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ECONOMICS DEPARTMENT

DEVELOPMENTS IN POTATO HARVESTING

- Electronic and self-propelled harvesters

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Developments in Potato Harvesting

A study of electronic and self-propelled
potato harvesters operating in
S.E. Scotland in 1969.

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FOREWORD

The substantial gains in labour productivity in agriculture have only been made possible by the introduction of new or improved machinery and as the labour force diminishes, the continuance of certain enterprises depends entirely on the success of further mechanisation. Inevitably the task facing agricultural engineers becomes more formidable and the complexity of machines necessitates larger and more costly development programmes.

For the farmer under pressure to mechanise, there is the ultimate prospect of lower-cost production, but only at the expense of large capital outlays and a consequent increase in overhead costs. Hence, as machines become available, there is a growing demand for objective assessments of performance and operating costs under field conditions to be made as soon as possible, in order to assist investment decisions.

This report is perhaps unique in that it considers the performance of two new types of potato harvester, both of which incorporate major technical developments, in the first full year of commercial operation.

Obviously the significance of the data presented is limited by the fact that they relate to one year's operation of a relatively small number of machines carrying out a task that is particularly vulnerable to variations in climatic conditions. These limitations are taken into account in the report and allowance is also made for improvements that can reasonably be expected as a result of the experience gained in the first year.

It is considered that early publication of this information will be of benefit both to farmers who are currently faced with the problem of lifting large acreages of potatoes and to those likely to meet it within the next few years. More representative information will become available after the 1970 harvest, but in the meanwhile it is hoped that this report will provide an initial assessment of these new developments.

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CONTENTS

	<u>Page</u>
Introduction	1
The Survey	3
Lifting period	5
Organisation	5
Performance - electronic	6
- self-propelled	7
Working schedules	9
Planning data	10
Modifications to the electronic harvester	10
Lost time due to weather	11
Potential acreages	12
Team size for electronic, self-propelled and conventional harvesters	13
Other considerations	13
Costs of various systems	14
Summary and Conclusions	17
Appendix	i
Damage assessment	i

INTRODUCTION

During the period from 1955 to 1965, the acreage of potatoes grown in Scotland fluctuated from 125,000 to 140,000 acres. From 1966 onwards however, there was a steady decline to 95,000 acres in 1969, although provisional estimates suggest a slight increase in 1970.

The decline in acreage has been associated with a proportionately greater fall in the number of producers, particularly since 1965. Those continuing with the enterprise have tended to specialise, the average acreage grown having risen from 9.4 acres per producer in 1956 to 15.8 acres in 1968. The share of the total acreage grown by producers with 50 acres or more has risen by 16% to 41%, as shown in Table 1.

TABLE 1: Number and percentage of producers in Scotland related to the percentage of acreage grown - 1956 and 1968.

Acreage per producer	1956			1968		
	No. of producers: '000	%	% of acreage grown	No. of producers: '000	%	% of acreage grown
Under 10 acres	10.1	74	23	4.1	59	12
10 - 30 acres	2.5	18	32	1.7	25	26
30 - 50 acres	.7	5	20	.6	9	21
Over 50 acres	.4	3	25	.5	7	41
Totals	13.7	100	100	6.9	100	100

Source: Potato Marketing Board

Note: The number of producers excludes the number making nil returns. The percentages of acreages grown exclude acreages for which returns were not available when the figures were compiled.

The trend towards specialisation in potato production has been accompanied by a decline in the availability of casual labour and hence greater pressure has been placed on producers to substitute machinery for the traditional squads employed for harvesting. However, it is only during the last 5 or 6 years that development of the complete harvester has reached the stage of offering a practical alternative to hand work. Fourteen years ago there were only 73 complete harvesters on Scottish farms, but by 1967 the most recent year for which information is available, there were more than 1,000 machines (Table 2).

TABLE 2 : Trends in lifting equipment - 1956 to 1967

Implement	1956		1964		1967	
	No.	%	No.	%	No.	%
Spinners	16316	85	15407	78	14014	76
Elevator and shaker diggers	2848	15	3455	18	3459	19
Complete harvesters	73	...	733	4	1003	5
Totals	19237	100	19595	100	18476	100

Source: D.A.F.S. machinery censuses.

Note: The table shows the number of implements owned as distinct from being in use. Many of the spinners and some of the elevator diggers can be regarded as stand-by units.

Harvesting problems

Despite the continuing development of complete harvesters, the problems of lifting the potato crop remain basically the same. The time available for the operation is determined by the date of maturity of the crop, weather conditions during the lifting period and the demands of other enterprises for labour and machinery. Ideally the crop should be ready to spray down by late August for seed and early September for maincrop ware. This allows time for a two or three week ripening period before lifting starts. Harvest work should then be completed well before the weather breaks towards the end of October, the crop being stored under good conditions which permit rapid healing of the inevitable damage arising from the lifting operation. In practice, the length of the harvest period is to a large extent pre-determined by the height of the land above sea level, although choice of variety, chitting some of the seed and growing a mixture of seed and ware crops can all help to increase the time available for the operation.

The introduction of complete harvesters whilst reducing the dependence on casual labour for lifting the crop, tends to make soil and weather conditions more critical and, because of the slower rate of work often achieved, may result in a longer harvest period with repercussions on other enterprises. Greater care in seedbed cultivations and summer work is also desirable in order to reduce the problem of clods at lifting time.

In Scotland, an added complication is the inability of most complete harvesters to work satisfactorily in the stony and hilly conditions which are frequently encountered. Hence in many situations, there has been little practical alternative to the use of squad labour.

THE SURVEY

The 1969 season was notable for the introduction of two new potato harvesters; one, a fully automatic machine requiring, at most, only two people to work it, and the other, the first self-propelled machine to be used in this country. The automatic harvester employs the electronic/pneumatic system for separating potatoes from clods and stones which was developed at the Scottish Station of the N.I.A.E. The self-propelled machine is basically a conventional harvester but has its own power unit and incorporates a hopper of 10 cwt capacity, allowing some work to be done without a trailer in attendance.

Eight electronic harvesters and 5 self-propelled machines - all that could be traced in the east of Scotland - were visited during the harvest period and detailed work measurement and damage assessments were carried out at the time of the visits. In addition detailed records were kept by co-operators for 30 crops lifted by 6 of the electronic harvesters and for 23 crops lifted by 4 of the self-propelled machines. These records included hours worked, breakdowns and other lost time, soil and weather conditions, together with information regarding the impact of these machines on individual farm systems.

Table 3 gives an indication of the type of farm using these harvesters in 1969. Almost all the co-operators were growing a substantial acreage of potatoes, mainly for seed. Seven electronic machines lifted 508 acres, while 299 acres were lifted by 5 self-propelled units.

TABLE 3 : General information relating to the farms in the sample

Farm	Acreages				No. of full-time regular workers ¹ on the farm
	Total	Arable	Potatoes	Potatoes lifted by harvester	
<u>ELECTRONIC</u>					
EH 1	Merchant	-	270	107 ²	n.a.
" 2	350	300	210 ³	60	12
" 3	1169	797	90	65	12
" 4	440	370	68	61 ⁴	7
" 6	800	640	80	80	8
" 7	660	570	150	74	6
" 9	570	450	70	61	3
Total	-	-	938	508	-
Average	665	521	134	73	8
<u>SELF-PROPELLED</u>					
SPH 1	724	643	72	39	15
" 2	262	160	32	30	4
" 3	830	774	96	90	5
" 4	Merchant	-	200	85	n.a.
" 5	273	208	55	55	4
Total	-	-	455	299	-
Average	522	446	91	60	7

¹ Excludes dairymen

² Two shifts regularly worked by this machine

³ Includes rented land

⁴ A further 15 acres were lifted on contract.

Lifting period

The 1969 harvest period was notable for an exceptional run of fine weather. Three of the electronic harvesters worked for 7 to 9 weeks starting at the beginning of September and finishing at the end of October or early November. The remainder worked a more typical lifting period of 5 to 6 weeks as did the self-propelled machines. All of the latter finished work at the normal time or earlier for the farms concerned. Only 5 of the electronic harvesters completed the harvest in the normal period, the remaining two machines finishing later than would normally be expected despite the generally excellent weather conditions.

Organisation

The electronic harvester required a large tractor of at least 60 h.p.; in four cases, 70 h.p. models were used for harvesting on steeper land. The self-propelled model was generally powered by tractor units of around 45 h.p., although in the one case, the power unit was changed for one with slightly more power*.

Under normal conditions a team of 4-5 men were sufficient to operate the electronic machine, cart and store the crop. In one case a two shift system was operated for most of the season, working for about 15 hours per day, while one other machine was worked for a shorter period of time by two teams. Where only one team was available, 10 hours was about the maximum which could be sustained for any length of time. Work usually proceeded for 7 days a week, weather permitting.

The self-propelled model was dependent on a labour team of three casuals plus one regular worker on the harvester, together with the driver, two men carting and one in the store - a total of eight. Weekend working was more limited as a result of having to find casuals - one farmer employed a second team for this purpose - but more typically, an 8 hour day was worked for 6 days a week.

In most cases, for both machines two trailers were normally sufficient for distances up to about a mile from the store.

The introduction of the self-propelled harvesters did not make much difference to the general organisation on the farms concerned. However, on three farms where electronic machines replaced two conventional harvesters, thereby reducing the regular labour commitment for the harvesting operation, greater flexibility of working had resulted. In two cases other work on the farm had been delayed by the harvest taking longer than normal. Where the shift system had been introduced, no trouble had been experienced in getting the men to work the hours required.

* Gear ratios have been modified on the 1970 harvester.

Performance

A. Electronic harvester

The overall rates of work are given in Table 4. There was little difference between the average times calculated from the field records and those observed in the field at the time of visits.

TABLE 4 : Rates of work

Code No.	Acreage ¹ recorded	Rate of work ²	
		Field records: acres/hour	Observations: acres/hour
EH 1	107	.28	.24
" 2	51	.23	.26
" 3	56	.26	.35 1st visit .17 2nd visit
" 4	76	.35	.45 1st visit .32 2nd visit
" 5	-	-	.32
" 6	62	.35	.32
" 7	30	.35	.34
" 9	-	-	.30
Average	64	.30	.31

¹ In some cases records were not kept for the full acreage lifted by these harvesters.

² Inclusive of breakdowns and turns, but excluding all meals.

The range in average rates of work conceals a wider range from field to field for each harvester. The precise reasons for the range are more difficult to determine. Analyses on the basis of yield or soil type, do little to explain the differences. (Table 5).

TABLE 5 : Effect of yield and soil type on rates of work

Yield per acre	No. of records	Work rate: acres/hour	Soil type	No. of records	Work rate: acres/hour
low: 8.6 t/acre	5	.29	light	3	.37
medium: 11.2 t/acre	17	.25	light/medium	7	.24
high: 14.2 t/acre	8	.25	medium (stony)	9	.22
			medium/heavy	9	.28
			medium/heavy (stony)	2	.32

In general, ground conditions were uniformly dry throughout the period, which probably reduced the effect of the different soil types.

This lack of trend in performance is reinforced by field observations where obvious differences in losses were observed at similar speeds in apparently similar conditions. Also, on different farms where conditions and losses appeared similar, considerable differences in forward speed were noted. Part of this difference is bound to be due to different operators but a large part of the variation is thought to be due to the unstable performance of the X-ray modules and a slowing down of the pneumatically operated fingers. It is claimed that these faults have now been overcome, together with others which also had a bearing on performance.

B. Self-propelled harvester

Table 6 compares the overall rates of work calculated from the field records and those observed in the field. The average observed rate was better than the result obtained from the field records, being similar to the average performance achieved by the electronic machine. Actual work rate was slower, but there were fewer breakdowns and considerably less time was spent turning at the end of the drills - 0.8 minutes compared with 1.8 minutes for the electronic machine.

TABLE 6 : Rates of work

Code No.	Acreage recorded	Rate of work ¹	
		Field records: acres/hour	Observations: acres/hour
SPH 1	39	.22	.25 1st visit .36 2nd visit
" 2	30	.29	.23 1st visit .32 2nd visit
" 3	-	-	(.54 1st visit) ² (.54 2nd visit)
" 4	49	.27	.33 1st visit .28 2nd visit
" 5	55	.26	.46
Average	43	.26	.32

¹ Inclusive of breakdowns and turns, but excluding all meals

² Excluded from averages - see comment below.

The average figures again conceal a wider range in overall working speed from field to field. In general, these variations were less extreme than the ranges noted for the electronic harvester. Some users would have liked room for an extra picker on the sorting table on occasions, and this might have improved the rate of work somewhat. However, it is interesting to note that on one farm where a detailed field record was not kept, the average rate of work approached .5 acres per hour in a 14 ton crop, judging from the acreage lifted during the harvest period. A working rate of .54 acres per hour was in fact observed on the two occasions the farm was visited. Several factors contributed to this result:

- a) the crop was grown in 36 inch drills.
- b) a cleaner was in use at the steading so that complete separation in the field was less essential.
- c) few stones were present and the ground was remarkably free of clods.

Working schedules

The self-propelled harvester typically worked fewer days per week and fewer hours per day than the electronic harvester, mainly because of the physical demands of working at the picking table and because casuals are not readily available to work extended hours.

The effective differences in hours per week are summarised in Table 7.

TABLE 7 : Hours per week

	Electronic			Self-propelled
	1 shift (a) or (b)		2 shifts	1 shift
Start (a.m.)	7.30	7.30	7.30	8.00
Finish (p.m.)	6.00	8.00	11.30	5.00
Total hours	10.5	12.50	16.00	9.00
<u>less</u> tea break	.25	.25	.25	.25
lunch	1.00	1.00	1.00	1.00
tea break	.25	.25	.25	.25
high tea		1.00		
supper			.50	
Total hours worked per day	9.00	10.00	14.00	7.5
	average 9.5			
No. of days/week	7		7	6
Total hours/week	66.5		98	45

PLANNING DATA

In order that the 1969 results can be used for planning purposes, some allowance must be made for the fact that this was the first year in which these harvesters were available commercially and therefore it is reasonable to assume that, as a result of this experience, modifications will be made that will improve performance. On the other hand, weather conditions in 1969 were exceptionally favourable and in setting standards, it is necessary to adopt some concept of a more normal season.

These factors are considered in the following section.

Modifications to the electronic harvester

The most important modifications for 1970 are concerned with improving the performance of the electronic system for separating potatoes from stones and clods. Because of unstable X-ray modules and slowing down of the pneumatically operated fingers, the separator was acting as a limiting factor in 1969 in some cases. For example on one field being lifted on contract, the first few drills were lifted in 4th gear (1.9 m.p.h.) but because of losses through the separator, speed was progressively reduced until losses were at an acceptable level (2nd gear, 1.2 m.p.h.).

Another important improvement concerns the time required to turn at the end of each drill. In 1969 there was a delay (36 secs on average) at the end of each drill to allow the machine to run itself empty before turning. This is no longer necessary and the time needed to turn should fall from 1.8 minutes to 1.2 minutes.

The average speed observed in 1969 was 1.7 m.p.h. It is possible that the average might have been $\frac{1}{3}$ rd higher if the harvesters had been modified to 1970 standards, that is 2.25 m.p.h. or slightly faster than the highest speed observed in 1969. However, even a 33% improvement in forward speed and a 33% reduction in turning time would only have given a 30% improvement in overall rate of work because of the large proportion of working time still taken up by turns and stops. This is illustrated below, using average times for turns and stops and based on a drill length of 250 yards - typical of the fields visited.

	Hours/acre (1969 forward speed)	Hours/acre (1969 forward speed + $\frac{1}{3}$)
Lifting	2.00	1.50
Turns	0.75	0.50
Stops	<u>0.48</u>	<u>0.48</u> (as before)
Total	<u>3.23</u>	<u>2.48</u>
Acres per hour overall	0.310	0.403

Overall improvement $\frac{(0.403-0.310)}{0.310} \times \frac{100}{1} = 30\%$

These calculations assume 1969 working conditions. In another year, at least part of the acreage is liable to be lifted in difficult conditions so that, altogether, it would appear unwise to speculate on more than a 15% improvement as a result of the modifications currently being made.

There is also scope to improve performance through fewer stops and breakdowns. The breakdown time recorded in the field records amounted to an average of 0.61 hours per acre:-

TABLE 8 : Analysis of breakdown time

Mechanism	Lost time hrs/ac.
Share, discs	.11
Webs, belts, chains, shafts	.15
Conveyors, levelling table	.12
Miscellaneous	.08
X-ray mechanisms, compressor, fingers	.15
Total	.61

These figures probably understate the actual lost time slightly because short stops of up to 10 mins. would not be recorded as breakdowns. (Conversely the average figure of 0.48 obtained from work measurement studies in the field includes all the short stops but rarely includes the longer, less frequent stops.). It can be seen from Table 8 that failures in the X-ray separation systems only accounted for about 25% of the time lost - the rest of the lost time was due to faults in rather ordinary mechanical components. Any significant reduction in breakdown time must therefore depend on improved reliability of these components. In fact, we are advised that the major sources of trouble have been identified and are believed to be remedied. However the more difficult conditions to be expected in another year would normally be reflected in more frequent blockages, breakdowns and stops to clean out the machine. On balance, there seems little cause to reduce the figure of 0.48 hours per acre used in the calculations.

Lost time due to weather

In 1969 lost time due to bad weather amounted to only 3% of the potential working hours; well below normal expectations. In 1968 nearly 50% lost time would have been recorded in October when almost no lifting could be done during the first fortnight.

For planning purposes, a figure of 35% is suggested as a safe allowance if it is important to keep the work programme on target but 20% might be an adequate allowance where the consequences of occasionally being a week or so behind schedule are not very serious.

Potential acreages

The range in potential acres per week shown in Table 9 takes into account the above considerations.

TABLE 9 : Potential acreages per week

Harvester	Electronic		Self-propelled
	2 shifts	1 shift	
Maximum hrs/week	98 hrs.	66.5 hrs.	45 hrs.
Rate of work (1969 level)	0.30 ac/hr.	0.30 ac/hr.	0.26 ac/hr.
<u>ACRES/WEEK</u>			
<u>35% lost time</u>			
1969 rate of work	19.1	13.0	7.6
" " " " + 15%	21.8	14.9	*
<u>20% lost time</u>			
1969 rate of work	23.5	16.0	9.4
" " " " + 15%	27.0	18.4	*

* It is thought that the changes planned for the self-propelled harvester will have only a marginal effect on performance. But because field observations indicated a higher potential rate of work than the field records, it seems likely that the 1969 rates of work would be maintained in a more typical year.

Team size for electronic, self-propelled and conventional harvesters

The number of regular men required for the harvester, carting and storing is the same, regardless of the type of harvester used:

	<u>No. of men</u>
Harvester	1
Cart	2*
Store	<u>1</u>
	<u>4</u>

* occasionally 3 for distances over 1 mile and/or high yields.

In addition to the regular workers, an extra man is usually required with the electronic harvester, either walking behind to pick up missed tubers or on the machine, picking large stones and rubbish off the back conveyor. Four to five casuals are needed at the picking table of both the self-propelled and conventional harvesters. Hence the electronic harvester normally requires a team of 5, whilst 8-9 are necessary for both self-propelled and conventional machines.

Other considerations

The self-propelled harvester carries its weight on the driving wheels and may be expected to do better in difficult conditions than the equivalent conventional harvester pulled by a tractor of the same horse power (45 h.p.), but not necessarily better than the conventional harvester pulled by a tractor of say 70 h.p.

The 10 cwt hopper on the self-propelled harvester allows a few minutes extra for the trailer to get back to the field. This could make the difference between 2 and 3 trailers either where the store is a long way from the field or where the trailer has to wait while tipping to an elevator, instead of tipping directly on to the floor for loading with a foreloader and bucket.

The hopper also contributes to a slightly faster turn than would otherwise be possible, because there is no need to wait for the trailer to line up before starting a new drill. In practice the average time per turn was 0.8 minutes for the self-propelled harvesters compared with 1.1 minute per turn for six trailed harvesters observed in 1969. The advantage of the hopper, together with the advantage in manoeuvrability from being self-propelled, should be more apparent in wetter conditions.

The power unit on the self-propelled harvester is completely demountable for use at other times of the year as a tractor.

Costs of various systems

Costs are given in Table 10. Trade-in values and repair costs are estimated, while interest is charged at 9% on the average value.

TABLE 10 : Total annual overhead charges and variable costs per acre

	Squad - 2 Row digger	1 Row harvester (conventional)	Self - propelled harvester	Electronic harvester	
<u>Overheads</u>	£	£	£	£	£
New price	350	1700	4000*	5350	
<u>less</u> grant	-	-	400	-	
Value after 4 years	100	350	1000*	800	
Cost	250	1350	2600	4550	
Deprn./annum	65	340	650	1140	
Interest	20	90	210	280	
Annual charge	83	430	860	1420	
<u>Variable costs</u>	£	£	£	£	£
				1 shift	2 shifts
Casuals	26.0	4.5	4.5	-	-
Regular overtime	1.5	2.0	2.0	3.5	5.5
Repairs	1.5	3.0	4.0	6.0	6.0
Total	29.0	9.5	10.5	9.5	11.5

* Includes power unit. If an existing tractor is used the new price drops to £3000 and the annual charge to £760. (Grant would not be available).

Total costs per acre depend on the acreage lifted - the greater the acreage the lower the overhead cost per acre. Table 11 summarises the costs of various systems over a range of acreages. Two diggers or harvesters are assumed to be necessary for 80 and 100 acres in all cases, except for the electronic machine.

TABLE 11 : Summary of lifting costs per acre

System	Acreage lifted per season				
	20 acres	40 acres	60 acres	80 acres	100 acres
<u>Squad + 2 row elevator digger</u>				<u>2 diggers</u>	
	£	£	£	£	£
variable costs	29.0	29.0	29.0	29.0	29.0
overheads	4.2	2.1	1.4	2.1	1.6
total	33.2	31.1	30.4	31.1	30.6
weeks to lift ¹	2.0	3.5	5.0	3.5	4.0
<u>1 row conventional harvester</u>				<u>2 harvesters</u>	
	£	£	£	£	£
variable costs	9.5	9.5	9.5	9.5	9.5
overheads	21.5	10.8	7.2	10.8	8.6
total	31.0	20.3	16.7	20.3	18.1
weeks to lift ¹	2.5	5.0	7.5	5.0	6.5
<u>Self-propelled harvester</u>				<u>2 harvesters</u>	
	£	£	£	£	£
variable costs	10.5	10.5	10.5	10.5	10.5
overheads	43.0	21.5	14.3	21.5	17.2
total	54.5	32.0	24.8	32.0	27.7
weeks to lift ¹	2.5	5.0	7.5	5.0	6.5
<u>Electronic harvester</u>					
	£	£	£	£	£
variable costs ²	9.5	9.5	9.5	9.5	9.5
overheads	71.0	35.5	23.7	17.8	14.2
total	80.5	45.0	33.2	27.3	23.7
weeks to lift ¹ :					
1 shift	1.5	2.5	4.0	5.0	6.5
2 shifts	1.0	1.5	2.5	3.5	4.5

¹ Approximate harvest period under typical conditions

² Add £2 per acre if working two shifts.

If comparison is made with land lifting, the break-even acreage is likely to be around 20 acres for the conventional harvester, 40 acres for the self-propelled unit and 70 to 80 acres for the electronic machine. Provided the machine in question can handle the crop in the time available, small differences in costs will tend to be less important; matters of convenience, suitability for the job, availability of capital and of labour, are likely to be more significant in determining the choice of system.

When equipment cannot be easily matched to acreage within the available time for harvesting, some degree of over-mechanisation can probably be justified, rather than risk leaving part of the crop in the ground. Greater flexibility of working should result and the crop ought to be lifted under better conditions, with the possibility for reducing unit costs by doing some contract work at the end of the season.

An alternative is to match acreage to the capacity of available equipment. In most cases it will probably not pay to reduce the potato acreage, while increases may be ruled out for other reasons. Any benefits to be obtained by this approach will depend on the individual circumstances.

SUMMARY AND CONCLUSIONS

1. Any conclusions presented must be regarded as tentative because the machines were in an early stage of development and have been studied over one season only.
2. In a given period it appears that the electronic harvester will be able to lift at least 75% more than a conventional harvester costing about £1700. This extra capacity is mainly due to the longer hours that can be conveniently worked when lifting is independent of the use of casual workers.
3. In the dry conditions prevailing in 1969, the self-propelled harvester was generally unable to demonstrate an advantage in capacity over the conventional type of harvester.
4. Factors other than cost per acre will often be the main influence on choice of harvesting system, viz:-
 - i) the availability of casual workers
 - ii) the availability of capital to buy a machine
 - iii) the availability of enough regular workers to allow the use of 2 harvesters or 2 squads for large acreages of potatoes.

Where the choice is not limited by such factors, cost considerations may be more important. The table below gives a comparison of harvesting costs per acre.

Summary of lifting costs per acre:

Summary of lifting costs per acre

Method		Acres per season								
		20	30	40	50	60	70	80	90	100
Squads		£	£	£	£	£	£	£	£	£
Approx. £31 at all acreages										
Conventional harvester	1 machine	31	24	20	18	17	16	-	-	-
	2 machines	-	-	-	-	24	22	20	19	18
Self-propelled harvester	1 machine	55	39	32	28	25	23	-	-	-
	2 machines	-	-	-	-	39	35	32	30	28
Electronic harvester		81	58	45	38	33	30	27	25	24

Note: Costs include casual labour and regular labour overtime, depreciation, repairs and interest on the digger or harvesters.

One or two machines may be necessary, depending on capacity and available time.

It can be seen that the electronic harvester becomes cheaper than squads above 70 acres, but is more expensive to use than the conventional machine at all acreages. However, at higher acreages, where it would become necessary to use 2 conventional harvesters, the difference in cost is less than £10 per acre. Savings of this order will often be less important than the saving of 2 regular men during lifting, that is permitted by using the electronic harvester.

At all acreages, the self-propelled harvester would cost more than the conventional type. The advantages offered by this machine to offset the extra cost are not yet obvious.

APPENDIX

Damage assessment

The Damage Index as calculated from the results of the para-cresol test is a generally accepted measure of the extent to which potatoes have been damaged during the lifting process.

A number of factors can make an important contribution to the amount of damage during lifting. For example:-

(i) Method of lifting A 1967 survey at Edinburgh University gave these results:-

<u>Method</u>	<u>Damage Index</u>
Spinner	94
Elevator digger	102
Complete harvester	145

This trend towards less damage with simpler methods was also shown in the 1961 survey sponsored by the P.M.B.

<u>Method</u>	<u>Damage Index</u>
Spinner	115
Elevator digger	169
Complete harvester	245

(ii) Varietal susceptibility Work at N.I.A.E. over a number of years has shown that different varieties show consistent differences in their susceptibility to damage. For example, the variety Pentland Crown at one extreme is more than twice as damage prone as Record at the other extreme.

(iii) Soil conditions A dry free soil tends to separate rapidly from the potatoes while a moist, heavier soil tends to stay with the potatoes and cushion them against damage as they go through the harvester. The damage index for potatoes lifted in dry conditions could easily be 50% higher than the index obtained in the same field in a wetter state.

Samples of tubers were collected from the electronic and self-propelled harvesters for damage testing. The results are given in Table A.

TABLE A : Damage Assessment

Electronic			Self-propelled		
Code No.	Variety	Damage index	Code No.	Variety	Damage index
EH 1	Maris Peer	269	SPH 1	King Edward	155
" 2	Maris Piper	199	" 2	Majestic	197
" 3	Record	144	" 3	Record	170
" 4	Pentland Dell	312	" 4	Golden Wonder	197
" 5	Pentland Hawk	209	" 5	Maris Piper	183
" 6	Record	132	" 6	Pentland Crown	290
" 7	Golden Wonder	230			
" 9	Pentland Crown	335			
Average		228	Average		182

The actual level of damage is high for both machines but this is to be expected as a consequence of dry conditions. Of more interest is the difference in damage levels. Ideally the comparison would need to be made using samples taken from the 2 machines working together in the same field. The results above do not allow the difference to be quantified with any confidence because the number of tests is too small to adequately eliminate the effect of factors other than soil moisture, which was uniformly low, and varietal susceptibility, which can be taken into account. If taken at face value, the results suggest that damage was about 25% higher with the electronic harvester (35% if the figures are adjusted to take account of differences in varietal susceptibility) and this is enough to suggest that the mechanical separation process was responsible for at least some rise in damage.

In the event, all reports indicated that the crops came out of storage in extremely good condition and it would seem that the high damage levels were more than offset by the dry, clean condition of the tubers going into storage.

