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Mechanization in Agricultural Working

UNIVERSITY OF BRISTOL

Department of Economics (Agricultural Economics)
Bristol II. Province

THE TECHNICAL AND ECONOMIC EFFICIENCY OF THE FARMYARD MANURE SPREADER AND HYDRAULIC LOADER

By
A. H. GILL, B.SC. (ECON.)

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Price : Two Shillings

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DEPARTMENT OF AGRICULTURAL ECONOMICS
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With the Compliments of
Stanley T. Morris

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CONTENTS

FOREWORD.

Farm mechanisation has proceeded apace during recent years and some disappointment at the costs and accomplishments of this increase has been expressed in many quarters. The rapid development that war conditions demanded did not permit many of the changes to be put on a satisfactory economic basis and time alone, which will bring a greater understanding of existing machines and mechanisation generally, should promote greater efficiency. But mechanisation is likely to continue still further and improved results in the future cannot be sought in any one direction. The need for an individual farm mechanisation programme, greater care in the actual choice of the machine, better work organisation and a careful assessment of the possibilty of an extension of co-operative use are some of the factors which must be considered in the quest for greater efficiency. This need applies to farms of all sizes, but especially to the small farm, where the problems would seem to be intensified.

This study, which is an interim report on a wider investigation into farm mechanisation problems, deals with certain aspects of farmyard manure handling. Technical matters relating to the quality of farmyard manure and the efficiency with which it is used are not discussed. Reference must be made to other sources for such information and there would seem to be scope for considerable improvement on many farms. But it may be stated that there appears to be no reason to believe that any increased loss of manurial values will result from the efficient mechanisation of manure handling and, indeed, greater speed may well reduce such losses. An attempt is made here to relate the information provided to the needs of the farmer in the hope that it will assist him in his choice of machinery and method and their efficient incorporation in the farm organisation as a whole.

S.T. MORRIS.

Provincial Agricultural Economist.

INTRODUCTION

Purpose and Content of Report

Economic and social considerations are compelling an increasing number of farmers to review their methods of handling farmyard manure. They have to decide not only whether they should mechanise this job, but also how far the mechanisation should proceed. It is hoped that the information set out in this study will assist in answering these problems.

The Report consists of two main parts. Firstly, it sets out the findings of a survey which had, as one objective, to establish the experiences and methods of farmers who have already either partly or completely mechanised their farmyard manure handling and it discusses the reasons given by some farmers for not yet doing so. In the second part, data collected during the survey and later are used to establish the costs involved over a range of tonnages for each of a selection of handling methods.

But before discussing these findings it may be appropriate to state the general economic principles involved when the farmer is considering the problems of the extent and nature of the machinery to be used. By so doing the place of such cost findings will be demonstrated.

General Economic Principles

The farmer must decide whether the mechanisation of his farmyard manure handling represents the most profitable way of spending the money required. To do this he must first balance the additional costs and additional returns he may expect as a consequence of buying, say, a manure spreader. If the returns are considerably greater than the costs, then the machine may represent the best possible use of his resources. But the farmer must also consider the alternative ways in which the money could be invested and balance the costs and returns associated with each alternative. He can then compare and choose the most profitable opportunity, which may or may not be the manure spreader.

What are the costs and returns that may be associated with a switch to mechanised manure handling? With this purchase, as with any new investment on the farm, there will be both direct and indirect costs and returns, representing the direct effect of the investment itself and the indirect effect it has on the farm organisation as a whole. With machinery two types of direct costs will be involved - fixed costs which will result simply through owning the equipment and variable costs, which are related to the use of it. The latter - such things as labour, petrol and oil - are easily understood and need no comment. The fixed costs include depreciation and interest on capital invested and, having purchased the machine, these costs will be fixed for perhaps 10 or more years ahead. The indirect costs will concern such things as alterations that may be needed to implement sheds, other equipment and so on. They may well be slight or even non-existent.

The fact that certain costs will be fixed for some years ahead must be remembered when the returns are being considered, for it is the returns to be expected over the same period that matter. There will be not only direct and indirect monetary returns but also non-monetary returns. With the use of a manure spreader there may be direct returns through higher crop yields resulting from quicker spreading and better use of the manure, but the greatest returns will be indirect - the machinery may replace labour or make possible the carrying of more

crops and/or livestock or enable the buildings and hedges to be kept in a better state of repair. The non-monetary return will spring from the elimination of a great deal of heavy hand work, a consideration of great importance nowadays.

This Report deals especially with the direct costs of certain methods of manure handling and provides comparisons of the costs incurred under each method. These comparisons show the changes in such costs that may be expected with a move from one method to another. If the indication is that the costs of a machine would not be prohibitive, the farmer may then assess the effect its introduction would have on the farm organisation as a whole. Unlike the direct costs, which will be reasonably uniform between farms, the indirect costs and returns will vary between farms, depending upon the individual farm situation. Thus no conclusions concerning these indirect effects that are generally applicable may be reached, and it is possible here only to indicate the changes that some existing owners have already made.

II. FARMERS' EXPERIENCES & METHODS WITH THE FARMYARD MANURE SPREADER & HYDRAULIC LOADER.

(1) Source and Nature of Information.

A survey of the use of certain expensive and specialised items of equipment on certain farms producing mainly livestock and livestock products was carried out during December, 1953 and January, 1954. The farmyard manure spreader was one of the items selected. Owners were interviewed and their experiences and methods with the machine and of manure handling generally were recorded. In addition those farmers seen in connection with the other items of equipment selected, but who did not own manure spreaders, were asked for their opinions of its place in the farm organisation and its technical capabilities.

The Survey Area.

The area covered was that part of Devon south and east of a line Plymouth-Exeter. The farming land ranged from the southern fringes of Dartmoor at 800' - 1000', with its emphasis upon grassland, to the low-lying, undulating and drier strip bordering the River Exe estuary with its larger tillage acreage. The area is generally hilly with many steep slopes. The fields average less than five acres and are often of very irregular shape. Rainfall ranges between 30" and 50" annually. Soils are very variable but are broadly of medium loam. The physical conditions collectively do not provide easy working conditions for machinery.

The Sample.

Data were obtained from 65 operators of whom six were contractors and six were joint owners with eight other farmers. Opinions of manure spreaders were obtained from 39 farmers who had not purchased machines up to the date of interview. Time would not permit all owners to be contacted, but the co-operators were distributed throughout the area and their selection was a matter of chance.

Acreages of Survey Farms.

Only 22% of the farms on which manure spreaders were found were between 15 and 150 acres. In Devon in 1953, 84% of the holdings of 15 acres-and-over were under 150 acres.[1] The distribution of the farms according to acreage is as follows:-

Acreage Group	No. of Farms	Percent. of Total.
15 - 100	3	4
100 - 150	12	18
150 - 200	16	24
200 - 300	20	30
300 - 400	11	16
400 & over	5	8
Total	67	100

The individual owner with the smallest acreage farmed 80 acres and, at the other extreme, one man with 476 acres used a similar machine.

1 Ministry of Agriculture, June, 1953.

Manure Spreaders as New Investments.

The farmyard manure spreader is a comparatively new item for the large majority of the farmers interviewed. With two exceptions, all the machines had been purchased since 1947, with a pronounced buying peak in 1951 when over a third - 37% - of the first purchases were made.[1] The oldest machine still in use had been purchased new in 1938. Only five farmers had taken over second-hand machines.

As a consequence of this recent buying, only in a few cases was it possible to get an accurate record of the incidence and amount of repairs and the life of the machine under normal working conditions. To obtain further information upon this most important aspect recourse has since been had to owners not included in the survey.

Makes of Manure Spreader Encountered.

Eleven makes of spreader were found on the various farms:- Albion, Bamford, Bloor, Dening, Evans, Fairmile, Ferguson, Hart, International, Massey-Harris and Salopian.

(2) Some Technical Aspects of the Farmyard Manure Spreader and Hydraulic Loader.

Quality of Work Done.

In the opinion of users - owners, hirers and borrowers - there is no doubt that mechanical spreading is better than hand spreading. Only two owners expressed opposite views. The machine will provide finer shredding and more even coverage than is possible by hand and is better able to spread a light coating. Some fifteen farmers expressed a preference for well-rotted dung and short straw for the best results. Present-day baled and combined straw is very suitable and should aid effective use of the machine.

Where the spreading has not been as good as hoped for, the remedy may well lie partly with the farmer. Judging from operations seen, many of the stoppages were, in the writer's opinion, due to over-loading. The temptation, especially when loading by hand, to build high and shapely loads should be resisted. Bale cords remaining in the dung were also often troublesome. Both these hindrances could easily be avoided and should result in more satisfactory service.

Tractor Power Required.

Light-medium tractors such as the Ferguson and David Brown Cropmaster TVO models were used effectively. The heavy-medium tractor such as the Fordson Major and Nuffield was more than adequate. (The diesel engined models will, of course, develop more power than their TVO counterparts). In particularly hilly or greasy fields an intelligent use of the slope and perhaps rather less than maximum load will reduce the risk of wheel spin. Generally, however, the farmers seen had little difficulty in arranging their work so as to spread manure during the drier periods and thereby avoid such problems.

Mechanical Reliability and the Cost of Repairs.

An estimate was obtained from each owner of the total amount spent on repairs since purchasing. It appeared clearly that heavy repairs had been almost entirely associated with particular makes and models and, further, that one trouble predominated - the conveyor chains were unequal to their job. Other machines had provided comparatively trouble-free service throughout. In most cases the unsatisfactory models have been replaced by improved machines, but many farmers undoubtedly, and not unnaturally, suspect the mechanical reliability of the manure spreader, for it is very difficult for the prospective buyer to make comparisons on this account. However, models have been improved and, if given reasonable handling and maintenance, should prove reliable and inexpensive implements over a comparatively long lifetime.

The following table, which shows the amount spent upon repairs, other than the renewal of conveyor chains due to faults in design,

[1] Machinery sales generally reached a peak in the U.K. in 1951.

in relation to years of use, will help to illustrate this point. The majority of these farms produced less than 300 tons of manure per year.

No. of years used	No. of Farms reporting Total Repairs:					
	Nil	Under £5	£5 - £10	£10 - £15	£15 - £20	£20 & over
1	8	-	-	1	-	-
2	2	7	2	-	-	-
3	8	4	1	-	2	-
4	1	1	-	-	-	-
5	-	-	2	-	-	-
6	-	1	-	1	1	-
Total	19	13	5	2	3	-

Mechanical Maintenance Undertaken.

To obtain information relating to the care taken of machinery and the adequacy of machinery buildings, the farmers surveyed were asked whether they normally housed their manure spreaders under cover. Virtually one half - 33 of 67 - did so regularly and a further 8 did so occasionally. Fourteen farms had provided extra storage facilities and a shortage of such accommodation is no doubt a limiting factor on many farms of all sizes at the present time. It was a widespread practice to clean and wash the manure spreader after each spell of use.

Accessibility of Controls, etc.

The ease with which the manure spreader can be controlled from the tractor seat is a factor to be considered. Three of the farmers seen preferred to use one tractor rather than another in order to lessen difficulties caused by this technicality. Several farmers found the range of tractor engine gears inadequate on the older models. Newer tractor designs are providing wider and more suitable ranges. Speedy and efficient coupling of tractor to spreader is essential and the hydraulic-lift type if perhaps the best available. A faulty or slow-working jack can mean the loss of many minutes during the course of a day. Many farmers have not fully appreciated this point and some of the consequences suffered are illustrated in a later paragraph.

Hydraulic Loaders - their Efficiency and Uses.

Twenty four farmers among the 59 seen considered that their buildings and yards were either too cramped or too poorly surfaced to work a loader efficiently. This matter must, of course, be considered separately on each farm. (But the figures give an indication of the extent of one problem created through outmoded fixtures). In six instances tractors with no hydraulic systems were in use. Four farmers were compelled to reject a mechanical loader because its operation would require a second tractor. These last points must also be considered in relation to individual circumstances. But those farmers, now loading by hand, who feared that the large forkfulls of the mechanical loader would both harm the machine and result in poorer spreading were probably exaggerating the consequences of these matters, although those commenting upon the effects of stones in the manure certainly were not. It is possible here to say that those farmers who used loaders, one in every three, were generally satisfied on both these counts and, if the quantity of manure is such that a loader would be justified in terms of cost, it is unlikely that any technical disadvantage would outweigh the balance.

Moreover the other tasks of which a mechanical loader is capable must be remembered. Many farmers found it and its various attachments very worth-while implements capable of a wide range of tasks which include lifting sacks, silage, stones, earth, mud, muck on to the muck heap, hedge trimmings, thorns on to bonfires, providing the attachment for their hedge trimmers and many others. (These various uses for the

loader tend against the argument that a spreader is a better investment than a loader because spreading takes longer than loading).

An Illustration of the Need for Planned Mechanisation.

Minor technical matters, such as those described in the two previous sections, are important in the aggregate and serve to emphasise that mechanisation must be carefully planned. The disadvantages of ignoring this need may be illustrated by an example which was repeated on several farms visited. The farmer already owned a tractor before buying a spreader. When buying the latter he did not appreciate fully the need for speedy coupling and the possibilities available, or, if he did, his tractor may itself have reduced the alternatives available. He is now considering a mechanical loader, but, because of the slowness of coupling, a second tractor would be necessary to work the loader, although efficient loaders are available for his first tractor. The second tractor is often out of the question and thus the use of a loader is ruled out too.

The farmer buying yet another machine must consider carefully how well it will work with the implements already on the farm and also how it will fit into any further mechanisation that he may undertake in the next few years.

(3) Examples of Joint Ownership and Machinery Exchange Systems.

Six instances of the joint ownership of manure spreaders were encountered. In two cases three farmers shared the one machine and with the remainder there were two joint owners.

The methods were simple and the sharing worked satisfactorily and easily in every case. The tendency for those sharing to farm similar acreages was probably a matter of accident rather than design but probably contributed to the successes of the ventures. In every case the initial costs were shared equally. With one exception the repairs were treated similarly. One pair paid an agreed sum per acre into a pool and this sum, which had been more than enough for required repairs, had been allowed to accumulate towards eventual replacement. With one exception each user employed his own tractor. The user cleaned the machine before returning it to his partner. No one reported any conflict of demand for the use of the machine.

Four other farmers used a neighbour's manure spreader as well as their own and provided their own manure spreader or other machine in return when required. These were firm agreements between the farmers and such a system is especially valuable where, for one reason or another, the capacity of the average manure spreader is inadequate.

Seven loaned their machine free of charge to their neighbours when they had satisfied their own needs. The method may well be ideal for the recipient, but suffers the disadvantage that it is probably unreliable and may lead to disputes over breakages.

Two farmers let their machines out on regular hire and the remainder - 40 - restricted their spreaders to their own farms.

The amount of work done each year by identical machines varied very considerably from farm to farm. One farmer of 80 acres owned his own machine; two farmers together farming some 570 acres successfully shared one of similar capacity. It will be demonstrated in a later chapter that joint ownership can bring manure handling costs down to very low levels, even for small tonnages, and is therefore worthy of very serious consideration on the part of the farmer.

(4) Organisation of Labour and Machinery in Farmyard Manure Handling.

Nature of Data Available.

The data collected relating to the organisation of the labour and machinery teams usually employed will not permit an appraisal of the efficiency of these organisations. Instead the teams will here be described and comments made upon outstanding features and systems, where a general observation seems permissible.

One point may be stressed, however. It is important for the farmer to appreciate that a loss of time that may be small in itself - perhaps only a minute or two - will, repeated during the course of a day, add to perhaps half an hour or an hour. A series of such losses may well mean the difference between efficiency and inefficiency for the job as a whole.

Time of Year Manure Hauled.

Spring and autumn were the peak handling periods. Some farmers continued at intervals throughout the year. Only four out of the fifty-nine farmers seen spread manure daily.

Places of loading.

On every farm visited at least part of the manure was loaded from a heap built in the yard and the remainder was usually taken either direct from cattle sheds or yards.

Number of Handlings.

The ideal would appear to be one handling only for all farmyard manure - from the place where it is made into the spreader. The majority handled it twice - from shed to yard heap and then yard heap to spreader. A few sometimes handled it three times - from shed to yard, yard to field heap by trailer and then from field heap to spreader.

The reasons for twice or thrice handling were that the land was often too wet for daily hauling, that fields were not always available for daily dunging and that the intention was to avoid heaps near the buildings.[1] The strength of such opinions must be measured against individual circumstances. Some thought daily loading considerably shortened the life of the machine. This factor may be discussed generally from the cost side. If such loading as much as halved the life of the spreader, it would, on the basis of costings given later, be cheaper to accept the shorter life for the spreader if upwards of 200 tons are handled annually.

Some handled their manure three times either to ensure that their loaders and spreaders were fully occupied in the field when spreading was eventually done or to cut down labour and power requirements during the busy spring periods, getting the manure to the fields by tractor trailer during winter periods too wet for the spreader. An additional spreader, possibly hired without man and tractor, might eliminate the need for the third handling and may be the more profitable proposition resulting in a net saving of labour and tractor power in the handling. Such a saving would then be available for other jobs.

Systems of Hand Loading into Manure Spreaders.

Manure was loaded by hand on thirty-eight farms. On thirty four of these farms one spreader and one tractor were employed. Two men were the normal team on twenty-one farms; in eight instances one man normally worked alone and on five of the farms three men were sometimes loading. Where more than one man is employed the need is to ensure that the man remaining in the yard has neither too little to do nor loads throughout the day, virtually without a break. One farmer found it difficult to provide sufficient yard work and was hoping to borrow a second spreader. By contrast, another found that other demands on his labour and power resources sometimes compelled him to employ extra men loading in order to speed the handling knowing that the yard men were not fully occupied.

On the remaining four farms two spreaders were employed and two used two tractors and two used one. The second spreader was included precisely to keep the labour and tractor force fully occupied thus ensuring a fast tempo of work. Each farm obtained the second machine under an exchange system. On three of the farms the men were either loading or hauling and spreading with no interchange of jobs.

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[1] An additional reason, which was not recorded, may be that one handling would require using the tractor for one brief task only during the day and this may be uneconomic.

Such a method means an unequal distribution of the heavy work and could create discontent. To use the labour to greatest advantage, methods must be flexible and much will depend upon the hauling distance.

Systems of Mechanical Loading into Manure Spreaders.

Twenty of the farmers interviewed had front-mounted hydraulic loaders and one used a crane. In instances where one man, a loader and a spreader were used, there were either one or two tractors. The aim should be to eliminate the second tractor which increases expense but not efficiency. Technically this resolves itself into the question of the speed and efficiency with which the coupling can be carried out and the need to ensure that the tractor that may be coupled and uncoupled quickly will also work the loader effectively.

On one farm where loading was done mechanically a second man operated the loader and remained working in the yard during the hauling and spreading operations. His task was to keep the loading place clean. The value of this second man needs to be measured carefully. It must be remembered that he may be so employed for perhaps five or ten days per year and some big change or improvement, such as concreting or levelling the yard, may be justified.

Two spreaders and two tractors, one with a loader, were worked by two men in one instance. The man and the loader will here be kept fully occupied only if the hauling distance is short and on this particular farm the manure had been carted to the field by trailer in order to achieve this.

Reasons for Not Mechanising Manure Handling and Comments thereon.

The reasons provided by farmers for not buying either a spreader or loader centred round two considerations. First, that the labour force on the farm was virtually fixed and that neither a spreader nor a loader nor both would allow it to be reduced. Second, that manure handling was normally done during the slacker periods of the year and the farmer was often glad to have a job for the men to do. Not only was the labour force fixed, but two or three trailers were also available. Moreover two or three muck spreaders - so low is the capacity of one - would be needed and the expense would not be justified.

Further machinery on a farm will only be justified if it either reduces costs or increases production. On most farms the labour cost is virtually a fixed cost - an 'overhead' cost - and the introduction of a spreader will not reduce the total labour bill. It will, however, reduce the labour hours required for manure handling and thus labour will be freed for other work. The result may be a net increase in the output of the labour and tractor resources on the farm, obtained economically. The individual farmer must make the assessment, as indicated in the Introduction, and he must endeavour to get the maximum output from his labour, to set against the fixed labour cost.

A few farmers who were able to borrow machines at very low cost from their neighbours had very sound reasons for not purchasing. But those who rejected the mechanical spreader for the quality of its spreading and its heavy depreciation rates were most probably not justified in doing so.

Although the difficulty of the question was appreciated, present owners of spreaders and/or loaders were asked what additional work was undertaken as a consequence. Twenty-one of those who answered stated hedging and ditching and three added building and other odd repairs. One found more time available for broccoli handling, and another, in contrast mentioned easier work and shorter hours. Hedging and ditching may not be called 'productive' work by some, but stock-proof fences and the removal of surplus water from the soil are both beneficial and if additional work of this nature can be done by the existing labour force with no increase in costs then it is an indirect return to be credited to the machinery.

(5) Contractors' Charges.

All charges encountered were made on a time basis, usually 'per hour'. They were as follows:

man, tractor and spreader	- 12/6 to 20/- per hour (most frequently 15/-)
spreader only	- 4/- per hour and 30/- per day
man, tractor and loader	- 15/- per hour

One man varied his charge according to the tractor provided, but there appeared to be no variation according to the type of machine used. It is apparent that charges for virtually identical services vary widely and the considerable effect this may have upon costs will be seen later.

These quotations are considerably below those recommended by the British Agricultural Contractors' Association for its members in the South West. In May, 1954 the latter were as follows:-

man, tractor and spreader	- 22/6 per hour
man, tractor and loader	- 20/- per hour
man, tractor, loader and spreader	- 27/6 per hour
spreader only	- 8/6 to 10/- per hour [1]

[1] Central office of the B.A.C.A.

III. THE COSTS OF HANDLING FARMYARD MANURE BY SELECTED METHODS.

(1) Handling Methods Selected.

Attention has been concentrated upon three systems:

(a) hand loading from heaps and yards into trailers for hand spreading from field heaps.
(b) hand loading from heaps and yards into trailer-type wheel-driven mechanical spreader and
(c) mechanical loading by tractor-mounted hydraulic loader from heaps and yards into trailer-type wheel-driven mechanical spreader,

with a tractor for hauling in each case.

The first system is probably the most common unmechanised loading and spreading method employed. The second and third systems represent the most likely directions in which mechanisation will develop on the small and medium sized farms. The survey findings indicated that most farmyard manure is loaded from a heap and also a preponderance of wheel-driven type spreaders. This last reflects the medium size of the farms concerned and, with some, tractors with no power-take-off systems. As previously noted, the extension of mechanical loading will be retarded on many farms by a lack of space and suitable surfaces.

(2) Data Used.

The cost comparisons made are based upon information recorded on various farms. A series of hand and mechanical operations were timed on each farm and care was taken to ensure that the men were working normally and not 'putting on a spurt' for the occasion.

In order to overcome the difficulty of measuring the weight of manure handled, co-operators were sought near weighbridges who were prepared to weigh sample loads. This was done in each case with the farmers using mechanical spreaders and with five of those using tractor trailers. In two instances, with those spreading by hand, sample field heaps were weighed.

Details of performances and quantities handled were obtained from 14 farms. Seven farms employed the hand loading and spreading method and seven used mechanical spreaders. Three of the latter used mechanical loaders. To supplement this data, reference has been made to a N.A.A.S. study "Machinery and Labour in Farmyard Manure Handling" which provides results for identical operations obtained from 46 farms.

(3) Rates of Work - Labour and Machinery.

Average number of Man-minutes required per ton.

Operation	Vehicle and Method		
	Trailer (over 40 cwt. cap.)	Manure Spreader	
		Hand Loading	Hydraulic Loader
	man/mins per ton	man/mins per ton	
Loading	20	15	6
Hauling (600 yds.)	4	7	7
Setting out Field Heaps	13	-	-
Spreading	26	3	3
Total	63	25	16

These work-rates for labour, manure spreader and hydraulic loader have been extracted from the data recorded on the farms and the labour and tractor costs provided are based upon them.

Average Number of Tons handled per hour, by three methods.

The three total figures above indicate that in one hour under normal conditions and with a return journey of 600 yards it should be possible for one man to load, transport and spread the following:-

0·95 tons by hand loading from a heap into a trailer and hand spreading from field heaps.

2·40 tons by hand loading and mechanical spreading and

3·75 tons by mechanical loading and mechanical spreading.

These rates enable an estimate to be made of the time that may be saved by a change from one method to another, e.g. if a farmer now using hand methods throughout spends some 15 days a year on manure handling, a spreader, operating two and a half times as fast over the job as a whole, should cut the time requirements down to about 6 days per year.

Reliability and Significance of the Average Rates of Work.

The number of results available and the reasonable uniformity shown indicate that the rates may be treated with confidence. They represent average rates of work and better times may be achieved, but, in the writer's opinion, having observed the work being carried out, sustained improvements in individual performances will not be easy. The individual figures and further discussion is provided in Appendix 1.

To compare rates of work actually achieved with the standards, time spent on any work other than the operations listed should be excluded, e.g. if one man remains in the yard during hauling and spreading by mechanical spreader, and during this period is engaged in cleaning out sheds or doing a job apart from handling manure, such as feeding cattle, his time on such jobs should be excluded. If, however, he waits for the spreader to return and has virtually nothing to do during this period, his time should be included. Similarly, where the gang of both men and machines is larger and the intention is that the loading and other direct operations should keep the men fully occupied, the number of man-minutes to be reckoned will equal total time spent on the job multiplied by the number of men engaged. The work organisation may, in fact, be such that both men and machines are not used to the best advantage - men may be waiting for the spreader to return from the field, a second man travelling with the load may not be justified, and so on. Such factors may mean that the average rates quoted are not attained in practice. (To compare money costs actually incurred with the standards provided in the next section, the man-minutes to be costed should be counted as indicated here).

(4) Costs of Handling.

A schedule of average costs per ton for handling specified tonnages[1] of manure by various methods is shown in Table 1. The costs are based upon the rates of work set out above. Methods of costing and details of the costs are provided in Appendix 2, but some more important points may be mentioned here.

Depreciation on the manure spreader has been charged on a basis making allowance for both the 'use' and 'deterioration and obsolescence' elements. Depreciation on the mechanical loader has been based on the 'use' aspect, i.e. the amount of work it does annually. No charge for depreciation or other fixed costs on the tractor trailer for hauling manure has been made, hence the constant cost per ton.

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[1] Tonnages produced per year will, of course, depend upon the number and type of stock and the period during which it is housed indoors. The farmer must make an individual assessment and some aids to doing this are provided in Appendix 3.

Manure handling services are usually hired on a 'per hour' basis. It is, therefore, in the farmer's interest to achieve the highest possible output per hour from each machine. The rate of work per hour is usually controlled by the farmer only when loading is by hand, for the contractor will normally do the actual hauling and spreading and, if a mechanical loader is hired, work the loader. Provided the farmer ensures that his men have adequate and useful work while the load is being hauled and spread, it will pay him to assist with the loading. In this study it is assumed that he manages to keep his men so occupied, and it will be seen that this method makes low handling costs possible. A charge of 15/- per hour for the hire of man, tractor and spreader has been used. Charges vary widely and the manner in which adjustments may be made to the appropriate column in Table 1 is provided in Appendix 2, page 28.[1]

Table 1. Average Costs per ton for Handling Stated Tonnages of Farmyard Manure by Selected Methods.

Tons per Year	Hand Loading into				Mechanically Loading into				Hired Contractor[a]
	Tractor Trailer (over 40 cwt. cap.)		Manure Spreader (wheel driven)		Manure Spreader (one tractor)		Manure Spreader (two tractors)		Hand Loading into Manure Spreader
(1)	(2)		(3)		(4)		(5)		(6)
	s.	d.	s.	d.	s.	d.	s.	d.	s. d.
20	5	1	18	10	24	1	24	8	4 9[b]
40	5	1	10	10	13	3	13	10	4 9
60	5	1	8	2	9	8	10	2	4 9
80	5	1	6	9	7	10	8	5	4 9
100	5	1	6	0	6	9	7	4	4 9
120	5	1	5	5	6	0	6	7	4 9
140	5	1	5	1	5	6	6	1	4 9[b']
160	5	1	4	9	5	1	5	8	4 3[c]
180	5	1	4	7	4	10	5	5	4 3
200	5	1	4	5	4	8	5	3	4 3
220	5	1	4	5	4	7	5	2	4 3
240	5	1	4	4	4	6	5	1	4 3
260	5	1	4	4	4	5	5	0	4 3
280	5	1	4	4	4	4	4	11	4 3
300	5	1	4	3	4	3	4	11	4 3[c']

[a] 15/- per hour for man, tractor and spreader
b - b' 2 men loading c - c' 3 men loading

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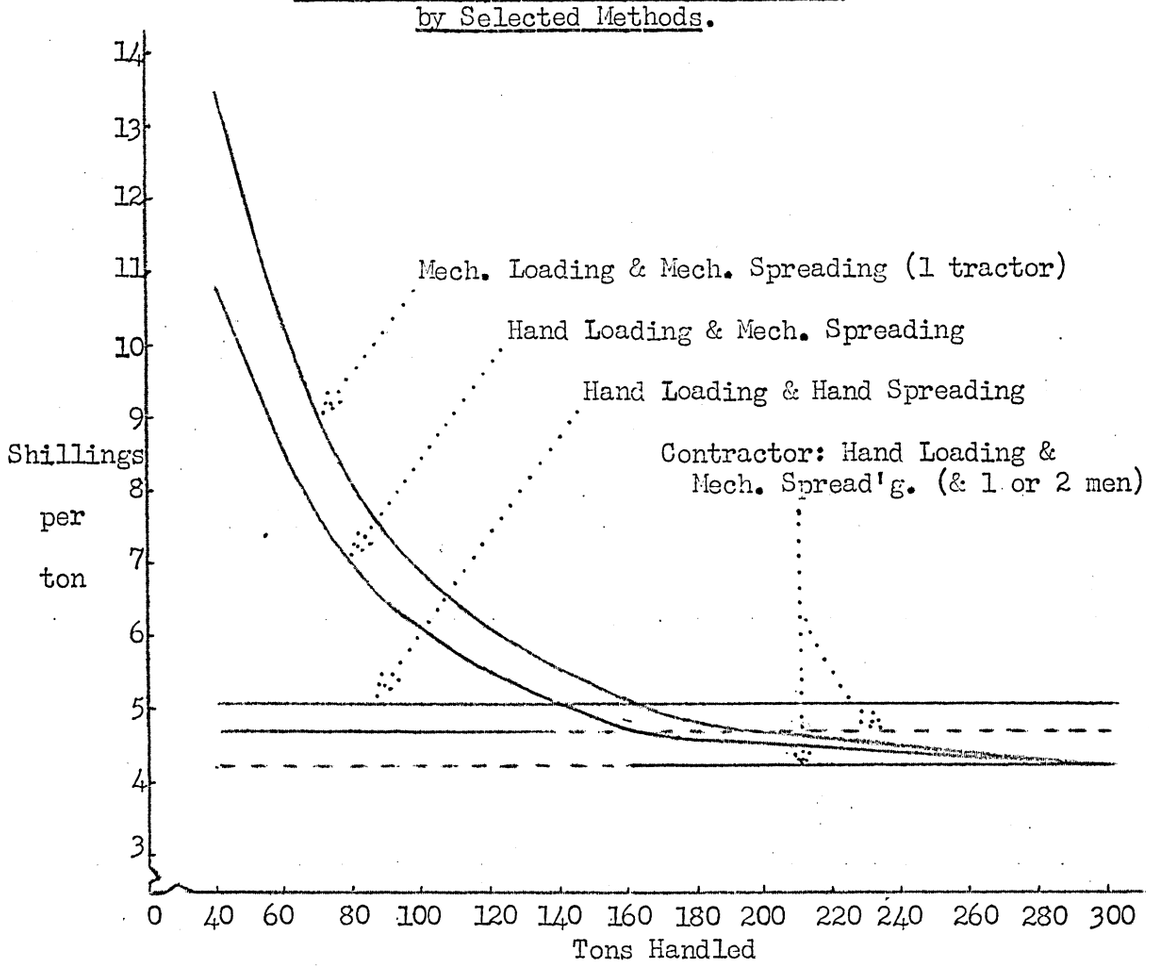
[1] Services available also vary widely and if the farmer wishes to leave the job entirely to the contractor and at the same time select the team giving the lowest cost per ton he must relate the probable output of each team to its cost. The lowest cost will depend not only upon differences between contractors' charges, but also upon the job itself, e.g. on a short haul two spreaders may keep a loader fully occupied whereas three would be needed for a longer haul. The farmer is unlikely to get the cheapest handling costs if he always hires the same team.

The costs in Table 1 are illustrated on the following graph.

Average Costs per ton for Handling Farmyard Manure in Relation to Tons Handled per year, by Selected Methods.



Discussion of Results.

The schedule and diagram illustrate that if it is possible to hire a man, tractor and spreader at the hourly rate of 15/- and provide additional men to assist with the loading who are usefully employed during hauling and spreading, that, up to 300 tons per year, this will be the cheapest method of handling manure.[1] The cost advantage declines quickly as the tonnage handled increases towards this limit and, in terms of total costs per year may be £5 or less, but to this direct saving must be added the benefit of labour and a tractor released for other jobs and the benefit of capital released for investment in other directions. Against this must be set the possibility that the contractor will not be available when required, though this may not be such an important consideration with manure handling.

If the farmer finds it virtually impossible to provide useful work for his men during hauling and spreading, the cost of this method will rise sharply. The whole cost of the extra labour will now be added to the cost of hire. With the same rates of work and the same charge for hire, the cost per ton will then be 5/3. At this higher level, hand operating with a trailer becomes the cheapest method for quantities up to 140 tons per year. For tonnages between 140 and 300[2] hand loading into a mechanical spreader is the cheapest method and from about 300 tons upwards it will be cheaper to use a mechanical loader with a spreader.

Owing to the fixed charges involved, the costs per ton with a mechanical spreader fall sharply up to 160 tons per year. Thereafter the cost per ton declines only slowly. Over the range of 140 tons

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[1] The cost per ton may be further reduced if more than two extra men are provided, but it will, of course, be increasingly difficult to avoid wasted labour.

[2] p. 28, Table 9.

to 300 tons the cost balance in favour of hand loading into a mechanical spreader becomes slight and an increase in the rate of handling by mechanical loader and spreader from $3\frac{3}{4}$ tons to $4\frac{1}{4}$ tons per hour would offset this advantage from about 200 tons and more. The use of only one tractor is being considered, however, and the comparison implies that the spreader can be hitched and unhitched rapidly. It will be seen that when two tractors are employed, one with the loader and the other with the spreader, mechanical loading remains substantially more expensive than hand loading at 300 tons per annum. Indeed it is only at about 240 tons that the method employing two tractors and a loader becomes cheaper than complete hand loading and spreading.

Costs under Joint Ownership.

The total fixed costs of a manure spreader range from £16. 5s. to £26. 5s. per year for the tonnages in question. These fixed costs would be halved for the individual farmer if he owned a spreader jointly with a neighbour. The effect such a saving would have on the costs of each co-owner is illustrated in the following table.

Table 2. Schedule of Costs per Joint-Owner for Hand Loading Farmyard Manure into Mechanical Spreader with Two Joint-Owners.

Tons per year per farm (1)	Total Labour & Tractor Costs (2)		Half-Share of Fixed Costs (3)		Total Costs (4)		Average Total Cost per ton (5)	
	£.	s.	£.	s.	£.	s.	s.	d.
20	2	12	8	5	10	17	10	10
40	5	2	8	10	13	12	6	10
60	7	13	8	15	16	8	5	6
80	10	2	9	0	19	2	4	9
100	12	14	9	13	22	7	4	6
120	15	5	11	1	26	6	4	5
140	17	15	12	9	30	4	4	4
160	20	4	13	17	34	1	4	3

The amounts in column (2) have been taken from Table 7, page 26. The share of the fixed costs (col. (3); also taken from Table 7) equals one-half of the total fixed costs appropriate to the total tonnage that the machine would carry during the year, assuming there were equal quantities on both farms. A comparison of the figures in column (5) above with those in Table 1, indicates that hand loading into a spreader which is jointly owned by two farmers becomes cheaper than hand loading and hand spreading when each farm produces no more than about 75 tons per year. It will be seen further that for approximately 80 tons and more such joint ownership provides a lower cost per ton than that incurred under a contractor, hired and worked on the bases used in this report.

A similar reduction in fixed costs may be achieved through jointly owning a mechanical loader. The costs where both loader and spreader are jointly owned and are used with one tractor are as in Table 3.

Table 3. Schedule of Costs per Joint-Owner for Mechanically Loading Farmyard Manure into Mechanical Spreader (one tractor), with Two Joint Owners.

Tons per year per farm (1)	Total Labour & Tractor Costs (2)		Half-Share of Fixed Costs: Spreader (3)		Half-Share of Fixed Costs: Loader (4)		Total Costs (5)		Average Total Cost per ton (6)	
	£.	s.	£.	s.	£.	s.	£.	s.	s.	d.
20	2	1	8	5	3	0	13	6	13	4
40	4	0	8	10	3	4	15	14	7	10
60	6	0	8	15	3	7	18	2	6	0
80	7	18	9	0	3	11	20	9	5	1
100	9	19	9	13	3	14	23	6	4	8
120	11	18	11	1	3	18	26	17	4	6
140	13	18	12	9	4	1	30	8	4	4
160	15	16	13	17	4	5	33	8	4	2

The results in column (6) show that such an arrangement between two farmers would (1) be justified at roughly 80 tons per year on each farm, compared with hand methods, (2) be cheaper, from rather under 100 tons per year, than one man assisting a contractor to hand load and (3) be cheaper than hand loading into a spreader, which alone was jointly owned, from approximately 140 tons and upwards.

Most small farms produce at least 75 tons per year and the figures illustrate the considerable advantages to be derived from joint ownership even between two farmers. The two instances encountered during this study where three farmers successfully work one machine must be examples of many similar ventures and the participants will, of course, face costs even lower than those shown above. Moreover all these figures make no allowances for the benefits derived from the elimination of the toil and drudgery of hand methods.

Adequacy of One Spreader.

The use of only one spreader is allowed for and some farmers may find one inadequate, perhaps because weather and ground conditions usually demand that the dung must be got out into the field quickly. A second spreader would not, of course, increase the total labour and tractor costs of manure handling for the year - the variable costs - but it would double the fixed costs. On the present assumptions these will amount to an additional £20 to £26 or so[1] per year, fixed for perhaps 8 - 10 years ahead. This may be prohibitive and a cheaper alternative may be the hire of a second spreader. One obtained for, say, 5 days at 30/- per day would cost only £7. 10s. and may meet the need for speedy movememt. An exchange system with a neighbour may be more acceptable, but the 'cost' of this to the farmer will be greater annual depreciation on his machine.

[1] page 23, Table 4.

SUMMARY.

Introduction

(1) This Report consists of two main parts. The first analyses the experiences and methods of a sample of farmers with the farmyard manure spreader and hydraulic loader. The second compares the costs of handling farmyard manure by selected methods for each of a range of tonnages.

I. Farmers' Experiences and Methods with the Farmyard Manure Spreader and Hydraulic Loader

(2) This first part is based upon a survey embracing 65 operators carried out in Devon, south and east of a line Plymouth - Exeter in December, 1953 and January, 1954.

(3) The survey area is hilly and the fields are generally small and irregular. The rainfall ranges between 30" and 50" annually. Machinery working conditions are not usually easy.

(4) The farms on which the manure spreaders were found were comparatively large, the majority being between 200 and 300 acres.

(5) Most of the machines discussed had been purchased since 1947; 37% of the total were bought new in 1951. Models by eleven makers were encountered, including all the main suppliers.

(6) The owners were unanimous that the machine provided better spreading and commented favourably upon its ability to spread a light coat. Some difficulties were caused through overloading and bale cords.

(7) Light-medium tractors were used effectively.

(8) Mechanical reliability was unsatisfactory with particular makes; other makes gave good, trouble-free service.

(9) The ease with which the spreader may be controlled from the tractor seat and the speedy coupling of tractor to spreader are important considerations. The latter because of the need to bear in mind the ease and economy with which a loader may later be added to the system.

(10) Hydraulic loaders were rejected by 24 of the 59 farmers on the grounds of inadequate yard room and/or surfaces. Twenty farmers each used a loader satisfactorily and many were enthusiastic about its usefulness for other jobs.

(11) Six instances of joint ownership were encountered and all worked simply and efficiently; four exchanged machines and seven loaned free of charge.

(12) Manure was carted especially during autumn and spring. The greater part of it was loaded from yard heaps.

(13) Most manure was handled twice. Daily loading, if it halved the life of the machine, may well be worth-while at even medium tonnages. A hired spreader might eliminate economically the need for a third handling.

(14) Manure was loaded by hand on 38 farms. Usually one man remained in the yard. On four farms second spreaders were obtained by exchange in order to overcome the difficulty of keeping the yard men fully occupied.

(15) On the 20 farms working hydraulic loaders two tractors were usually engaged during handling and the aim should be to eliminate the second tractor. The justification of a second man during mechanical loading and spreading needs to be carefully assessed.

(16) A fixed labour force and the off-peak labour needs of manure handling were the commonest reasons provided for not mechanising. If the labour costs cannot be reduced, mechanisation will be justified only if it facilitates an economic increase in output (non-monetary factors apart). Present owners considered that they now spent more time especially upon hedging, ditching and repairs generally.

(17) Contractors' charges for identical services varied widely.

II. The Costs of Handling Farmyard Manure by Selected Methods.

(18) Three handling methods have been selected viz:-

(a) Hand loading from heaps and yards into trailers for hand spreading from field heaps.
(b) hand loading from heaps and yards into trailer-type wheel-driven mechanical spreader.
(c) mechanical loading by tractor-mounted hydraulic loader from heaps and yards into trailer-type wheel-driven spreader

with a tractor for hauling in each case. Costs over a range of tonnages have been set out for each method.

(19) The costs are based upon labour and machinery output performances recorded on 14 farms. On 12 of the farms the manure was weighed on weigh-bridges. Performance rates for 46 farms in "Machinery and Labour in Farmyard Manure Handling" (a N.A.A.S. study) have been used as supplementary data.

(20) Average man-minutes required per ton were as follows:-

	Trailer (over 40 cwt. cap.)	Manure Spreader: Hand Ldg.	Hydr. Ldr.
Loading	20	15	6
Hauling (600 yards)	4	7	7
Setting out Field Heaps	13	-	-
Spreading	26	3	3
	63	25	16

(21) On the basis of these time requirements one man in one hour travelling 600 yards should load, haul and spread 0·95 tons, 2·40 tons or 3·75 tons by methods (a), (b) and (c) above respectively.

(22) The number and/or uniformity of the performances indicate that they may be used with confidence. To compare results actually achieved with the theoretical rates in (21), only time spent on the operations listed should be included in the assessment of man-minutes expended.

(23) On the basis of individual ownership and the performance rates and cost methods used here the following conclusions relating to the selected handling methods are reached:-

(a) A man, tractor and spreader hired at 15/- per hour or less together with extra labour assisting to hand load and which is usefully employed during hauling and spreading provides the lowest handling costs per ton up to 300 tons per year. (A note on costs per ton at charges higher than 15/- is provided in Appendix 2.
(b) If such hire is excluded, hand loading and spreading is the cheapest method for tonnages up to 140 per year.
(c) From 140 tons - 300 tons hand loading into a mechanical spreader is the cheapest method, but if the rate of work with the mechanical loader can be increased to about 4½ tons per hour, mechanical loading will be cheaper from approximately 200 tons.
(d) Above approximately 300 tons it will be cheaper to use a mechanical spreader and hydraulic loader, both operated by the same tractor.

(24) On the present assumptions, joint ownership by two farmers of a manure spreader would be justified if a total of about 75 tons per year per farm were handled. A loader (for use with one tractor) and spreader would be similarly justified if 80 tons per year per farm were handled.

(25) Aids to assessing the weight of farmyard manure handled are provided in Appendix 3.

APPENDIX 1

ANALYSIS OF LABOUR AND MACHINERY PERFORMANCE RATES IN FARMYARD MANURE HANDLING.

(1) Loading by Hand from Heaps.

Vehicle Loaded	Farm No.	No. of Men	Wt. of Load cwts.	Man/mins. per ton
Trailer	8	2	48	20·8
	9	3	50	25·4
	10	2	50	24·2
	11	3	47	14·0
	12	2	30	26·9
Average	-	-	45	22·3
Manure Spreader	1	2	23	13·2
	2	2	21	19·1
	3	2	26	13·9
	4	2	23	11·0
Average	-	-	23	14·3

Loading rates per ton tend to be faster when loading into spreaders. There are sound reasons why this should be so - the height of a loaded muck-spreader is about 4½' to 5', the height of a loaded trailer will often be seven or more feet and it is usually necessary to deliberately build up the heaps on a trailer to avoid losses during travelling; possibly the comparative smallness of the spreader load itself encourages a faster rate of work. This time difference is borne out in N.A.A.S.[1] investigation.

On the basis of all available records, average time requirements per ton loaded by hand are:-

into (a) trailer over 40 cwt. cap. - 20·6 man/mins. per ton on 10 farms
(b) manure spreader - 14·9 man/mins. per ton on 14 farms

For cost comparison purposes, 20 man-minutes and 15 man-minutes per ton have been taken for trailers and spreaders respectively.

Loading by front-mounted Hydraulic Loader from Heaps into Mechanical Spreader.

Farm No.	No. of Men	No. of Tractors	Wt. of Load cwts.	Man/mins. per ton
5	1	1	20	7·8
6	1	2	20	4·1
7	1	2	20	4·6
Average	-	-	20	5·5

On farm No. 5 the manure was under cover and vertical supports restricted movements, in addition a sharp slope caused wheel-slip.

Loading rates are available for thirteen farms.[2] They

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[1] National Agric'l. Advisory Service. "Machinery and Labour in Farmyard Manure Handling", Table 2 and Section 8·3.
[2] ibid p.11 Table 2D.

indicate an average requirement of 5·5 man-minutes per ton with only one man engaged.

For purposes of comparison, 6 man-minutes per ton has been used.

(2) Transport Time according to Type and Size of Vehicle.

Method of transport	Farm No.	Distance yards one-way	Wt. of Load cwts.	Actual transport time mins.	Mins. per ton over 600 yds.
Tractor and: Trailer, (over 40 cwt. cap.)	8	240	48	2·5	2·6
	9	180	50	3·0	4·0
	10	1150	50	14·0	2·9
	11	760	47	5·3	1·8
Average	-	-	49	-	2·8
Trailer, (under 40 cwt. cap.)	12	180	30	3·0	6·7
	13	1540	16	10·5	5·1
	14	1580	18	12·3	5·2
Average	-	-	21	-	5·7
Manure Spreader	1	1450	23	6·4	2·3
	2	1770	21	7·8	2·5
	3	1060	26	7·3	3·2
	4	210	23	2·1	5·2
	5	380	20	5·3	9·5
	6	350	20	2·8	4·8
	7	290	20	4·4	9·1
Average	-	-	22	-	5·2

In terms of man-minutes required per ton, the table above provides an indication in favour of the large tractor-drawn trailer. Although the cases are too few to be conclusive in themselves, in conjunction with others available[1] they strengthen the tendency in favour of the large trailer in terms of labour costs.

Referring to all available records, average time requirements per ton for travelling 600 yards[2] are by tractor and:

(a) trailer of over 40 cwt. capacity - 4·3 man/mins. on 15 farms
(b) manure spreader of under 40 cwt. cap. - 7·3 man/mins. on 27 farms.

For cost comparison purposes, 4 man-minutes and 7 man-minutes per ton have been taken for large trailers and spreaders respectively.

It would be reasonable to assume that this time-cost relationship remains over the range of hauls likely to be encountered on most farms. The rates may therefore be changed proportionally if it is desired to compare costs over other distances e.g. for 200 yards $\frac{1}{3}$ of each rate may be taken and for 800 yards each may be increased by $\frac{1}{3}$. The farmer with a small-to-medium sized trailer, considering the purchase of a spreader may, for practical purposes, regard the labour needs per ton for hauling to be identical for both vehicles.

The labour-saving advantage of the large trailer may easily be lost if two or more men travel with the trailer. Unless the travelling distance is very short, a second man is probably rarely justified.

[1] ibid p.16 Table IV [2] ibid p. 13

(3) Setting out Field Heaps by Hand.

Farm No.	No. of Men	Wt. of Load cwts.	Av. no. heaps per Load	Man/mins. per ton
8	2	48	19	11·7
9	2	50	14	10·4
10	1	50	11	6·7
11	2	47	10½	8·1
12	2	30	7½	16·0
13	1	16	6½	10·3
Average	-	40	-	10·5

Setting out heaps required, on the average, 10·5 man-minutes per ton. With the exception of Farm 13, where a cart with extra sideboards was used, trailers were employed. The trailer on Farm 12 did not tip.

Records are available for 24 farms[1] and the average time requirement was 12·5 man-minutes per ton.

For comparative purposes, 13 man-minutes per ton has been taken.

(4) Spreading by Hand from Field Heaps.

Farm No.	No. of Men	Man/mins. per ton
8	1	36·8
9	4	28·0
10	2	31·4
11	3	20·0
12	2	25·1
13	1	31·6
Average	-	28·8

Hand spreading times per ton ranged from 20·0 minutes to 36·8 minutes and averaged 28·8 minutes. The time required will vary considerably with the condition and nature of the dung and the quality of the spreading, but the records available and performances observed enable time ranges to be set-down with reasonable certainty. Any rates much faster than 20 man-minutes per ton or slower than 35 man-minutes per ton would appear to be exceptional.

The average time on 12 farms[2] was 26·2 man-minutes per ton. For comparative purposes, 26 man-minutes per ton for hand spreading has been taken.

[1] ibid p. 17. Table 5.
[2] ibid p. 17. Table 6A.

Spreading by Mechanical Spreader.

Farm No.	No. of Men	Wt. of Load cwts.	Man/mins. per ton
1	1	23	2·8
2	1	21	4·0
3	1	26	1·8
4	1	23	2·8
5	1	20	2·8
6	1	20	2·4
7	1	20	3·9
Average	-	22	2·9

On all farms the machines were wheel-driven types. The N.A.A.S. investigation established an identical time requirement for spreading on 15 farms[1].

For comparative purposes, 3 man-minutes per ton for mechanical spreading has been taken.

[1] ibid p. 18 Table 6E.

APPENDIX 2.

COSTING METHODS AND COST SCHEDULES FOR SELECTED METHODS OF HANDLING FARMYARD MANURE.

(1) Manure Spreaders.

Depreciation.

The depreciation of a manure spreader will arise through use and through rust and deterioration when not in use. Depreciation will also arise through obsolescence for designs will no doubt continue to improve, though it may be reasonable to assume that obsolescence is a relatively unimportant consideration with a manure spreader.

The relative importance of these sources of depreciation will depend upon the amount of use. On the smaller farm, with less manure, deterioration will be the more important factor in determining the life of the machine whereas on the larger farm the amount of use will be of greater significance.

The fact that a spreader will rust and deteriorate, even when lying idle, places a maximum life upon the machine. There is, therefore, a minimum annual depreciation charge which must be met.

As the objective is to compare the cost of operating a manure spreader over a range of tonnages annually, the method of depreciation employed must make allowance for the changing relative importance of the use and non-use elements. In other words, allowance must be made for the fact that a given machine will have a longer life on a smaller farm, assuming it is cleaned and maintained as well as on the larger farm.

Only four farmers out of 59 stated they hoped to trade-in their spreaders, which indicates that the great majority buy the machine for use rather than resale and intend to retain it throughout its serviceable life. It is thus appropriate to write off the difference between its cost when new and its scrap value, rather than the difference between cost and present second-hand value.

To calculate the annual depreciation charge two assumptions have been made:-

(1) that the maximum life of a manure spreader in terms of non-use deterioration and obsolescence is 16 years. In other words, the farmer would be wise to write off the machine in that period regardless of the use he makes of it.

(2) that the life of the present-day manure spreader in terms of use is some 3,000 tons, i.e. after carrying that tonnage the machine will be worn out.

To make these estimates recourse has been had to information other than that collected during the survey. The estimates are based upon inspection and discussion with the owners of machines that had provided 16 years of service, with contractors who had replaced machines after three years of use, with farmers who had been spreading some 250 tons - 300 tons annually for the past 5 - 7 years and with farm machinery engineers.

It is assumed that the machine receives reasonable attention during its life - that it is cleaned after each period of use, lubricated adequately and kept under cover.

Assuming a life of either 16 years or 3,000 tons and £171 to be written off, the annual charge for depreciation is either £10. 14s. or 1/1¾ per ton, whichever is the greater. It will be seen in Table 4 that between 180 tons and 200 tons per year, the tonnage carried - the 'use' factor - becomes more important than physical deterioration and obsolescence.

From the standpoint of the individual farmer with a fixed tonnage to handle each year, the method used assumes an equal amount of depreciation for each year of the life of the machine.

Interest on Capital.

Interest at 5% has been charged on the average annual investment, taken as one half of the new cost less 5% scrap value.

Repairs.

These are the costs incurred in the renewal of minor parts and repairs. Their amount will vary mainly with use and, upon the basis of the survey data, 3d. per ton would appear reasonable. This rate is charged

Cleaning and Maintenance.

Labour for cleaning and washing down 1 day per annum, say £1.

Table 4. Fixed-cost Schedule for Manure Spreaders[1] for stated tonnages handled.

Tons handled per year	Depreciation per year[2]		Other fixed costs[3]		Total		Average Total Cost per ton	
	£.	s.	£.	s.	£.	s.	s.	d.
20	10	14	5	11	16	5	16	3
40	10	14	5	16	16	10	8	3
60	10	14	6	1	16	15	5	5
80	10	14	6	6	17	0	4	3
100	10	14	6	11	17	5	3	5
120	10	14	6	16	17	10	2	10
140	10	14	7	1	17	15	2	6
160	10	14	7	6	18	0	2	3
180	10	14	7	11	18	5	2	0
200	11	9	7	16	19	5	1	11
220	12	12	8	1	20	13	1	11
240	13	15	8	6	22	1	1	10
260	14	18	8	11	23	9	1	10
280	16	1	8	16	24	17	1	9
300	17	4	9	1	26	5	1	9

1 Cost £180: scrap value 5% of new price and useful life either 16 years or 3,000 tons.
2 £10. 14s. per year or 1/1¾ per ton, whichever is greater.
3 Interest on capital, repairs, maintenance.

(2) Hydraulic Loaders.

Depreciation.

Because of the many uses found for the mechanical loader it would be unreasonable to charge all the depreciation on the loader to manure handling. Instead, one half (an arbitrary proportion) of the initial cost will be charged, plus the total cost of the manure bucket.

Present-day prices for the larger loaders range from about £90 - £130 and for buckets from £15 - £20. Smaller loaders, with a reduced range of attachments, are available at approximately £70. A suitable sum would thus appear to be £70 less 5% scrap value.

Little information seems available as to the years of life that may be expected from a loader under different conditions. The twenty farmers contacted during the survey had, on the whole, received trouble-free, inexpensive service. For this study two periods have been arbitrarily selected. There seems to be no reason why a loader should not last as long as a manure spreader and 16 years has been taken as the life of the loader handling only 20 tons per year.

For the loader dealing with 300 tons annually, 10 years has been selected. Depreciation charges between these extremes vary proportionally.

The 'non-use' element - obsolescence and physical deterioration - has been ignored.

Interest on Capital.

Interest at 5% has been charged on the average annual investment, taken as one half of the sum set against manure handling less 5% scrap value.

Repairs.

No charges have been made. Given average usage and maintenance this item will not be heavy, on the basis of the survey findings.

Table 5. Fixed-cost Schedule for Hydraulic Loaders for stated tonnages handled.

Tons handled per year	Depreciation per year[1]		Interest on Capital[2]		Total		Average Total Cost per ton	
	£.	s.	£.	s.	£.	s.	s.	d.
20	4	3	1	13	5	16	5	10
40	4	7	1	13	6	0	3	0
60	4	10	1	13	6	3	2	1
80	4	14	1	13	6	7	1	7
100	4	17	1	13	6	10	1	4
120	5	1	1	13	6	14	1	1
140	5	5	1	13	6	18	1	0
160	5	8	1	13	7	1		11
180	5	12	1	13	7	5		10
200	5	15	1	13	7	8		9
220	5	19	1	13	7	12		8
240	6	2	1	13	7	15		8
260	6	6	1	13	7	19		7
280	6	9	1	13	8	2		7
300	6	13	1	13	8	6		7

1 Useful life ranging from 16 years to 10 years; £70 chargeable cost: scrap value 5%.
2 at 5% on one half of £70 less 5%

(3) Tractors.

Tractors have been costed at 4/6 per hour. When standing idle, half this rate has been charged.

(4) Labour.

Labour has been costed at 2/11 per hour. This is equivalent to a weekly wage of £6 and an allowance for insurance contributions, holidays with pay and perquisites for a 47 hour week.

(5)

Schedule of Costs per year for Handling Stated Tonnages of Farmyard Manure by Hand loading into tractor-drawn Trailer of over 40 cwt capacity.

Table 6.

Tons handled per year	Loading		Hauling (600 yds)		Setting out Heaps		Spreading	Total			Average Total Cost per ton
	Labour	Tractor	Labour	Tractor	Labour	Tractor	Labour	Labour	Tractor	Labour & Tractor	
	£ s.	£ s.	£ s.	£ s.	£ s.	£ s.	£ s.	£ s.	£ s.	£ s.	s. d.
20	19	15	4	6	13	1 0	1 5	3 1	2 1	5 2	5 1
40	1 19	1 10	8	12	1 5	1 19	2 11	6 3	4 1	10 4	5 1
60	2 18	2 5	12	18	1 18	2 19	3 16	9 4	6 2	15 6	5 1
80	3 18	3 0	16	1 4	2 11	3 18	5 1	12 6	8 2	20 8	5 1
100	4 17	3 15	19	1 10	3 3	4 18	6 6	15 5	10 3	25 8	5 1
120	5 17	4 10	1 3	1 16	3 16	5 17	7 12	18 8	12 3	30 11	5 1
140	6 16	5 5	1 7	2 2	4 8	6 17	8 17	21 8	14 4	35 12	5 1
160	7 15	6 0	1 11	2 8	5 1	7 16	10 2	24 9	16 4	40 13	5 1
180	8 15	6 15	1 15	2 14	5 14	8 16	11 7	27 11	18 5	45 16	5 1
200	9 14	7 10	1 19	3 0	6 7	9 15	12 13	30 13	20 5	50 18	5 1
220	10 14	8 5	2 3	3 6	7 0	10 15	13 18	33 15	22 6	56 1	5 1
240	11 13	9 0	2 7	3 12	7 12	11 14	15 3	36 15	24 6	61 1	5 1
260	12 13	9 15	2 11	3 18	8 4	12 14	16 8	39 16	26 7	66 3	5 1
280	13 12	10 10	2 14	4 4	8 17	13 13	17 14	42 17	28 7	71 4	5 1
300	14 12	11 5	2 18	4 10	9 9	14 13	18 19	45 18	30 8	76 6	5 1

Table 7

Schedule of Costs per year for Handling Stated Tonnages of Farmyard Manure by Hand loading into tractor-drawn wheel-drive Mechanical Spreader.

Tons handled per year	Loading		Hauling (600 yds)		Spreading		Total			Total Fixed Costs on Spreader	Total All Costs	Average Total Cost per ton
	Labour	Tractor	Labour	Tractor	Labour	Tractor	Labour	Tractor	Labour & Tractor			
	£ s.	£ s.	£ s.	£ s.	£ s.	£ s.	£ s.	£ s.	£ s.	£ s.	£ s.	s. d.
20	15	11	7	11	3	5	1 5	1 7	2 12	16 5	18 17	18 10
40	1 9	1 3	14	1 1	6	9	2 9	2 13	5 2	16 10	21 12	10 10
60	2 4	1 14	1 0	1 12	9	14	3 13	4 0	7 13	16 15	24 8	8 2
80	2 18	2 5	1 7	2 2	12	18	4 17	5 5	10 2	17 0	27 2	6 9
100	3 13	2 16	1 14	2 13	15	1 3	6 2	6 12	12 14	17 5	29 19	6 0
120	4 8	3 8	2 1	3 3	18	1 7	7 7	7 18	15 5	17 10	32 15	5 5
140	5 2	3 19	2 8	3 14	1 0	1 12	8 10	9 5	17 15	17 15	35 10	5 1
160	5 17	4 10	2 14	4 4	1 3	1 16	9 14	10 10	20 4	18 0	38 4	4 9
180	6 11	5 1	3 1	4 15	1 6	2 1	10 18	11 17	22 15	18 5	41 0	4 7
200	7 6	5 13	3 8	5 5	1 9	2 5	12 3	13 3	25 6	19 5	44 11	4 5
220	8 0	6 4	3 15	5 16	1 12	2 10	13 7	14 10	27 17	20 13	48 10	4 5
240	8 15	6 15	4 2	6 6	1 15	2 14	14 12	15 15	30 7	22 1	52 8	4 4
260	9 10	7 6	4 8	6 17	1 18	2 19	15 16	17 2	32 18	23 9	56 7	4 4
280	10 4	7 18	4 15	7 7	2 1	3 3	17 0	18 8	35 8	24 17	60 5	4 4
300	10 19	8 9	5 2	7 18	2 4	3 8	18 5	19 15	38 0	26 5	64 5	4 3

Table 8

Schedule of Costs per year for Handling Stated Tonnages of Farmyard Manure by mechanically Loading into tractor-drawn wheel-drive Mechanical Spreader (using one tractor)

Tons handled per year	Loading		Hauling (600 yds)		Spreading		Total			Total Fixed Costs on Spreader	Total Fixed Costs on Loader	Total All Costs	Average Total Cost per ton
	Labour	Tractor	Labour	Tractor	Labour	Tractor	Labour	Tractor	Labour & Tractor				
	£ s.	£ s.	£ s.	£ s.	£ s.	£ s.	£ s.	£ s.	£ s.	£ s.	£ s.	£ s.	s. d.
20	6	9	7	11	3	5	16	1 5	2 1	16 5	5 16	24 2	24 1
40	12	18	14	1 1	6	9	1 12	2 8	4 0	16 10	6 0	26 10	13 3
60	18	1 7	1 0	1 12	9	14	2 7	3 13	6 0	16 15	6 3	28 18	9 8
80	1 3	1 16	1 7	2 2	12	18	3 2	4 16	7 18	17 0	6 7	31 5	7 10
100	1 9	2 5	1 14	2 13	15	1 3	3 18	6 1	9 19	17 5	6 10	33 14	6 9
120	1 15	2 14	2 1	3 3	18	1 7	4 14	7 4	11 18	17 10	6 14	36 2	6 0
140	2 1	3 3	2 8	3 14	1 0	1 12	5 9	8 9	13 18	17 15	6 18	38 11	5 6
160	2 7	3 12	2 14	4 4	1 3	1 16	6 4	9 12	15 16	18 0	7 1	40 17	5 1
180	2 13	4 1	3 1	4 15	1 6	2 1	7 0	10 17	17 17	18 5	7 5	43 7	4 10
200	2 18	4 10	3 8	5 5	1 9	2 5	7 15	12 0	19 15	19 5	7 8	46 8	4 8
220	3 4	4 19	3 15	5 16	1 12	2 10	8 11	13 5	21 16	20 13	7 12	50 1	4 7
240	3 10	5 8	4 2	6 6	1 15	2 14	9 7	14 8	23 15	22 1	7 15	53 11	4 6
260	3 16	5 17	4 8	6 17	1 18	2 19	10 2	15 13	25 15	23 9	7 19	57 3	4 5
280	4 2	6 6	4 15	7 7	2 1	3 3	10 18	16 16	27 14	24 17	8 2	60 13	4 4
300	4 8	6 15	5 2	7 18	2 4	3 8	11 14	18 1	29 15	26 5	8 6	64 6	4 3

Table 9. Schedules of Total Costs per year for Handling Stated Tonnages of Farmyard Manure by Selected Methods.

Tons per Year	Hand Loading into			Mechanically Loading into		Hired Contractor
	Tractor Trailer (under 40 cwt.cap.)	Tractor Trailer (over 40 cwt.cap.)	Manure Spreader (wheel driven)	Manure Spreader (one tractor)	Manure Spreader (two tractors)	Hand Loading into Manure Spreader
(1)	(2)	(3)	(4)	(5)	(6)	(7)
	£. s.	£. s.	£. s.	£. s.	£. s.	£. s.
20	5 2	5 2	18 17	24 2	24 14	4 15
40	10 2	10 4	21 12	26 10	27 14	9 10
60	15 3	15 6	24 8	28 18	30 14	14 5
80	20 2	20 8	27 2	31 5	33 13	19 0
100	25 3	25 8	29 19	33 14	36 14	23 15
120	30 5	30 11	32 15	36 2	39 14	28 10
140	35 5	35 12	35 10	38 11	42 15	33 5
160	40 4	40 13	38 4	40 17	45 13	34 0
180	45 5	45 16	41 0	43 7	48 15	38 5
200	50 7	50 18	44 11	46 8	52 8	42 10
220	55 8	56 1	48 10	50 1	56 13	46 15
240	60 7	61 1	52 8	53 11	60 15	51 0
260	65 7	66 3	56 7	57 3	64 19	55 5
280	70 8	71 4	60 5	60 13	69 1	59 10
300	75 9	76 6	64 5	64 6	73 6	63 15

Sources of Data in Table 7.

Column (2) has been calculated on the assumption that loading and travelling time rates for a small tractor-drawn trailer are the same as those for a manure spreader of similar capacity. It will be seen that costs by this method are slightly less than when a larger trailer is used - the faster loading time per ton more than offsets a slower travelling time per ton.

Columns (3), (4) and (5) have been taken from Tables 6, 7 and 8 respectively.

Column (6) has been calculated to show the additional cost of the extra tractor when one hauls the spreader and another works the loader. (Tractors remaining idle have been costed at half the full rate).

Column (7) has been based upon the same work-rates for labour and machinery and the assumption that 15/- per hour is charged for man, tractor and spreader. Between 20 tons and 140 tons a year a second man assists with the loading and with 160 tons and more three men are engaged loading. These extra men are assumed to undertake useful work during the hauling and spreading operations. Between 20 tons and 140 tons 4/9 is the charge per ton, and for 160 tons and more 4/3 per ton is charged. The method of calculation is as follows:-

With a second man loading at the standard rate, a trip, with a load of 1 ton, will take 17½ minutes, equal to 3·4 tons per hour (requiring 85·0 man-minutes). The cost to the farmer will now be 15/- plus the cost of the labour he provides i.e. 3·4 tons at 7·5 man-minutes per ton at 2/11 per hour equals 1/3. Total cost of 16/3 for 3·4 tons equals 4/9 per ton. Similarly, if 3 men are loading,

4 tons will be handled in one hour (requiring 100 man-minutes) and the total cost will be 17/-, or 4/3 per ton. If charges other than 15/- per hour are faced, the effect this has upon costs per ton, other assumptions remaining unaltered, can be quickly measured by substituting the new charge for the 15/- used here, e.g. if 17/6 is charged, total costs will be either 18/9 or 19/6, i.e. 5/6 or 4/10½ per ton.

APPENDIX 3.

AIDS TO ASSESSING THE WEIGHT OF FARMYARD MANURE.

(1) Capacity of the Mechanical Spreader.

Twenty one trailer spreader loads were weighed. The weights of manure recorded ranged from 17 cwt. to 31 cwt. and averaged 22 cwt. With two exceptions, the manure was taken from outdoor heaps and was mainly cows' dung that had been heaped for up to 12 weeks outside the shippons. The lightest load-17 cwt. - was taken from the dry, strawy outside of a heap; the heaviest loads - 30 cwt. and 31 cwt. - were very wet, such that the liquid was falling freely from the spreader. In almost every case the load was heaped and the machine filled to capacity. The models concerned were:-

Bamford FY2
Ferguson
International B200
Massey Harris 711

It may be taken that anything above 30 cwt. on these machines must be of exceptionally wet and heavy manure; a heaped load of manure such as that described above will weigh approximately 23 cwt. and a level load, some 4" - 5" above the spreader box, which has not been tightly loaded, will weigh approximately 20 cwt.

(2) Weight of a Cubic Yard.

Reckoned on the loads weighed during this investigation a cubic yard of farmyard manure ranged in weight from 9·1 cwts. to 13·2 cwts and averaged 11·7 cwts.

(3) An Estimate of Tonnages Produced.

Based on the figures for those farms in this study where reasonably accurate assessments were possible, total annual production on farms of 50 to 150 acres will range, broadly, from 50 tons to 200 tons where, as in South Devon, the majority of dairy herds have from 8 to 15 cows which are usually housed overnight for about four months of the year and where some 80% or more of the total manure is produced by cattle.