by far the most important in New Zealand, even in tower silos. It may be made from normal grass/clover pasture, from lucerne, or from sudan/sorghum type crops, and preferably when all these crops are in the leafy, pre-flowering stage of maturity. In comparison to corn grain-silage, it is likely that here protein levels will be considerably higher, total digestibility similar or slightly lower, and digestible carbohydrate considerably lower. In physiologically less mature plants the moisture content will also be higher. In all cases recorded for New Zealand of leaf-silage being stored in towers, the material was wilted to some degree before ensiling. The term 'haylage' will be used as synonymous with 'wilted leaf-silage'through this report.

Typical nutritive analyses of the main silage types stored in towers in this country may be as follows (grazed pasture is included for comparison):

		D.M. Basis			
	% D.M.	% TDN	% Crude Fibre	% Crude Protein	% Digestible Protein
(1) Grain-Silages					
Corn	30-35	65-70	25	8.5	4.5
(2) Leaf-Silages					
Ryegr./clover pasture. →	depends on degree of wilting eg. 55%.	→60-65	25-30	18-20	12-14
Lucerne →		→ 60	30	18-20	12-14
(3) Grazed Pasture	80-85%	70-75	20-25	20-25	14+

With leaf-silage types particularly, the last four figures will vary considerably depending on the stage of maturity of the crop when cut. However, present evidence suggests that only the D.M. percentage will be affected to any great extent by the degree of wilting, and that the method of storage (tower, bunker, stack, pit or vacuum pack) will not greatly affect any of these figures. Other values will be affected by the dryness of the material and the method of storage; - particularly the extent of fermentation of the silage (and hence palatability and subsequent animal D.M. intake), and the degree of wastage incurred. Nevertheless, the quality of the original crop appears to be by far the major determinant of the feeding value of the ultimate silage.

Overseas evidence for the nutritive value of the various types of silage stored in towers is contained in the following references, which are listed in full in the Bibliography: U.S.D.A. (1962.a), American Forage and Grassland Council (1966), Iowa State Univ.(1968), American Grassland Council (1963), Morrison (1936), Evans (1960), Owen (1967), Univ. of Illinois (1964), Owen & Kuhlman (1967), Donker et al. (1968), Gordon et al. (1959, 1961, 1963, 1965), Ward et al. (1966), Hempken & Vandersall (1967), Perry & Beeson (1966.a, 1966.b), Wittwer et al. (1958), Wragg,, Godsell and Williams (1968), Dawson (1968, Baker (1967), Rogers & Bell (1953), Huber et al. (1965), Neidermeyer et al. (1961), U.S.D.A. (ARS 44-176), Klosterman (1963), Smith (1961), Gay (1967).

METHODS OF FEEDING TOWER SILAGE

Unloading Operation:

All farmers contacted were equipped with mechanical silo unloaders.

Conveyance from silo base to feeding site:

Three transported the material by self-unloading trailer, and fed on the ground in the paddock. The remainder fed in troughs (feed bunks) set on a concrete feeding pad, which in all cases was situated in close proximity to the tower silo(s) and was roofed (roof continuous with a bedding area in five cases). The transport of material in the latter cases, from silo base to troughs, was achieved mechanically with the use of an auger worm (11 cases) and/or a chain conveyer (4 cases).

Effluent Disposal:

Most farmers who feed their tower silage mechanically into troughs keep the area of concrete around the troughs clean by regular removal of droppings. This task is commonly performed daily, though a few cases of both more regular and of less regular cleaning than this were reported. Most used a tractor mounted scraper blade to clean the feeding area. A few (4) used high-pressure hoses. In these latter cases the effluent was considerably diluted and ultimate disposal to the paddocks was by pumping, or, in one case, by liquid tanker.

In one case the bedding area extended right up to the feeding trough: there was no distinguishable feeding area. Here, all animal waste accumulated in the bedding material, and was cleaned out only once per year. This practice is apparently common in Britain, where provision is normally made for the feeding troughs to be easily raised

in height as the floor area builds up.

Disposal of cleared effluent was not usually carried out with the same frequency as cleaning. In the majority of cases paddock spreading was achieved using a tractor-drawn muck spreader, most makes of which are able to handle material effectively over quite a wide range of dryness. One farmer used a tip truck for spreading, and one a liquid manure tanker. The remainder (4) diluted the effluent, usually in a specially built concrete storage tank, to a stage where it could be pumped on to their paddocks via irrigation pipes and coarse-jet or special liquid manure nozzles.

DEGREE OF RELIANCE ON TOWER SILAGE IN FEEDING PROGRAMS

a. Acres cut:

As a proportion of total farm acreage this varied from 1% to 75% on the properties surveyed. This includes both acres of special crops (a full summer's production) and pasture acres (shut up for a varying number of months). About 40% of farmers harvested at least part of the season's production from 50% or more (by area) of their farms, while another 40% fell into the category of harvesting from 10% or less of their total farm acreage.

b. Tower silage as a proportion of total hay and silage conserved:

On approximately half of the farms with tower silos, these structures alone were used for fodder conservation. On the remainder they constituted the major method of conservation in all except two cases where tower silos filled a subsidiary role to hay and/or high moisture stack/pit silage.

c. Tower silage conserved as a proportion of total annual pasture and crop production (D. M. basis):

An estimate was made of this figure for each farm. The results varied from 2% up to 40%. For three quarters of the farms this figure was below 20%.

d. Proportion of total diet when fed:

This varied from 20% to 100% of total daily intake, depending on the time of year, the type of animals fed, and the farm. Only three farmers fed tower silage at any time as a complete and sole ration.

Most of the beef farmers feeding haylage supplemented this with a grain (crushed barley or wheat) to add to the energy content of the ration. A few of the dairy farmers supplemented their haylage with concentrate meal and/or 'dairy ration', while many fed some hay in addition. Most of the dairy farmers for most of the time they were feeding tower silage, and some of the beef fatteners for some of the time, allowed the animals a certain amount of time per day on pasture grazing. Overall, pasture grazing was perhaps the most important adjunct to tower silage in terms of total daily dietary intake.

e. Additives:

One farmer had added chopped hay at the time of silage storage in order to further reduce the moisture content of his partly wilted silage material.

Another farmer added limestone while ensiling, and common salt (NaCl) when feeding out. This same farmer indicated his intention to also add urea to his corn silage in the coming season in order to increase the effective protein content of the feed ration. This was to be added as evenly as possible during loading of the tower.

Reference has already been made (above) to instances of

grain and concentrates being mixed with tower silage just before feeding. Apart from these few cases, no farmers were using any additives either at time of ensiling or at time of feeding.

ASSOCIATED LIVESTOCK HOUSING

All except four of the farmers contacted had, or were constructing, barns for the purposes of housing livestock for at least part of the year. Some of these barns (5) are extensive structures, fully enclosing bedding and feeding areas. The remainder are predominantly three-sided structures, being open towards the feeding area, and covering the bedding area only. In a few cases the walls were designed only as wind-breaks, e.g., being constructed of wooden slats with considerable ventilation. Obviously the degree to which animal maintenance feed requirements are reduced by the shelter provided would vary with these different types of structure, and the degree of protection afforded.

In all cases housed beef animals had free access to the whole bedding area, except in so far as this was divided into different large pens.

The majority of dairy farmers who housed their cows, on the other hand, had barns constructed on the 'free stall' principle. This allows cows to select any one of many cubicles designed to accommodate one cow without allowing her room to turn around, so that when she stands up her hind end always protrudes over a concrete lip into a central race between the rows of cubicles. These central races will normally be of concrete and be cleaned regularly with a tractor-mounted scraper blade. When the stalls are built to the correct dimensions for the size (breed) of cow housed, then they will remain clean themselves, and are commonly just earth-floored.

Bedding Material with Free Access System:

Two farmers bedded their animals on spaced wooden slats in all or part of their total barn area. These slats were raised above floor level so that the effluent fell between them and accumulated underneath. In one case this accumulated material was cleaned out twice per year and spread in a fairly solid state with a muck spreader. In the other it is cleaned more regularly, with the aid of a high pressure hose, and in the diluted state pumped away to the paddocks.

The majority bedded with either straw, sawdust or wood shavings, depending on the local availability of each of these three materials. In each case as the faecal material becomes mixed with the bedding material, a certain amount of decomposition takes place with some resultant heating and drying out of the bedding area. A useful manure remains at the end of the bedding season - usually three to four months. Where animals were housed for the whole year, the bedding area was usually cleaned out every 3-4 months.

Where straw was used it was normally added frequently (e.g. twice daily) and in larger quantities at first. As decomposition and heating develop, then the need for fresh straw decreases and it may be added in smaller quantities and at much longer intervals. Three respondents are using straw at present, three wood shavings, and three sawdust. The frequency of addition of fresh sawdust and shavings reported, varied from every two days up to once per week.

Usage of Barns:

For the beef units with barns, livestock housing is confined mainly to the winter/spring period of 5-6 months. One farmer, however, rears calves inside over the summer/autumn period.

Dairy farmers tend to be more variable and flexible in the degree to which they house their cows. In no case were cows housed

continually (and fed wholly conserved and concentrate rations), except during periods of bad weather. Most were housed only at night for all or part of the year, sometimes on a compulsory and sometimes on a voluntary basis.

Effluent disposal from barns:

Cleaning of race areas of free-stall type barns was usually performed in conjunction with cleaning of the feeding area (see p.13).

In the case of free access barns with some form of bedding material, cleaning was usually after every 3-4 months of use, and therefore commonly in the spring/early summer period. This material, usually of a fairly dry consistency, was often spread on fallow ground and ploughed in ahead of a summer crop of, for example, corn. Alternatively it was spread on pasture.

ATTITUDES OF OWNERS/OPERATORS

Worthwhileness:

Twelve farmers felt they were able to make some evaluation of the worthwhileness of their overall investment in tower silo(s) and associated buildings and equipment. Of these, all considered the step to have been worthwhile, six on the grounds of economic criteria, and six when non-profit factors were considered. Four of the latter thought the enterprise had not proved profitable on economic grounds alone, taking into consideration the rates of interest which can be expected from the investment of capital in alternative avenues.

Regrets: Different directions of development they would pursue if starting again:

No farmer indicated that he regretted moving into the use of tower silo(s).

More than half of the farmers indicated ways in which the tower silo developments of their farm would have differed, had they initially had the benefit of their present knowledge and experience. One emphasised the need to move slowly to avoid costly mistakes, while another stated that he would have moved more quickly to the present position. Several more specific points were mentioned by different respondents, such as:-

(a) Silo erection costs would have been lowered by use of farm labour.

(b) Investment in higher capacity machinery to allow for performances not reaching the level of manufacturers' claims.

(c) Care in selection of harvesting and handling machinery: machines developed and adapted primarily to handle corn, not always being satisfactory for haylage.

(d) Modifications in design of the present mechanised feeding system.

(e) More planning of layout to provide for the potential for future expansion into more silos.

However, the biggest problem appeared to relate to the lack of finance in the secondary phase of development. Several farmers indicated that, partly because of an unfavourable swing in the economic climate, and partly because of an under-estimation of the increased demands for working capital in the post-purchase years, they had become short of finance and unable to complete the development to the extent which seemed warranted. That is, they were unable to utilise the full potential of the silos which they had purchased.

More planning for contingencies such as interest payments,

increased livestock purchases, increased maintenance and repair costs, and further capital investment, would appear to have been needed in many cases. Two farmers indicated that if starting again they would have sought considerably more long term finance, and at least one of them considered that this money would have been readily available.

The Advantages and Disadvantages of Tower Silos.

The pros and cons of tower silos and mechanised feeding systems have already been discussed to a certain extent in a previous section. However it is worth listing these as the farmers themselves see them, and note the frequency with which they were mentioned. This is done below.

Fifteen farmers gave answers to this section of the questionnaire. In a few cases the meaning of certain reply statements was not clear: these have had to be disregarded. Others have been grouped, where the change of meaning with a change in wording appeared to be negligible.

The reasons given for the tower silo investment have been interpreted as advantages of the system. Where the farmer stated that the original reasons had proved to be unjustified in practice, these have been excluded. On the other hand unexpected advantages observed since beginning operations have been included. The frequency with which each advantage (or disadvantage) was stated is noted in brackets in each case.

(a) Advantages;

- those relating to tower silos alone:

1. Reduced total D.M. losses (over harvest, storage, and feeding) with this type of conserved feed, as compared to hay and high moisture silage. (8)

2. Reduced total D.M. losses of utilization when compared to grazing pasture in situ. (6)

3. A higher quality conserved feed than hay and/or high moisture silage, sufficient in most cases as a sole and above-maintenance diet. (2)

4. A more controlled, even level of livestock feed intake is possible all the year round: this is particularly important for town supply dairy farmers in correcting for fluctuations in pasture supplies, and giving independence from seasonal climatic effects. (5)

5. The greater flexibility given: considerable variations from week to week in the numbers of stock on hand provides no great embarrassment; c.f. a pasture grazing policy. (2)

6. Reduced risk and worry for the farmer due to points 4 and 5 above. (4)

7. By counteracting the effect of seasonal imbalances in the nutrient content of pasture, tower silage feeding results in a reduction in stock health problems due to such things as bloat, facial eczema, and milk fever. (6)

8. It provides a method of handling certain high yielding crops and therefore facilitates increased production of forage D.M. per acre. (2)

9. It provides a method of utilisation of locally available low-cost fodder, e.g. sweet corn waste, aerodrome grass toppings. (4)

10. Far less dependence on good weather for harvest when compared to hay. (5)

11. Some machinery can be used for other farm operations, thus spreading the overhead costs. (1)

12. Feeding from a tower silo is more easily stopped and started than from silage stacks. (1)

13. The higher value of animal production, and therefore the

higher value per feed unit consumed , over the winter period (tower conservation allows concentration on such winter production). (2)

- those relating to the whole tower silo, mechanised feeding and/or stock housing system:

14. Reduced physical work load with mechanisation. (7)

15. A more interesting work atmosphere. . (4)

16. A more convenient system for good stock management. (1)

17. Livestock are quieter, easier to handle, and quicker to fatten. (3)

18. Reduced maintenance feed requirements of housed livestock. (1)

19. Animal manure can be returned to the pasture in an even, controlled manner. (2)

20. Having such a system overcomes most problems where the land is exposed to frequent flooding. (1)

(b) Disadvantages;

1. A greater mental effort involved in planning for the change and carrying it through. (1)

2. The nuisance value of large numbers of visitors. (1)

3. The high purchase costs of silos and associated equipment. (8)

4. The increased costs of repair and maintenance and increased risk of mechanical breakdown. (6)

5. Other secondary or second-phase costs such as capital repayment, further developments and expansion, higher electricity charges, higher fertiliser and expenditure. (5)

6. A lack of know-how and experience of the system in New Zealand at present amongst technical and managerial advisers, and equipment manufacturers and agents. (3)

7. Silo unloading difficulties and machinery imperfections. (2)

8. Difficulties of import restrictions: a high proportion of necessary equipment must be imported. (N.B. the proportion and range of equipment now manufactured in New Zealand - in some cases under licence - is much greater now than in previous years.) (3)

9. Difficulties with wind when handling tower silage material. (1) (Observation of farmer who feeds out tower silage on pasture.)

10. High water requirements of stock being fed on low moisture silage. (1)

11. The costs and problems of effluent disposal. (1)

THE DIFFERENT POTENTIAL ROLES OF TOWER SILAGE IN THE OVERALL FEEDING PROGRAM

There is considerable variation in the role which the tower silage plays in the year-round feed organisation on the farms surveyed. It appears that each of these different roles can be classified arbitrarily as fitting into one of four basic patterns:

A. As a supplementary fodder in times of feed deficit, particularly during the winter.

B. As an all-year-round supplementary fodder.

C. As the main basis of a beef enterprise diet where

concentration is on winter (out-of-season) production.

D. All-year-round feeding of tower silage as the main diet constituent.

Each of these main roles is discussed in turn below. It should be noted that the alternatives to the use of silage stored in towers will vary, depending on the role which tower silage fulfils. An attempt is made to note here the points which should be considered when comparing tower silos with alternative systems in each case. These considerations will be further discussed in the next section.

An effort is made to separate the arguments for and against tower silos per se, as a method of food conservation, from the arguments for and against stock housing and mechanised feeding. At the same time it is recognised that in some cases, if and where a necessary association exists as discussed in the opening section of this bulletin, then an argument for either of these may become an argument for tower silos.

A. Tower silage as a winter (or other feed-deficit period) supplement.

Traditionally, food grown in periods of surplus has been conserved for use in periods of deficit in such forms as hay, high moisture silage in pits and stacks, and as standing pasture or crops. Such conserved fodders tend to be costly, in terms of effort, machinery and feed wastage, when compared to pasture grazed in situ as it is growing. For this reason the level of feeding in deficit periods is often restricted to a maintenance (or only slightly above-maintenance) diet.

The choice, on economic grounds, of tower silage in this role, would involve the following considerations, each in relation to alternative systems:

(1) Total annual costs (interest, depreciation, maintenance, running costs) of storage structures and the necessary associated machinery and equipment.

(2) Harvest and storage D.M. losses.

(3) Harvesting costs, particularly in terms of labour requirements.

(4) D.M. yield and feeding value of the crop to be harvested for storage.

(5) Fertiliser seed and cultivation costs associated with the crop grown.

Only two respondents could be classed as using tower silage solely in this role. In both cases special circumstances affected the considerations involved.

The first was a dairy farmer who was forced to keep his cows off the pasture in the winter, because of very bad pugging problems. His choice of tower silage, rather than a wintering system based on, for example, hay, depended largely on the low labour requirements for feeding, with a fully mechanised system.

The other farmer fed haylage to stud animals at considerably above-maintenance levels in the late-winter, early-spring period. His main reasons in favour of tower silage were that he was not exposed to the uncertainty of yield with winter crops, and that he could regulate quantities fed much more effectively.

B. Tower silage as an all-year-round supplement.

In this case the tower silage may be fed, in varying daily quantities, for most of the year. By its use in this way feed supplies throughout the year can be maintained at an even level, even through periods of non-anticipated pasture shortage. The mixed diet including

low-moisture silage may help to avoid certain metabolic disease problems at particular times of the year, and particularly with the rapid flush of new pasture growth in the spring. On the other hand, in this role the silage is being used to a certain extent as an alternative to grazing pasture in situ.

In addition to those listed for the previous role (A.) some further points now come in for consideration when comparing such a tower silage system with other alternative feeding systems.

(6) Differences in herd death rates and replacement rates; differences in veterinary and stock health expenses.

(7) The value of maintaining milk production and growth at more constant levels throughout the season.

(8) The level of worry associated with any one system, due to differing degrees of risk and uncertainty.

(9) Harvest and storage D.M. losses as compared to losses and wastage with pasture grazed in situ.

(10) The labour costs involved in harvesting, storing and feeding tower silage as compared to those involved with grazing pasture in situ.

The use of tower silos in this manner appears to suit dairy farmers, and particularly town suppliers, more than other types of farmers. Approximately one half of the dairy farmer respondents used their towers in this way.

C. Tower silage with concentration on winter production:

Because of the seasonal variation which regularly occurs on the store and fat livestock markets (see Watson 1964), out-of-season weight gains with beef animals tend to be far more valuable than weight gains during the summer. Similarly returns to whole milk produced

tend to be higher in the winter. Hence it becomes profitable to feed a higher cost ration for out-of-season production. It should be noted, however, that winter feeding of cattle with tower silage in this country is commonly associated with feedlot feeding, and often also with stock housing, because of difficulties with pasturing these animals at this time of year.

Indications are that for the fattening of older store animals over the winter the low-protein/high-energy corn silage may be a sufficient diet on its own without protein supplementation. One farmer at present is obtaining good rates of weight gain feeding a mixture of corn silage and haylage to older cattle.

For the rapid fattening of younger animals (whose weight gains have a higher protein requirement) over the winter, a more desirable diet would appear to be haylage with a high energy supplement such as crushed grain (5 farmers at present), or, alternatively perhaps, corn silage with a protein or non-protein nitrogen supplement (e.g. high protein stock concentrate, or urea). No cases were recorded of farmers in New Zealand having yet fed in this latter alternative manner, though two farmers indicated their intention to try such a system in the near future.

For overwintering young store beef cattle, with perhaps modest weight gains, haylage would appear to be sufficient as a sole ration. One farmer is planning to do this in future, having fed haylage and hay to date. For greater gains he would add crushed barley.

The philosophy of a large scale carry-over of feed produced in the summer for feeding to livestock in the winter depends on certain further considerations (in addition to those outlined for the above roles):

(11) The higher value of milk production and beef weight gains (or even of returns to food fed solely for liveweight maintenance) in the

off-season.

(12) The costs of grain and any other supplements fed with the basic ration.

D. All-year-round feeding of tower silage as the main diet basis.

This feeding system almost certainly implies all-year-round 'zero grazing'. No farmers in New Zealand are as yet relying on tower silos to this extent, but some show sisngs of developing towards this system, which is common in some overseas countries.

The points to be considered are similar to those already enumerated, except that the question of seasonal premiums, above annual average product prices, does not arise in this case.

Further considerations arise when mechanised feedlot feeding and/or livestock housing systems are being evaluated. The majority of New Zealand tower silo systems at present incorporate mechanical feeding, and a large proportion livestock housing as well.

Mechanised Feedlot Feeding

Points to be considered are:

(1) Labour savings in the feeding-out of stored fodder; job-satisfaction aspects of a mechanised and modern system.

(2) The effects on short-term and long-term pasture production of having livestock removed from the pastures for at least part of the day or year.

(3) Total annual costs of the machinery and feedlot system.

(4) Total annual costs of the manure disposal system.

(5) The effects on pasture production of having at least part of the animal return spread in an even manner.

(6) The control exercised over the quantities of food consumed by the animals, and the resultant efficiency of utilisation of available feed supplies.

(7) The level of feeding losses with such a system as compared to other systems of feeding stored feed.

(8) Quietness and ease of handling of livestock.

Livestock Housing.

(1) Total annual costs of the housing system.

(2) Costs of bedding material.

(3) Reduced feed requirements for maintenance due to the shelter provided.

(4) Total annual costs of manure disposal.

(5) The effects of even return of animal manure to the pasture.

SOME OF THE ARGUMENTS FOR AND AGAINST TOWER SILOS, MECHANISED FEEDING, AND STOCK HOUSING, RE-EXAMINED

(1) Costs of storage:

The costs of storage, per unit of feed D.M., in tower silos will depend on the size and number of silos, the frequency of filling, and the degree to which the overhead costs of the necessary machinery can be spread across other uses. Systematic analyses have yet to be published in this country, but the evidence suggests that, at least with the quantities stored at present by most users in this country (full range of harvesting

equipment spread over only one or two medium-sized silos), this method represents a higher cost method per unit of D. M. stored than conventional and vacuum-pack high moisture silage systems.

For some overseas evidence on this point see McLeod (1967), Newman (1966), Hendrix (1960), Mortimer (1964-pp. 134-137), Univ. of Illinois (1964-pp. 9, 10), U.S.D.A. (1964), Gurney et al. (1946), Iowa State Univ. (1968), N.A.A.S. (1967), Dawson (1968), Suter (1966. b), Hoglund (1965), Baker (1967), Lugg & Gould (1966), Merridew & Ross (1967), Helme & Anderson (1968).

(2) Harvest and Storage Losses

Overseas evidence shows quite clearly that combined harvest and storage D. M. losses with wilted leaf-silage and corn grain-silage in towers will be less than conventional high moisture silage and hay systems if the recommended storage techniques are followed. There appears to be no reason to doubt that these results would apply similarly to New Zealand. Where the more expensive air-sealed types of tower silo are used, then losses will be even lower.

Average losses with hay may be quite high in some districts where the risk of rain spoilage is high. At the same time intake limitations may rule out high moisture silage as an alternative fodder for the growth required. In such circumstances the differences in expected losses may be quite considerable in favour of tower silage when compared with the next best alternative.

Because of weather, and other considerations, it is obvious that overall average losses may be quite inappropriate when applied to a particular district. However, losses of the following order would not be uncommon:

Mixed ryegrass/clover pasture	Field losses	Storage losses (due to seepage, oxidation & heating)	Total Losses
Wilted leaf-silage in towers (concrete; covered with plastic top surface)	10%	10% (mainly oxidation & gaseous loss)	20%
Wilted leaf-silage in towers (air sealed)	10%	4%	14%
Unwilted leaf-silage in pit	5%	20% (mainly seepage loss) (vacuum packed 15%)	25%
Baled hay	25% (can be much higher)	4%	29%

Published overseas research which provides evidence in this regard includes that of Browning (1966), McLeod (1967), Mortimer (1964-p. 130), Merrill & Stack (1965), U.S.D.A. (ARS 52-11), Univ. of Illinois (1964-p. 6), U.S.D.A. (1962, a), Gordon (1967), Gordon et al. (1961, 1959), Hendrix (1960), Hoglund (1964, 1965), Iowa State Univ. (1968), Wittwer et al. (1958), N.A.A.S. (1967).

See also Lancaster (1967) for some New Zealand evidence on high moisture silage losses under some alternative systems of storage.

Estimates of percentage utilisation of pasture D.M. by the grazing animal vary considerably, depending on the type of animal, the stocking rate, and the system of grazing management. It has been suggested that with heavy stocking and rotational grazing, wastage can be kept as low as 5 per cent or less. It seems likely that this degree of utilisation would be difficult to achieve under farm conditions.

The effect of the grazing animal on total pasture production should also be considered.

(3) Harvesting Costs and labour requirements.

Published overseas evidence is in far less agreement on this point. It seems likely that differences, at least with respect to total harvesting costs, reflect variation in the methods of analysis used as well as in harvesting methods and local conditions relevant to the analyses.

Some New Zealand tower silo farmers are quite convinced that the harvesting costs and/or labour requirements with towers are considerably less than they had been with the previous system of hay or high moisture silage. However, as yet there does not appear to be sufficient objective evidence to conclude that harvesting costs and labour requirements vary significantly between the three main systems.

For some overseas reports of harvesting costs and labour requirements see McLeod (1967), Calverly (1967.a, 1967.b), Messer (1966), Hendrix (1960), U.S.D.A. (1962.a), Amer.Soc.Agr.Engineers (1967), Iowa State Univ. (1968), Dawson (1968), Suter (1966.a), Baker (1967), Lugg & Gould (1966).

(4) Yield and feeding value of alternative crops.

The feeding values of some of the main crops ensiled at present have been briefly discussed in a previous section (see pp. 9-12).

Relative yields will vary by district. On the non-irrigated light plains land of Canterbury, for instance, lucerne may outyield grass/clover pasture by as much as 30-40 per cent over the full year, while in some other climatic and soil conditions the annual D.M. yield from lucerne will be considerably lower than from conventional pasture.

The position with regard to corn in this country requires a lot

more investigation. There are wide variations in cultivation, seeding, fertilizing and weed control practices at present among growers in this country, and there is evidence to suggest that those practices so far chosen by the Department of Agriculture for their trials may not be optimal. Furthermore, such trials to date have been mainly concerned with testing the yield of corn as a greenfeed crop, rather than for cutting for grain-silage at a more mature stage when overseas evidence suggests the D.M. yield will be highest. So far trial results have not borne out the claims for the potential of the hybrid corn varieties offered by some scientists. On the other hand some private growers have consistently been obtaining very good yields which, while not known exactly, can be estimated with a certain amount of accuracy.

A conservative conclusion at present would appear to be that, at least in the more favourable corn growing areas of the North Island, the D.M. yield of corn in its 4-5 month growing season will be at least as great as that which can be obtained with grazed pasture over the whole year. Thus any crop which can be grown on the corn land over the 7-month off-season will represent a clear lift in D.M. production over the grazed pasture system.

The cropping system suggested as showing most potential is a summer crop of corn, followed by a winter crop of high producing S.R. ryegrass - e.g. Western Wolths (Mitchell 1965). Both crops would be harvested into tower silos or the latter may be fed as green-chop or even grazed. It appears that in some areas, with heavy application of nitrogenous fertilisers, continual cropping along these lines is becoming quite feasible. One farmer has grown his fifth consecutive crop of corn with little, if any, apparent depression of yield yet evident. In certain areas of the U.S., with prices of, particularly, potassic and nitrogenous fertilisers showing a downward

trend, continuous cropping, coupled with heavy rates of fertiliser application, is becoming a common practice. It is assumed that weeds and pests can now be satisfactorily and economically controlled with chemicals. Some are doubtful whether this situation really exists yet, e.g. with soldier fly in corn in some districts.

To sum up on this point it appears that non-grazing cropping systems can well outyield the best pasture in terms of annual D.M. production. The D.M. digestibility level of corn grain-silage would appear to be roughly as high as grazed pasture, and higher than either leaf-silage or hay.

(5) Stock health aspects.

Most dairy farmers contacted indicated that by feeding tower silage as a supplement to pasture over the early-spring and spring-flush periods, and over the bloat and facial eczema periods, losses from such metabolic diseases as milk fever and ketosis, as well as from bloat and facial eczema had been substantially reduced over levels incurred in pre-tower days. This observation is not surprising, as the feeding of conserved feed is well known to be of benefit in all these periods. Without further objective evidence, it is difficult to estimate for any one case just what reduction in herd replacement rate, veterinary costs, bloat spraying costs etc., could be expected in an average year with such a feeding system. Nevertheless, this is almost certainly a significant feature of the system where a potential for all-year-round supplementation is planned, and such an estimate should be made.

The fear that the concentration of cattle under feedlot conditions would be predisposing to many other disease problems does not appear to have been borne out in practice. One farmer indicated that he had

stepped up his leptospirosis vaccination program, and hence costs, to guard against a greater incidence of this disease under feedlot conditions. However, death rates reported in confined cattle, possibly largely due to the shelter offered in many cases, appeared to be, if anything, lower than might be expected with the same animals under grazing conditions.

(6) The value of maintaining even production.

For the unusual case of a town milk supplier whose quota closely approaches his average daily production, maintenance of quota level will depend largely on his ability to maintain an even level of milk production. In the more general situation, the effect of a check in feed level on subsequent production for a milking cow, or on subsequent growth rates for a young growing animal, is reasonably predictable. The value of maintaining a constant environment (including feed supply), is generally appreciated as far as animal production is concerned.

However, to put this value in quantitative terms is exceedingly difficult, and the figure will no doubt vary considerably between different farm situations. Volume of production per pound of D.M. ingested over the production season may be a suitable measure of animal efficiency. The advantage of a system of even, controlled feeding over one where feed intake varies with pasture growth rates may eventually be evaluated in such quantitative terms for different situations. An informal estimate of the value of this advantage seems warranted until more precise figures are available.

(7) Seasonal price premiums for milk, store beef cattle and prime beef cattle.

Watson (1964) presented a very useful paper in which he examined seasonal variation in cattle values on the store and fat markets, as apart from longer term annual trends. His figures indicated a June → Septemb wintering margin of $10-11 for most classes of cattle maintained in "good-

average store condition". On the fat cattle market he found that spring prices tend to be up $\$1\frac{1}{2}$-2 per 100 lb. carcase weight on autumn values. Unpublished analyses of the Addington and Westfield fat stock market reports for several past years by the present author have led to similar conclusions about the size of this spring premium.

Town milk companies tend to pay considerably more for quota milk over the winter months. There is therefore a strong incentive for town supply farmers not to drop below their "effective" quota at this time. Some companies pay out at quota price on a larger "effective" quota (actual quota plus quantity of surplus milk paid at quota price) in the winter period. In these cases an incentive exists for farmers to produce more milk per day over the winter period, at least up to the level of their "effective" quota.

(8) The necessity for feed supplements with tower silage.

The sum of American experience would appear to be that animals which have been in a feedlot for most or all of their lives will require supplements such as antibiotics and Vitamin A. Where total housing occurs for long periods then Vitamin D may also be desirable. Animals, on the other hand, coming into a feedlot for the first time at the beginning of a winter may be able to rely on body reserves and may not need any such supplementation for the few months required to fatten them.

(9) Labour saving with mechanised feeding systems.

In comparison with hay and conventional 'other-than-self-fed silage, mechanised feeding of tower silage appears to offer considerable labour saving at the feeding out stage. The effort required is such that the routine work can be done by an older man, or, alternatively, a woman or child. In most cases reported, another job was carried out simultaneously with feeding; e. g. milking or loafing barn race cleaning.

In all cases only one person was required for feeding, and the time taken varied from 1 to 3 hours per day. This time varied according to the number of times fed per day, but most farmers fed twice and took 1 to 2 hours.

There will of course be periodic labour requirements for unloader maintenance and adjustment which should not be forgotten. Also, where the system is being compared to feeding-out in the paddock, the time involved in effluent cleaning and disposal should be considered. For the feeding area alone, this amounted to 1 to 3 hours per week for one man over the feeding period.

(10) Effects of livestock housing on feed requirements for maintenance.

At present it appears that very little is known about how maintenance feed requirements of cattle vary with the severity of the environment. Scientific estimates which have been made have been based on experiments with housed cattle, and it has been suggested that these requirements should be increased by 40-50 per cent to allow for outside conditions over the average New Zealand winter. Obviously the severity of the winter and the degree of shelter offered varies considerably over different farm situations. It may be expected that maintenance requirements will similarly vary considerably from one locality to another.

Until more is known on this matter it will be very difficult to assess the value of stock housing. One town supply farmer offered the subjective estimate that with ad lib. feeding of his cows (which were producing in the region of 3 gallons per day over the winter), his barn was probably worth 0.5 - 1.0 gallons per cow per day over the winter period.

SUMMARY AND CONCLUSIONS

A preliminary survey of tower silo usage in New Zealand has shown that these structures, though not numerous, are being used in many different ways on many different farm types. In several cases the choice of towers has been considerably influenced by some special characteristic of the particular locality or farm concerned, which makes a tower silo system more suitable than alternative forage conservation systems. The author suspects that there are many such situations involving special circumstances where the use of tower silos would prove to be justified on economic grounds.

It should not be concluded, however, that tower silos can only be justified (economically) in a few special and unusual circumstances. It appears that a good case exists for this method of conservation on typical units in some lines of production. The best example of this would probably be where concentration was an out-of-season production, where towers were used to allow high yielding crops to be handled, thus increasing feed production per acre, and where the scale of operation was fairly large so as to enable the costs of associated machinery to be spread over a large silo storage volume.

It is quite apparent that broad generalisations cannot be made about the profitability of tower silo systems. Further investigatory work of an economic nature would appear to be well justified, and indeed well overdue. The results of some such work will be presented in a subsequent bulletin in this series. It seems likely at this stage that the profitable use of tower silos for forage conservation will prove not to be restricted to the odd isolated 'special' situation.

At present contracting services are not generally available for harvesting and storing tower silage, and for effluent disposal. Until there are enough towers in a given district to justify such services,

the smaller operators, with, for example, one tower only, will be forced to adopt the more costly alternative of owning their own equipment. Because they are pioneers, the present operators have had to overcome several drawbacks and frustrations, particularly those due to lack of knowledge and to the difficulties of obtaining supply and subsequent reliable servicing of the required equipment. It is quite clear that past performances by the present operators cannot validly be taken as representative of what will be achieved with tower silos in this country in the future.

REFERENCES AND BIBLIOGRAPHY

AMERICAN FORAGE AND GRASSLAND COUNCIL 1966
Quality Forage. 30p.
(Several contributed papers)

AMERICAN GRASSLAND COUNCIL 1963
Quality Silage. 38p.
(Several contributed papers)

AMERICAN SOCIETY OF AGRICULTURAL ENGINEERS 1966
Management of Farm Animal Wastes
A.S.A.E. Pubn. SP-0366
(containing: Proc. Nat. Symposium on Animal waste mgemt.)

AMERICAN SOCIETY OF AGRICULTURAL ENGINEERS 1967
Farm Machinery Costs and Use. pp. 252-257
in Agric. Engineers Yearbook.

BAKER, V. 1967
High dry matter silage in tower silos :
some experiences in South West England.
N.A.A.S. Quarterly Rev. 77 (Aut. 1967)

BROUGHAM, R.W. 1967
Some factors that influence the rate of growth of pasture.
Proc. N.Z. Grassld. Ass. Conf. 1957 : 109-116.

BROUGHAM, R.W. 1959
The effects of frequency and intensity of grazing on the
productivity of a pasture of short-rotation ryegrass and
red and white clover.
N.Z. Jl agric. Res. 2.6 : 1232-1248.

BROWNING, C.B. 1966
Four-year results, concrete stave and gas tight silos.
Paper to Silage Short Course, Rock Eagle 4H Center,
Eatonton, Georgia, Feb. 1966.
Publ. in Silo News (National Silo Ass. of America) Winter 1966.

BYERS 1965
Comparison of feeding value of alfalfa hay, silage, and low moisture silage.
J. Dairy Sci. 48 : 206-

CALVERLY, D.J.B. 1967.a
Men and machines : A study in the effect of management of labour and machinery in the operation of a mechanical feeding system.
Paper to 3rd Am. Tower Silo Conf. Cheltenham April 1967.

CALVERLY, D.J.B. 1967.b
Management of mechanical feeding systems.
Farm Mechn. and Buildings 19.214 : 53-54.

CAMPBELL, A.G. 1964
Grazed pasture parameters : dead herbage, net gain, and utilization of pasture.
Proc. N.Z. Soc. Anim. Prod. Conf. 24 : 17-28.

DAWSON, P.M. 1968
Towers for forage - Ivory castles?
Paper to U.K. Agric. Mgmt. Conf. 1968 (Cyclostyled).

DECKER, M. 1960
Unloading silos mechanically
Agric. Engineering 41.6 : 378-380.

DONKER et al. 1968
Forage evaluation (3 papers)
J. Dairy Sci. 51.3 :

EVANS, R.E. 1960
Rations for Livestock
U.K. Min. of Agric., Fish., and Food.
Bull. 48 HMSO
See particularly : Tables of feeding stuffs pp. 94-124.

FLETCHER et al. 1948
Effects of multiple feeding upon a performance of Guernsey heifers fed urea-treated corn silage.
J. Dairy Sci. 51.2 : 202 -

GAY, N. 1967
What shall we grow for silage?
Proc. 21st Amer. Hybrid Corn Industry-Research Conf.
pp. 45-49.

GORDON, C.H. et al. 1959
Nutrient losses, quality and feeding value of wilted and direct cut orchard grass stored in bunker and tower silos.
J. Dairy Sci. 42 : 1703.

GORDON, C.H. et al. 1961
Preservation and feeding value of alfalfa stored as hay, haylage, and direct cut silage.
J. Dairy Sci. 44.2 : 1299.

GORDON, C.H. et al. 1963
Feeding value of low moisture alfalfa silage from conventional silos.
J. Dairy Sci. 46. : 411-

GORDON, C.H. et al. 1965
Effects of dry matter in low moisture silage on preservation, acceptability and feeding value for dairy cows.
J. Dairy Sci. 48. : 1062-

GORDON, C.H. 1967
Storage losses in silage as affected by moisture content and structure.
J. Dairy Sci. 50.3 : 397.

GURNEY, W.W. et al. 1946
Recommended practice for the construction of concrete farm silos (Amer. Concr. Inst. Std).
J. Amer. Concr. Inst. 18.2 : 149-164.

HELME, W.H. & ALDERMAN, G. 1968
Tower silos at Nafferton : a rejoinder.
Farm Management 1.3 : 42-43.

HEMKEN, R.W. and VANDERSALL, J.H. 1967
Feasibility of an all-silage forage program.
J. Dairy Sci. 10.3 : 417-

HENDRIX, A. T. 1960
Equipment and labour requirements for storing and feeding silage.
Agric. Engineering. 41.3 : 162-167.

HOGLUND, C. R. 1964
Comparative storage losses and feeding values of alfalfa and corn silage crops when harvested at different moisture levels and stored in gas-tight and conventional tower silos : An appraisal of research results.
Michigan State Univ. Dept. of Agric. Economics.
Agric. Economics 947.

HOGLUND, C. R. 1965
Some Economic considerations in selecting storage systems for haylage and silage for dairy farms.
Michigan State Univ. Dept. of Agric. Economics.
Agric. Economics Rep. 14. 8p.

HUBER, J. T. et al. 1965
Effect of maturity on nutritive value of corn silage for lactating cows.
J. Dairy Sci. 48 : 1121-

HUTTON, J. B. 1963
The efficiency of utilization and conversion of pasture herbage by dairy cattle, beef cattle, and sheep.
Proc. N. Z. Inst. agric. Sci. 1963 : 97-110.

IOWA STATE UNIVERSITY 1968
Silage production and use.
Coop. Extn. Service. Pm-417. 27p.

JAGUSCH, K. T. 1968
The food requirements of ruminants.
Lincoln College. Dept. of Animal Sci.
Unpubl. cycl. paper. 11p.

KLOSTERMAN, E. 1963
Full utilization of the corn plant.
Proc. 18th Amer. Hybrid Corn Research-Industry Conf. pp. 90-94.

LANCASTER, R.J. 1967
Losses and feeding values of vacuum and conventional silage.
Proc. Ruakura Farmers' Conference Week. 1967.

LANCASTER, R.J. 1968
Quality and storage losses of silages made in bunkers, stacks, and by vacuum compression.
N.Z. J.Agricultural Res. 11.1 : 63-70

LARSEN, H.J. 1959
J. Dairy Sci. 42 : 574.

LUGG & GOULD 1966
A comparative study of the economics of silage and haylage.
Farm Mechn. and Buildings 18.206 : 17-19.

LYNCH, P.B. 1956
Pasture production in New Zealand.
N.Z. Jl. Agric. 93.1 : 77-78.

McLEOD, J. 1967
The place of conservation in an intensive system.
Farm Mechn. and Buildings 19.214 : 57-58.

MERRIDEW, J.N. & ROSS, G. 1967
Tower silos at Nafferton?
Farm Management 1.2 : 16-20

MERRILL, W.G. & SLACK, S.T. 1965
Feeding values of perennial forages for dairy cows.
N.Y. State Coll. of Agric, Cornell Univ.
Mimeo. Series No. 3.

MESSER, H.J.M. 1966
Observations on tower silo systems 1962-1965
Paper to 2nd Amer. Tower Silo Conf.
Chester, March 1966.

MITCHELL, K.J. 1959
Results of climate studies and their implications for seasonal productivity of pastures.
Proc. N.Z. Grassland Ass. Conf. 1959 : 108-114.

MITCHELL, K.J. 1963
Production potential of N.Z. Pasture land.
Proc. N.Z. Inst. agric. Sci. 9 : 80-96.

MITCHELL, K.J. 1966
Alternative forage crops for livestock feeding.
N.Z. Agricultural Sci. 2.2 : 23-29.

MORRISON, F.B. 1936
Feeds and feeding 1050p.
Morrison Publ. Coy. Ithaca, N.Y.
Appendix pp.953-993. Composition of feedstuffs.

MORTIMER, R. 1964
Mechanised livestock farming. 160p.
Farming Press (Books) Ltd. Ipswich.

NATIONAL AGRICULTURAL ADVISORY SERVICE (U.K.) 1967
Tower Silos for forage conservation.
N.A.A.S. S.E. Region Tech. Bull. 67/21, 14p.
(prepared by Dairy Commodity Group).

NEIDERMEIER et al. 1961
Digestibility, consumption and milk production by cows fed low moisture (43%) .v.. wilted (68%) grass silage as the only roughage.
J. An. Sci. 20 : 962-

NEWMAN, G. 1966
Cost of operating a high dry matter silage system.
Paper to 2nd Ann. Tower Silo Conf. Chester March 1966.

OWEN, 1967
Factors affecting the nutritive value of corn and sorghum silage.
J. Dairy Sci. 50.3 : 404-

OWEN and KUHLMAN, 1967
Effect of maturity on digestibility of forage sorghum silages.
J. Dairy Sci. 50.4 : 527-

PERRY, T.W. & BEESON, W.M. 1966
Corn silage for fattening cattle.
Purdue University. Agric. Expt. Stn.
Res. progress report 254. 9p.

PERRY, T.W. & BEESON, W.M. 1966
The nutritive value of haylage for beef cattle.
Purdue University. Agric. Expt. Stn.
Research progress report 251. 8p.

PERRY, T.W. & CALDWELL, D.M. 1968
The value of corn silage made from the corn plant at various stages of maturity.
Purdue University. Agric. Expt. Stn.
Research progress report 331. 4p.

ROGERS, C.F. & BELL, D.S. 1953
Acceptability of high dry matter silages.
Ohio State Univ. Agric. Expt. Stn.
Research Circ. 20.

SMITH, L.H. 1961
The competitive position of corn in total digestible nutrients.
Proc. 16th Amer. Hybrid Corn Industry Research Conf.
pp. 22-26.

SUTER, R.C. 1966.a
Forage crops : Harvesting
Purdue University. Agric. Expt. Stn.
Res. Progress report 218 30p.

SUTER, R.C. 1966.b
Forage crops : Storing.
Purdue University. Agric. Expt. Stn.
Res. progress rep. 219 17p.

UNITED STATES DEPARTMENT OF AGRICULTURE
The value of mature corn for silage.
Agric. Res. Service. Bull. 44-176

UNITED STATES DEPARTMENT OF AGRICULTURE
Agric. Res. Service, Bull. 52-11.

UNITED STATES DEPARTMENT OF AGRICULTURE 1962.a
Making and feeding hay-crop silage.
Farmers'Bull. 2186. 20p.
U.S. Govt. Printing Office, Washington.

UNITED STATES DEPARTMENT OF AGRICULTURE 1962.b
Mechanical silo unloaders for upright silos.
Farmers' Bull. 2188. 16p.

UNITED STATES DEPARTMENT OF AGRICULTURE 1964
Farm Silos.
Misc. Publn. 810 Agric. Res. Service 28p.

UNITED STATES DEPA RTMENT OF AGRICULTURE 1968
Silos, silage handling practices, and minor feed products.
Economic Res. Service. Statistical Bull. 415. 16p.

UNIVERSITY OF ILLINOIS 1964
Illinois forage handbook.
College of Agriculture. Co-op. Extn. Service.
Circ. 895, 16p.

UNIVERSITY OF WISCONSIN 1943 (Revised 1953)
Kernels are the key to good corn silage.
Extension Service, College of Agriculture,
Circ. 337, 8p.

UNIVERSITY OF WIS CONSIN 1961
Systems of summer feeding dairy cattle.
Agric. Expt. Stn. Bull. 549 8p.

WADSWORTH, H.A. 1964
Analysis of economic and management considerations of housing cattle in free stall barns.
Purdue University. Agric. Expt. Stn.
Research progress report 106. 7p.

WARD, G.M. et al. 1966
Relationship between dry matter content and dry matter consumption of sorghum silage.
J. Dairy Sci. 49 : 399-

WATSON, N. 1964
Seasonal livestock values.
Sheepfmg A. 1964 : 58-68.

WITWER, L.S. et al. 1958
Effects of storage methods upon nutrient losses and feeding value of ensiled legume and grass forage.
Cornell University Agric. Expt. Stn.
Bull. 931 35p.

WRAGG, S.R., GODSELL, T.E., and WILLIAMS, G. 1968
Co-operative research on input/output relationships in beef production. 112p.
O.E.C.D. Documentations in agriculture and food No. 82. (1966-67 series).

RECENT PUBLICATIONS

RESEARCH REPORTS

15. *The Problem of Scheduling Sales of New Zealand Butter on the United Kingdom Market,* Robert Townsley, 1965.
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4. *An Illustrative Example of Evaluation Procedures,* A. C. Norton and R. C. Jensen, N.Z. Assn. of Soil Conservators, May 1968.
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