Tractors

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DIESEL TRACTOR COSTS AND PERFORMANCE IN THE EAST OF SCOTLAND, 1956-57

by

A. S. HORSBURGH, B.Sc.

THE EDINBURGH AND EAST OF SCOTLAND COLLEGE OF AGRICULTURE

(Department of Economics)

22 ROSE STREET, EDINBURGH, 2.

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DEPARTMENT OF ECONOMICS

STAFF

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C. Miscellaneous :-

Dairy Labour in the East of Scotland.
Economics of Bracken Eradication, 1951-53.
Team Work in Grass Silage Making.
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Piece-Work Potato Gathering.
Blackface or Cheviot, 1946-53?
Hill Farming in the East and South-East of Scotland during the Post-War Period.
Some Notes on Reseeding Old Grassland on Hill and Upland Farms, 1955-57.

Inquiries regarding the above publications should be addressed to either the Secretary of the College or the Advisory Economist.

C O N T E N T S

REPORT ON DIESEL TRACTOR COSTS AND PERFORMANCE IN THE EAST OF SCOTLAND

I. INTRODUCTION

For several years now the diesel tractor has been well established on farms in the East of Scotland. The growing preference for the diesel in favour of other types is said to be due to its better fuel economy and improved performance despite the fact that it is more expensive to buy. Table I indicates the changes which have taken place in the number of diesel and other tractors in Scotland during recent years.

TABLE I. NUMBERS OF MEDIUM-POWERED WHEELED TRACTORS IN SCOTLAND

(Scottish Agricultural Statistics)

	1954 000's	1956 000's
Diesel	8	16
Other	34	30
TOTAL	42	46

The changes which have taken place concern not only the introduction of the diesel, however, for there has also been a wealth of technical improvements to the design of the tractor and to the implements which it uses. The trend to-day is towards greater ease of handling and versatility which is still further increased by the various accessories in which the modern tractor seems to abound. Whatever the reason the cost of operating a tractor is still the vital consideration and it is the purpose of this report to examine various aspects of the costs of operating diesel tractors. Cost records have been obtained for a limited number of tractors and these are discussed in the following sections. Details of the sample of tractors and the method of costing are contained in the Appendix.

II. DIESEL TRACTOR COSTS, 1956-57/

II. DIESEL TRACTOR COSTS, 1956-57

The average cost of operating a diesel tractor during the year 1956-57 is set out in the table below.

TABLE II. DIESEL TRACTOR COSTS, 1956-57

No. of tractors costed			17
Average purchase price (including extras)			£590
Average age at end of year			3 yrs. 6 mths.
Average number of hours worked in the year			1352
Average fuel consumption for the year (Galls.)			621
Average rate of fuel consumption per hour (Galls.)			.459
	Per Year £ s. d.	Per Year £ s. d.	% %
RUNNING COSTS			
Fuel			
Diesel	41: 4: 4		21
Lubricating Oil	7: 5: 5		4
Total Fuel		48: 9: 9	25
Maintenance and Minor Repairs			
Farm Staff	6:12: 6		4
External Agency	4: 6: 3		2
Total Repairs		10:18: 9	6
TOTAL RUNNING COST		£59: 8: 6	31%
FIXED COSTS			
Depreciation	62:15: 4		32
Major Overhauls and Replacements	69: 2: 2		35
Tax and Insurance etc.	4: -: -		2
Total Fixed Cost		£135:17: 6	69
TOTAL TRACTOR COST		£195: 6: -	100%
		s. d.	
Running Cost per Hour		- : 10	
Fixed Cost per Hour		2 : 5	
TOTAL COST PER HOUR		3 : 3	

The/

The total cost of operating the sample of tractors for the year averaged £195: 6s. of which running costs were £59: 8: 6d. and fixed costs £135: 17: 6d. It is clear, therefore, that fixed costs are by far the most important items of cost and represent about two-thirds of the total cost. By comparison running costs, fuel, maintenance and minor repairs are of lesser importance. For this reason a moderate total cost per hour depends essentially on there being a sufficient number of hours of work to spread these heavy fixed costs.

Fuel. The most outstanding feature of the diesel tractor is its remarkable fuel economy. The consumption of diesel oil is normally about one-half that of paraffin, while the price of diesel is about 1d. per gallon cheaper than for paraffin. As fuel costs comprise over 80 per cent of running costs it is likely that the use of the diesel tractor has enabled substantial economies to be made in the running costs of tractors on the farm.

Maintenance and Minor Repairs. The other items of running cost concern the day-to-day servicing and repairs required throughout the year. Much of this work is often carried out by the tractor driver himself, but where a trained mechanic is employed, the responsibility of looking after the tractor falls to the more experienced man. In a few cases, a minimum of running repairs are carried out on the farm but often this work is confined only to the slacker periods of the year. It should be kept in mind, however, that constant attention to the care and maintenance of the tractor is essential for reliability and the prevention of costly breakdowns as well as for the maintenance of a high standard of performance. The cost of this work is comparatively insignificant, representing on average only 6 per cent of the total cost and may be considered a most worthwhile outlay.

Depreciation. This item of fixed cost is the initial cost price of the tractor less the estimated resale value. This difference is spread over the life of the tractor to give the annual depreciation charge. It is the second largest single item of cost, representing 32 per cent of total cost, and depends ultimately on two unknowns - the length of life of the tractor on the farm and the price realised for the tractor when finally sold. Provided it is kept in reasonably good running order, the longer the tractor is kept on the farm the lower the depreciation charge is likely to be. For reasons which will be discussed in a later section, however, it is often better to replace the tractor more quickly. Even where a shorter term of, say, 4 to 5 years is advisable, it can be expected that the good resale values available for diesel tractors at the present time will ensure a moderate depreciation charge.

As two of the farms in the sample had workshops with full-time trained mechanics and were able to deal with most repair jobs on the farm/

farm, it is thought that a comparison of those farms with little or no workshop facilities and those having fully equipped workshops would be of interest. It should be kept in mind, however, that the two farms in question are both exceptionally large farms of 870 and 950 acres of mainly arable land operated at a fairly high level of mechanisation with fleets of 8 and 9 tractors respectively.

Running repair and maintenance costs are also shown since the time spent by the mechanic or tractorman on repair work is included.

TABLE III. A COMPARISON OF AVERAGE REPAIR COSTS ON FARMS WITH WORKSHOPS AND THOSE WITHOUT WORKSHOPS

	Without Workshop	Workshop Without Mechanic	Workshop With Full-Time Mechanic
	£ s. d.	£ s. d.	£ s. d.
Annual Cost of Repairs and Service by Farm Staff	2:16: 7	16: 6: 5	6: 7: 5
Annual Cost of Repairs and Service off Farm	2:17: 4	9:10: -	3: -: 4
Average Annual Cost of Major Overhauls and Replacements	90:14: 5	72:16: 6	57: 7: 2
TOTAL REPAIRS	£96: 8: 4	£98:12:11	£66:14:11
Number of Tractors per Farm	3 to 4	4 to 6	8 to 9

The figures in the above table suggest that there are advantages to be gained where the scale of the farm operations as a whole warrants the installation of a properly equipped workshop and the employment of a trained mechanic. Where there are workshop facilities but no mechanic the position is broadly the same as where there are neither workshop facilities nor mechanic; in both cases the total annual charge for servicing, minor repairs and major overhauls and replacements is likely to be in the order of £95 to £100. The figures for the two farms with trained mechanics are incomplete in that it has not been possible to include the appropriate charge for/

for the mechanic's time and the cost of workshop overheads in the item of £57: 7: 2d. for major overhauls etc. It is unlikely, however, that this charge would amount to the £33 per tractor required to bring this cost up to the level of the more usual situation where neither workshop nor mechanic is available. There should be some gain on that account but over and above that there is undoubtedly a considerable advantage on the grounds of convenience and time saving, particularly at times of peak operational requirements. It must be repeated, however, that the decision to have a workshop and mechanic on the farm depends on the scale of mechanisation being such as to provide adequate employment for both.

Generally, the tractor repair shop was constructed very cheaply from an old building converted by the farmer's own staff or from the cheaper types of building materials which are available at the present time. The cost of the equipment for the workshop ranged from a few pounds to almost £1000 in the case of a fully equipped shop with a full-time mechanic.

III. REPLACEMENT POLICY

The crucial factor as far as the level of fixed costs is concerned is the replacement policy which should be carefully planned to ensure, as far as possible, a low depreciation cost with minimum expenditure on major repairs. The level of depreciation cost depends, to a large extent, on the length of life of the tractor on the farm; the longer the life of the tractor the more the annual depreciation will tend to a minimum. There are several reasons, however, why a farmer might wish to replace his tractor more quickly. Thus the standard of performance or the fuel economy of the tractor might be impaired if kept for long years of use. Again, the tractor may become obsolete and require to be replaced by a machine of superior type. Perhaps the most important point in relation to quick replacement to-day, however, is the high cost of repairs and where few facilities are available for the care and maintenance of machinery on the farm the frequency of breakdowns after a few years may result in a drastic increase in costs. On the other hand, where repair facilities are provided and servicing of the machine is efficiently and systematically carried out, the life of the tractor on the farm may be extended by the prevention of costly breakdowns.

Where a farmer has only limited use for a tractor the problem of keeping depreciation costs within reasonable proportions becomes even more acute due to the fact that the life of the tractor on the farm cannot be extended indefinitely. Buying within the cheaper range of tractor models will keep the initial cost price of the tractor fairly moderate, while astute selling to take advantage of the good resale prices which obtain for popular diesel models at the present time may result in comparatively little loss from this cause.

A/

A common practice where there are two or more tractors on the farm is to extend the life of the tractor due for replacement by keeping it for use at peak periods instead of disposing of it when a new one is bought. In this way the cost of depreciation can be kept fairly low. This practice can only be recommended, however, where the cause of replacement arises from the introduction of a tractor with a better standard of performance and not from the incidence of excessive repair costs on the old tractor. There can be very little case for holding on to a mechanically unreliable tractor, particularly if its use is confined to the peak periods of the year.

IV. SEASONALITY, WORK DONE AND COST

A study of tractor economics necessarily involves some consideration of the work which is carried out during a year's cycle of operations. A general indication of this is the total number of operating hours done in the year. There are, of course, differences both in the kind of work on which a tractor may be engaged and in the amount of time which may be spent on relatively unproductive running. It has been shown that a moderate cost per hour depends to a large extent on there being a sufficient amount of work to spread the heavy fixed costs and a full and uniform programme of work throughout the year may be essential to ensure this. Should a tractor be engaged only on seasonal work it is likely that the total number of hours worked will be small.

Seasonality is a difficult thing to measure but an indication of whether a tractor is mainly engaged on seasonal work and is comparatively idle at other times can be obtained from the following calculation. The monthly average number of hours worked over the year was found simply by dividing the total number of hours worked by twelve. The total difference in the actual hours worked each month from this average was then found and also divided by twelve. The ratio of this average deviation per month to the average number of hours worked per month expressed as a percentage provides a measure of the degree of seasonality of tractor work. For example, should the deviations each month be zero, it is clear that the tractor does not display any seasonal variation in the work done throughout the year and the percentage degree of seasonality would accordingly be zero.

From the point of view of comparison it is perhaps unfortunate that the tractors included in this sample are mainly restricted to those in most constant use on the farms concerned. Nevertheless considerable variation can be seen in the seasonality of work even for this restricted sample of tractors.

TABLE IV/

TABLE IV. SEASONALITY, WORK DONE AND COST

Fluctuations in Seasonal Use	20% - 25%	26% - 30%	31% - 35%	36% - 40%	Over 40%
Number of tractors	3	5	3	3	3
Average hours worked annually	1591	1410	1560	1449	711
" " " on haulage	788	637	764	561	214
" " " on field work	803	773	796	888	497
Percentage of time spent on haulage	50%	45%	49%	39%	30%
Average tillage acreage per farm	535	643	603	413	170
" " " " tractor	77	87	81	73	57
Average cost per hour	2/6d.	2/6½d.	2/9½d.	2/10d.	5/9d.

Generally speaking the seventeen tractors included in this study are those which are most constantly in use but, even so, there are considerable variations in the seasonality of the work done. The effect of seasonality on cost is not, however, significant so long as the total hours running are kept high. Thus with a variation in the seasonal use of tractors of from 20 per cent to 40 per cent the range in cost was from 2s.6d. to 2s.10d. per hour, the hours worked being roughly 1500 hours per year or more.

The three cases where seasonality is over 40 per cent are interesting from two points of view. The number of hours worked per year was approximately half that worked on the other farms and, consequently, the cost per hour has more than doubled. These three cases were on farms much smaller in size but with a less than proportionate decrease in the number of tractors. The suggestion here is that the scale of farming operations is more important than seasonality and that where the size of the farm is small it becomes more difficult to find continuous use for any one of the tractors on the farm.

Full use of the tractors on the larger farms has been made possible by extensive haulage work which has accounted for between 40 and 50 per cent of the hours worked. On the smaller farms it appears obvious that the less dispersed layout has called for a smaller proportion of haulage work and, at the same time, for a smaller number of total working hours. From these observations it would appear that mechanisation on the basis of tractor units has still left the problem of how many machines are required or can be economically employed in relation to the size of holding. This comes out/

out more acutely in the case of the small farm where two tractors may not be enough to meet peak requirements and yet three are excessive in relation to the overall work for the year. This situation results in low total running hours per tractor per year and high costs.

The following table shows the nature of work performed and the time spent by the tractors on different jobs over a year's cycle of operations.

TABLE V. TIME SPENT BY TRACTORS ON DIFFERENT JOBS OVER A YEAR'S CYCLE OF OPERATIONS FOR 1956/57

Work Done	Time spent on each Job			
	Hours per Annum		Per Cent	
Cultivations			%	%
Ploughing	235		17	
Sowing Seed and Manure	81		6	
Other Cultivations	199		14	
TOTAL		515		37
Harvesting				
Hay and Silage	61		5	
Corn	14		1	
Pick-up Baling Hay and Straw	62		5	
Potatoes	31		2	
TOTAL		168		13
Other Work				
Haulage	617		46	
Odd Jobs	52		4	
TOTAL		669		50
TOTAL ALL WORK		1352		100%

These tractors were used for a great variety of farm work and, as might be expected, all tractors were fully occupied early in the year with cultivations for seed bed preparation. The winter ploughing continued on into the early spring and was followed later by discing, harrowing, ridging, rolling etc.

During/

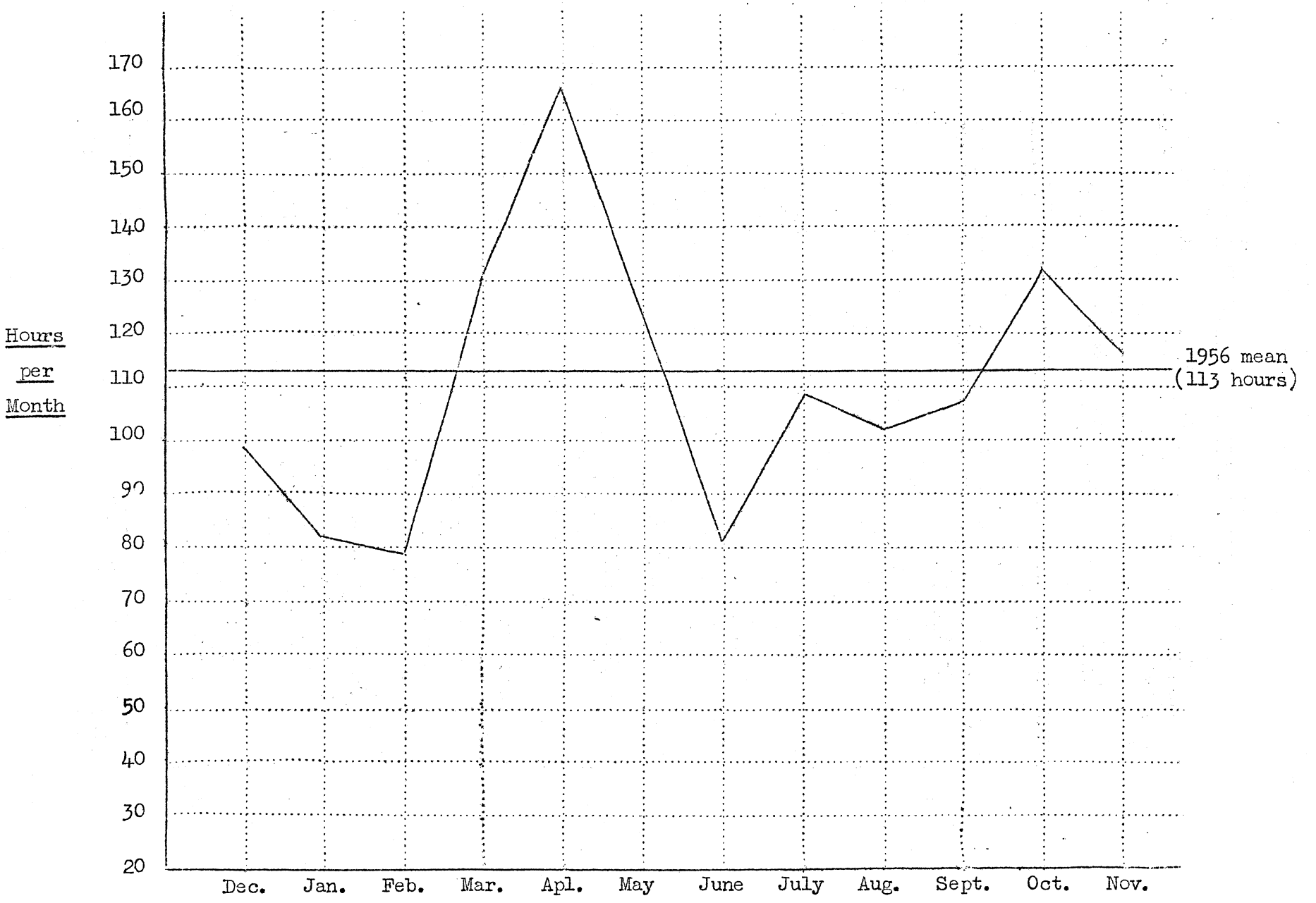
During the summer and autumn the tractors were engaged mainly on harvesting operations for the hay, grain and root crops in which the introduction of new methods of harvesting has brought about some changes in the demand on the tractors' time. Thus the traditional method of harvesting grain by means of the binder is being replaced by the combine. As a result the peak of tractor work at the harvest has been substantially reduced. On the other hand the problem of collecting the straw left behind by the combine has led to a demand on the tractor for pick-up baling immediately following the harvest. The net effect has been to reduce both the amount and the peak of tractor work at the harvest. There was very little indication, judging from this sample of tractors, of mechanical methods being used to a great extent for the harvesting of root and forage crops, most of the tractors' time being taken up with the leading of these crops later in the season.

The most outstanding feature of this survey of tractor utilisation is, undoubtedly, the importance of the tractor in farm haulage work. Most of this work was, in fact, concerned with the leading of harvested crops during the summer and autumn. In several instances haulage represented well over 50 per cent of all work carried out.

Seasonal Pattern of Work. Chart I shows the average seasonal pattern of work carried out by the tractors over the year's cycle of operations. As might be expected, the tractors were in most constant use in the spring and autumn with slack periods in midsummer and winter. The spring peak, however, was more pronounced than the autumn and was not spread over so long a period. It is evident that the greatest demand on the tractor's time takes place during a very limited period in the spring of the year. Since the farmer must budget his tractor requirement on the busiest season of the year it is clear that improved tractor performance and the effective organisation of tractor operations in the spring will make the greatest possible contribution to the efficiency of tractor work on the farm.

CHART I/

AVERAGE SEASONAL PATTERN OF TRACTOR WORK 1956 CHART I



V. TRACTOR PERFORMANCE - FIELD OPERATIONS

Table VI shows the acreages done by the sample of tractors on different operations in an 8-hour day.

TABLE VI. ACREAGES DONE PER 8-HOUR DAY

Job Done	Acreage 1956
CULTIVATIONS:	
Ploughing - 1 Fur.	1
- 2 Fur.	3
- 3 Fur.	3
Cultivating	8
Harrowing	26½
Rolling	48
Grubbing	7
Discing	11½
Ridging	9
Steerage Hoeing	13
Rotovating	6¼
Covering Potatoes	11½
TANDEM CULTIVATIONS:	
Grubbing & Harrowing	11½
Discing & Rolling	5¾
SOWING:	
Seeder Drill	18¼
" Broadcast	31
Fertiliser Distribution	21½
Spreading Dung	5
OTHER FIELD OPERATIONS:	
Mowing Hay & Silage	8
Harvesting Binder	9½
" Combine	7
Pick-up Baling	10¼
Baling Silage	5
Potato Lifting	2¾
Spraying	18

In/

In order to obtain a measure of the overall variation in performance from tractor to tractor a figure of performance efficiency was calculated. This figure was based on all the field operations on which the individual tractor was engaged and gives an indication of the comparative rate of carrying out field operations. This comparison is expressed as the ratio of actual hours worked to the number of hours which would have been taken had the tractor worked at the average rates per acre shown in Table VI.

The distribution of seven of these tractors according to this index of performance efficiency is presented in the following table.

TABLE VII. DISTRIBUTION OF THE TRACTORS ACCORDING TO THE PERFORMANCE EFFICIENCY

Performance Efficiency Index	87	90	103	104	105	106	Average = 100
Number of Tractors	1	1	2	1	1	1	7

It is interesting to note in the above table that considerable variation is to be found in the rates of carrying out field operations even in this small sample of tractors of similar type. Furthermore, it was noted that each operation carried out by the individual tractor was consistently either above or below the average rates of working shown in Table VI. This might indicate that rates of working have to do mainly with the scale or speed of operation which is possible under the different conditions prevailing on the farm. Certainly differences in the size and shape of the fields as well as the varying conditions of soil, topography and climate, to say nothing of the capabilities of the tractor driver, have considerable influence on the rates of carrying out field operations and any improvements in the handling and maneouvering of tractors to overcome these obstacles will be of considerable importance. The significance of a low figure of performance efficiency in the case of a tractor working under normal conditions is that it may reveal a deficiency in scale or speed of operation or the need for an appropriate set of implements for the work in hand.

Haulage/

Haulage. While no performance efficiency standard could be devised for haulage work, it is clear that inefficiencies of tractor loading may frequently arise if the tractor trailers are not of the best type and design for the materials being handled. On many farms, too, the lack of good roads may result in small loads and slow travelling speeds.

VI. FUEL CONSUMPTION

Table VIII shows the fuel consumption and cost per hour of the tractors on different operations for the year 1956/57.

In normal operation the diesel tractor uses about one half gallon of diesel fuel per hour. There is, however, considerable variation to be found in the fuel consumption of the diesel tractor on different operations. Thus on light work such as haulage, diesel consumption is only 0.3 gallons per hour whereas on heavier work it can be almost one gallon per hour. This ability of the diesel engine to adjust fuel consumption to the load may go a long way to cover up any deficiencies which may arise in tractor loading. It is clear that the fuel economy of the diesel tractor lies both in its low fuel consumption and in its ability to obtain full value from every gallon of fuel used.

TABLE VIII/

TABLE VIII. CONSUMPTION AND COST OF FUEL PER HOUR FOR DIFFERENT OPERATIONS

Job Done	Fuel Consumed Galls./Hour	Fuel Cost/Hour @ 1s.5d./Gall.
		s. d.
HAULAGE	.300	- : 5
CULTIVATIONS:		
Plough - 1 Fur.	.800	1 : 1½
- 2 Fur.	.641	- : 11
- 3 Fur.	.729	1 : -
Cultivating	.746	1 : 1
Harrowing	.565	- : 9½
Rolling	.553	- : 9
Grubbing	.532	- : 9
Discing	.746	1 : 1
Ridging	.534	- : 9
Steerage Hoeing	.413	- : 7
Rotovating	.950	1 : 4
Covering Potato Sets	.454	- : 8
Grubbing and Harrowing	.429	- : 7
Discing and Rolling	.351	- : 6
SOWING:		
Seeder Drill	.553	- : 9
" Broadcast	.500	- : 8½
Fertiliser Distribution	.463	- : 8
Dung Spreading	.492	- : 8½
HARVESTING:		
Hay and Silage Mower	.488	- : 8½
Binder	.523	- : 9
Combine Harvester	.616	- : 10½
Pick-up Baler	.459	- : 8
Potato Planter	.559	- : 9½
" Lifter	.606	- : 10
Forage Harvester	.562	- : 9½
OTHER WORK:		
Belt Work	.569	- : 9½
Spraying	.371	- : 6
Miscellaneous	.290	- : 5
AVERAGE ALL OPERATIONS	.459	- : 8

VII. SUMMARY AND CONCLUSION

It is not difficult to understand from the results of this investigation why the diesel tractor has come so rapidly into favour in recent years. On the costs side, the fuel economy of the diesel engine makes the running costs of the tractor very moderate indeed. The crucial factor as far as fixed costs are concerned is the replacement policy, which should be planned to take advantage of the good resale prices which can be obtained for diesel tractors at the present time and to ensure as far as possible a low depreciation cost with minimum expenditure on major repairs. This will depend, also, on the care given to the repair and maintenance of the tractor which is essential for a high standard of performance and the prevention of costly breakdowns.

As far as tractor utilisation and performance is concerned, it is clear that the effective organisation of all tractor work on the farm is of major importance in order to reduce peak requirements, minimise costs and achieve the greatest possible return from every working hour.

ACKNOWLEDGMENT

Grateful thanks is hereby made for the valuable help given by the farmers who co-operated in this investigation. Their courtesy on the occasion of the visits paid to them and their willingness to provide the accurate data required was much appreciated.

A P P E N D I X

GENERAL INFORMATION ABOUT THE TRACTORS COSTED AND THE METHOD USED

Detailed records covering a whole year's operations were obtained for 17 medium-powered diesel tractors on 8 farms in the College area. Daily records were kept of the work done by the tractors, the fuel used and the acreages covered. Some additional information was also collected about the farms concerned and some of this has been used in the report. Of the tractors costed, 10 were Fergusons, 5 Fordson Majors and 2 Nuffields.

The farms were all arable in type, averaging about 508 acres of which 350 were tillage. The total number of tractors on these farms averaged about 5 per farm so that there was roughly one tractor for every 100 acres and every 70 acres under the plough.

All averages used in this report are on a 'per tractor' basis.