THE WEST OF SCOTLAND AGRICULTURAL COLLEGE

(ECONOMICS DEPARTMENT)

FARM LABOUR STUDIES No. 3

POTATO HARVESTING

SOME ASPECTS OF THE LABOUR ORGANISATION

By

R. TURNER

REPORT No. 7

June, 1953

6 BLYTHSWOOD SQUARE,

GLASGOW, C.2

FARM LABOUR STUDIES No.3

POTATO HARVESTING.

SOME ASPECTS OF LABOUR ORGANISATION.

CONTENTS

--------oOo--------

DIGEST AND SUMMARY OF REPORT.

The organisation of the work of harvesting potatoes on six Perthshire farms was studied to find out if any ideas could be suggested for reducing the labour required. In view of the small number of farms, the information and figures given must be taken with some reserve.

The farmer's object is to harvest as many acres of potatoes as possible in a day at the least cost per acre, using the resources available. Taking the average number of workers per day required to harvest an acre as a measure of the effectiveness of the labour, it is shown that the number of worker-days required varied from nearly 7 to just over 12 per acre. A team of workers usually harvested from 3 to 4 acres in a day.

The organisation of the work on the six farms is described. The differences in methods were relatively slight but there was some variation in the number of persons required to do the same operation on different farms.

The operations were divided into digging, picking, carting and pitting, and the work entailed in these is discussed. In order to use labour effectively, the operations should, as far as possible, fit in with each other so that labour is not wasted in unnecessary waiting for another worker to finish his part of the job. It may not always be possible to achieve this aim, but the more nearly the operations can be made to fit, the less will be the cost of carrying out the job. Picking the potatoes into baskets is the key operation in harvesting and on it all the others depend.

The speed of digging is discussed, and it is shown that digging in two directions on both sides of a "break" was more economical than digging in one direction only, because the time spent in turning at the ends was less than the time taken to travel back light. When turning or travelling back light the digger was not doing any effective work, but was merely moving to the place where the work had to be done.

The most striking feature of picking was that the pickers spent more time waiting than they did picking. In each round of the digger the average time taken by all squads was 3.26 minutes picking and 3.50 minutes waiting. The average length of "bit" or stint picked on each farm varied from 10½ to 15 yards. Although some rest is necessary, it is probable that the waiting time could be reduced without real hardship to the pickers. This could be done by increasing the length of bit, so that, in each round of the digger, more time would be spent in picking and less in resting. This would make it possible to do the work with fewer pickers. Probably the only way to induce pickers to give up some of their waiting time, would be to put picking on a piece-work basis.

The average speed of picking on each farm varied from .17 minute per yard to .30 minute per yard. Contrary to expectation there was no evidence that that speed of picking varied with the yield of the crop, and it is suggested that the heavier crops may have been due to larger tubers rather than to a greater number of tubers per acre.

The time spent by tractor carts travelling between the pits and drills varied from 10 to 20 per cent of the total time taken for each round journey of the cart. Therefore, the more the haulage time can be reduced by having the pits as near to the drills as possible, the shorter will be the time taken for the operation. On some farms, the tractor hauling the cart was set to travel up the drills without the driver, and this released the driver to empty baskets.

On the farm with the best record of labour effectiveness the whole job of lifting was carried out with 6.7 worker-days or 51 man hours per acre. The main reasons which contributed to this efficient performance were as follows:-

(1) Compared with other farms the pickers worked a longer bit so that they had less waiting time and were able to pick a bigger acreage per day.

(2) The amount of carting to be done was almost exactly equal to the capacity of a tractor, trailer and two men, so that they were fully employed and little time was lost.

(3) One man with some assistance was able to pit the crop so that the labour requirement for this was lower than on other farms.

--------oOo--------

INTRODUCTION

On many arable farms to-day one of the biggest problems which the farmer has to face is to find a supply of casual workers to gather the potato crop. In some areas the existing casual labour is insufficient to carry out the work and the aid of children, recruited from city schools, has been required to secure the crop. Further, the rise of wages in recent years has greatly increased the cost of labour. All this has led to many attempts to find ways of reducing the labour requirement of the job, and while some success has attended mechanisation, a complete harvester suitable for all conditions has yet to be put on the market.

The aim of this investigation was to make a preliminary study, on a few farms, of the organisation of the labour used for potato harvesting, in order to discover what differences existed in method and organisation. It was hoped that comparison between the different farms would show the reasons why labour performance varied and would point the way to saving time and labour. The times taken to perform the different operations were carefully recorded and these were related to yield and acreage harvested.

Owing to the shortness of the potato harvesting season it was not possible to study more than six farms. These were not sufficient to give an adequate sample of the potato growing farms in the area and the findings must therefore be regarded as tentative.

Observations and Method.

The six farms visited were situated in West Perthshire, and the observations were made between mid-September and mid-October, 1952. The fields studied were for the most part on undulating land and the soil on all of them was a light or sandy loam and was well drained. Harvesting conditions in 1952 were very favourable. Dry weather in the early autumn had caused all crops to mature early and had enabled farmers to be well ahead with their work. During the potato harvest, only a few days were lost due to wet weather.

Studies were made on each farm on the operations of digging, picking, and carting to the pit. The operation of pitting was observed but not timed in detail. The acreage harvested and the daily production were also measured. As the observations were carried out by the writer unaided, a measuring wheel was used for ascertaining the distances. This is not such an accurate instrument as the tape, so that it is possible that there may be a slight error in the estimation of the areas harvested.

Production in tons per day was obtained by measuring the length and cross section of the pit to find the volume of potatoes produced in a given time, from a known area. To convert this into tons, a figure of 42 lbs of potatoes per cubic foot of pit was used. This is, of course, an average figure and may not necessarily have been appropriate for the crops observed, so that there is a possibility of a further slight error.

DATA OBTAINED

Table I shows the principal information obtained from each farm. Where the calculated figure for tonnage per acre differs widely from the farmer's or overseer's estimate, data based on both are shown.

TABLE I

1 Farm No.	2 No.of Labour staff	3 Acres harvested per day	4 Yield per acre. (tons)	5 Production in tons per day	6 Man-hours per acre	7 Man-hours per ton	8 Production per worker per day. (cwts.)	9 Worker-days per acre harvested
A	21	2.0	(a)10.0 (b) 8	20.3 16.2	78.5	7.88 9.82	19.2) 15.4)	10.5
B	36	3.6	(a)12.4 (b) 9	44.3 32.2	76.2	6.21 8.96	24.6) 17.8)	10.0
C	44	3.6	10.9	39.0	92.1	8.42	17.8	12.2
D	23½	3.5	10.4	36.3	51.0	4.92	30.9	6.7
E	43	5.6 (b)4approx.	(a)13.6 (b)11.0	76.4 44.0	61.2 (b)86.0	4.50 7.82	35.6) 20.4)	7.7
F	36½	4approx.	11.6	46.4	73.0	5.95	25.4	9.1

(a) Figures derived from observation.
(b) Farmer's or overseer's estimate.

Acres harvested per day.

In general, the farmers visited considered that, with a normal picking gang, the outturn should be from 3 to 4 acres in a day - 4 acres being regarded as a good day's work.

The area harvested per day is governed by the following factors:-

(a) The number of workers employed.
(b) The ability and industry of the workers.
(c) The skill and experience of management in organising the work.
(d) The quality of the soil.
(e) The degree of slope of the field.
(f) The weather conditions at harvest time.
(g) The machinery that is available for the work.

(a) Number of Workers employed. Ideally, the number of workers - pickers, drivers and loaders and pitmen - should fit in with the length of drills to be harvested, the distance to and from the potato pits and the machines available, but the length of drills and distance from the pit frequently change as the day progresses, so that it is seldom that perfect integration can be achieved. If however, a good combination of workers and machines has been found, i.e. the ideal size of team and equipment, they will be able to harvest a certain acreage per day under given conditions. Generally speaking, that acreage could only be increased economically by bringing on another team of the same size as the first. If a few workers only, or a machine, were added, they would upset the balance of the team and the output per worker would decrease.

(b) Ability and Industry of workers. Gangs of casual workers vary much in quality Some contain a high proportion of industrious and experienced workers, while in others, many of the workers are careless and slack and have to be kept constantly up to the mark. Usually the rate of lifting is limited by the pace of the slowest worker, and one slow picker can hold up the digger and constantly waste the time of all the other pickers. Careless pickers who leave many potatoes in the ground may increase the later work of picking the harrowings. Slackness in other operations can cause needless delays, e.g. if the carting falls behind and the baskets are full, picking is held up. A skilled tractor-driver can manoeuvre the tractor better than a learner and thus save time in emptying the carts at the pits.

(c) Skill of Management. The first object of management is to ensure as far as possible that the machines and the labour force are suited to the job and to the existing conditions. It is the aim of this paper to throw some light on these points.

(d,e,& f) Physical factors. Harvesting can, of course, be done quicker on sandy free working soils than on heavy clays. Where the soil is sticky, some will adhere to the potatoes and add to the weight that has to be picked and carted to

the pits. On such soils too, more time will be spent in cleaning the digger. On hilly land, carts and digger tend to move more slowly up hill. Weather conditions can affect appreciably the area harvested, both by the effect of bad weather in preventing harvesting at all, and also because, under wet or very windy and uncomfortable conditions the speed of work tends to become slower.

(g) Machinery Available. The type and quantity of machinery available may affect the rate at which the crop is harvested. With the modern hydraulic tipping trailer, less time is taken to empty a load than with a hand-tipped cart. An elevator digger leaves the potatoes in a narrower row than a spinner and is said to reduce the time taken for picking.

Yield per acre.

This varies from farm to farm according to the different conditions under which the crop has been grown. Improvement in yield per acre is a technical problem and the farmer can influence it during the growing period by manuring and cultural practices. Once, however, the time of harvest is determined, the yield per acre is fixed, and the farmer can do nothing to improve it.

Production per Day.

This is the area harvested per day multiplied by the yield per acre. The farmer wishes production per day to be as high as possible, and since, by harvest time, the yield is fixed, he can increase production only by increasing the area harvested per day.

Man Hours per Acre.

This measures the effectiveness of the use of labour, and is the standard by which the efficiency of labour management can best be judged. Low man hours per acre is obtained by harvesting a large acreage relative to the number of persons employed on the job.

Comparison of the figures for different farms shows that Farm D has the lowest number of man hours per acre, 51.0, while Farm E follows with 61.2 man hours per acre. Both these farms harvested an average or large acreage of potatoes with a relatively small labour staff. In order to discover the reasons for this, the various operations must be considered in detail. Before doing so, however, a description of the operations on the different farms will help to give a clearer picture of the work being studied.

DESCRIPTION OF ORGANISATION ON FARMS

Farm A

The labour staff and equipment used were as follows:-

1 man with tractor and trailing spinner type digger.
16 pickers.
Carting: 1 man with tractor and trailer.
1 man loading.
2 men at pits.
Total: 4 regular and 17 casual workers.

Digging. This was done in one direction on one side of the break only. The field was moderately steep and the digger worked uphill and ran downhill light. At the top of each drill the driver dismounted, walked to the digger and raised the share out of the ground. He then cleared the shaws (haulms) from the digger and walked back to the tractor, mounted and drove to the bottom end. There he stopped and usually the farmer or one of the men came over from the pit, 18 yards away, and let the digger in. If no one was available to do this the driver dismounted and did it himself. Occasional stoppages occurred during digging - waiting either for a picker who had not finished or because the cart in which the potatoes were being loaded was in the way. The tractor driver supervised the pickers and this occasionally caused delay in waiting for a picker to clean up a badly picked bit.

Picking. The farmer was of the opinion that there were one or two pickers too many, but as he obtained them from a potato merchant he had to accept the gang sent to him. The drills were divided into 16 "bits" averaging 12½ yards each.

The potatoes were picked into wire baskets measuring approximately 22 inches long by 16 inches wide at the top by 8 inches deep. There were approximately 3 baskets to each picker. Pickers began picking the moment the digger had passed and used both hands. Some pickers worked rapidly and then went over the bit a second time picking up the potatoes left. Others worked more deliberately and did not return to glean the bit, but in both cases there seemed to be some potatoes left to be gathered in the harrowings. After picking, the pickers had a long rest period till the digger came round again. The produce of one bit filled $1\frac{1}{2}$ to $1\frac{3}{4}$ of a basket or approximately 65 to 80 lbs.

Carting. Emptying baskets into the trailer and carting was done by the tractor driver and one assistant. The tractor was driven up the undug drills. When it was in the drill, the driver adjusted the throttle to slow speed, dismounted and allowed the tractor to proceed along the drill unattended. The wheel tracks were spaced to fit in the furrows which kept the tractor straight and avoided the need to steer it constantly. This released the driver to empty baskets. The cart usually collected the produce of two or three drills on its upward journey, and often waited at the top for baskets to be filled before proceeding downwards. From the foot of the drills it travelled to the pit and backed in end on to the side of the pit. The load was discharged by tipping the trailer by hand and emptying out the potatoes with a graip. The workers at the pit assisted by holding a board at the other side of the pit to prevent the potatoes spilling. When the trailer was empty, it was drawn forward and the back-board replaced, and it returned to the foot of the drills for another load.

Pits. The pits were sited at the bottom end of the field running alongside the fence. The farmer and one man worked at the pits but a third man sometimes helped, leaving the farmer free to supervise. Straw for the pits was brought from the stackyard by a horse and cart, usually by the farmer himself. The pits were 6 ft. wide at the base, and about 2 ft. 6 inches high. They were covered with straw and earthed up at the foot and with a spit of soil half-way up each side. After about half the field had been harvested the first pit was closed and a second pit was made parallel to the first. As this was begun at the place where the first pit started, it entailed a longer haul from the potato drills but was necessitated by soil conditions.

Working Hours. 8 a.m. to 12 noon and 1 p.m. to 5 p.m., with a tea-break of 15 minutes in the morning and afternoon which is included in the time paid for. The farm staff, which, in addition to the farmer, consisted of two tractor drivers and one man at the pits, were available from 7 a.m. to fetch straw and make other preparations.

Farm B.

The labour staff and equipment used were:-

1 man with tractor and mounted spinner digger.
26 pickers.
Carting: 2 men with tractors and trailers.
2 men loading.
4 men at pit.
1 man supervising pickers.
Total: 5 regular and 31 casual workers.

The field was sloping and the ridges ran the length of the slope. The field was divided both across and down the ridges and into a number of "breaks".

Digging. When the work of the digger was first observed, it was working up one side and down the other of a break of drills which were 137 yards long. The digger being mounted, the tractor driver could operate it without leaving his seat, and as the shaws had been well burned, the digger seldom required to be cleaned. The digger usually waited for a short time at the bottom of the drill before travelling up and if the pickers immediately in front had not finished their bit, it would sometimes wait at the top as well.

The following day the digger worked one way only on a drill of 293 yards long. Two breaks were combined to form this, thus eliminating the need to lift an area by hand to form a "road" between them. Later however, digging both ways on a single break was resumed; it was thought to be more economical, because on the long drill, the digger tended to overtake the carts and was held up until

they were moved out of its way.

Picking. Picking was observed both on two sides, and on one side only, and there was some evidence to show that the rate of harvesting was quicker when picking on two sides. Here the average speed of harvesting was 54.2 yards per minute while on one side only it averaged 47.1 yards per minute. Another interesting feature of picking was that during each round of the digger, the pickers, on an average, spent $\frac{1}{3}$ of their time picking and two-thirds resting. The method of picking was similar to that of Farm A.

Carting. This was done with two tractors and trailers, one working in the drills while the other was discharging its load. Two men assisted in emptying the baskets into the trailer. The procedure was similar to that described for Farm A. The carts made two trips of the drills before proceeding to the pit for emptying.

Pits. The pitting methods were similar to Farm A, but 4 men were used for this work. They did not appear to be hard pressed.

Working Hours. These were similar to those of Farm A.

Farm C.

Labour Used. 1 man with tractor and trailing spinner digger.
34 pickers.
Carting: 1 man with tractor and trailer.
2 men and 2 one-horse carts.
2 men helping to load.
3 men at pit.
1 overseer in charge of the squad.
Total: 5 regular and 39 casual workers.

Digging. The procedure was similar to that of the last two farms. As the digger was trailed, the driver had to dismount at the ends to let it out of the ground and put it in again. Sometimes the overseer or one of the pickers did this to save the driver dismounting. At times the driver had to wait to let the carts get ahead, but on the whole there was little delay except where a large stone tended to foul the digger for 3 or 4 rounds. Digging was on two sides of a break of 40 drills.

Picking. The pickers on the whole seemed slower than those on farms A and B and several of them were married women who had brought with them young children who, from time to time, required attention.

Carting. The work of one horse cart only was observed in detail. The tractor cart could make two rounds before going to the pit to discharge, but the horse cart was often fully loaded when still 20 yards from the end of the drill. Sometimes the empty horse cart would arrive back at the head of the drills before the cart in front had started down and would have to wait until another round of the digger had been made.

When this farm was visited there was not a full day's work left and digging finished at mid afternoon, the rest of the day being spent harrowing the field. As it was known to the workers that to finish the field was not a full day's work, it is probable that they were not working as hard as usual, so that the times shown may not reflect the true capabilities of the gang.

Farm D.

The labour employed was as follows:-

1 man with tractor and mounted digger.
18 pickers - (12 schoolboys and 6 women and children)
Carting: 1 man with tractor and trailer.
1 man loading.
Pits: 1 man and 1 woman part time..
1 man supervising schoolboys.
Total: 3 regular and 20$\frac{1}{2}$ casual workers.

Digging. The method of organisation was similar to the foregoing. The length

of the drills was 269 yards and the farmer made it a practice to allow 8½ minutes for each round of the digger. Of this time, an average of 1.15 minutes was spent waiting at the foot of the drill. It is interesting to note that in the late afternoon a cold strong wind sprang up, with occasional showers, making working conditions very unpleasant. As a result, longer time had to be allowed and the total digger cycle was increased to an average of 9.20 minutes. Digging was done in one direction only and there were very few stoppages. The digger was not held up by the cart, because the latter started after the digger, and had reached the top before the digger came up again. The digger worked efficiently and only now and again did shaws require to be cleaned from the machinery.

Picking. The picking team consisted of 12 city schoolboys aged 13 and 14 under a supervisor, 4 small children who each had a half bit and 4 women, equivalent in all to 18 persona. The bits in this field were rather longer than on other farms, being from 15 to 18 yards long. The speed of picking was slower than on the other farms - 3.13 yards per minute as compared with 5.11 yards per minute on Farm B when picking on one side only. The reason for the slower picking was probably because the schoolboys were not so skilled and seemed to become tired more easily than the farm workers. On the following day the pickers moved to another field where the bits were only 12 yards long. There, the average picking rate was 3.24 yards per minute, which seems to confirm that this was the natural speed of the gang and did not depend on the length of bit. The average waiting time on the long bits was just slightly less than the picking time, while in the second field, on shorter bits, the waiting time was slightly more than the picking time. The pickers had plenty of baskets, so little time was wasted waiting for baskets to be emptied.

Carting. The tractor and trailer cart normally had little difficulty in keeping the baskets empty. The trailer was tipped by means of a handle and screw but a hydraulic lift was being fitted to one tractor, which, on the single occasion it was observed, took .65 minutes to empty the load as compared with an average of 2.19 minutes by hand. The cart travelled about 270 yards to the foot of the drills and by the time it reached the top it was full and from there it travelled about 90 yards to the pit. It is worth noting that the shorter travel was done when the cart was fully loaded. The tractor usually had to wait at the pit till the pitman was ready.

Pits. There was normally a man and a woman at the pits, but the work was carried on for most of the time by the man only.

Working hours were similar to thos of previous farms.

Farm E.

The working team was as follows:-

1 man with tractor and mounted digger.
32 pickers.

Loading: 1 man with tractor and trailer.
3 men with 3 horses and carts.
2 men loading.

3 men at pits.
1 overseer.
Total: 6 regular and 37 casual workers.

The field here was steep in parts and undulating with an irregular shape.

Digging. The digging procedure was much the same as at other farms. A good deal of time was wasted waiting for one picker who held up the digger on several occasions because she had not finished picking her bit. Digging took place on both sides of a break of drills. Normally the digger worked on the outsides of the break. When the number of drills left in the break had been reduced to six, the digger moved over to the next break and the pickers from the outer row of the old drills moved over to the new break. The digger then dug down the old break and up the near side of the new break. When the last row of the old break had been dug and digger had travelled up the near side of the new break it moved across 30 or 40 drills and opened up the first drill on the far side of the new break, and the pickers from the old break followed. This method

has the advantage that at the end of a break the pickers from each side do not get in each other's way and with only half the pickers changing over at one time, little time is wasted doing this.

Picking. The picking gang worked 16 on each side of the break, and the length of bits varied among the pickers from 12 to 16 yards. During part of the observations the digger screen was broken so that the potatoes were thrown over a wider strip than normal. It would be expected that the bit would take longer to pick under these conditions but there is hardly enough evidence to support this.

Carting. Both trailer and horse carts were studied, and the organisation of carting was similar to that previously described for other farms. The length of drill at the time the tractor and trailer were studied was 235 yards. The tractor and trailer travelled from the pits to the top of the near row of drills, moved down this and travelled up the far row to the top and thence back to the pit. A rough estimate of the average distance to and from the drills to the pits is 140 yards. The average weight of potatoes carried in a trailer, based on the number of baskets lifted into the cart is estimated to be about 27 cwts. The average time taken by the tractor and trailer to load, discharge, and return to the drills was 16.58 minutes, so the average rate of lifting and discharging the potatoes was approximately 12.3 minutes per ton.

The horse and cart travelled to the foot of the drills and loaded on the uphill journey only. On five trips, it carried, on an average, approximately 13 cwts of potatoes. At this stage the average distance from the top of the drill to the pits was 144 yards and from the pits to the bottom of the drill 267 yards. The average time taken for each round trip was 17.23 minutes which is equivalent to 26.15 minutes per ton.

The rate of loading and discharge of the tractor and trailer was, therefore, approximately twice as fast as that of the horse and cart. From the labour point of view, however, the tractor and trailer required two men to load it in addition to the driver. The time taken by loaders (including the time spent in changing from one trailer to the next) was 10 minutes per man per journey, making the total man time per round trip 36.58 minutes. This is equivalent to 27.1 man minutes per ton, which is a minute more per ton than the time taken by the horse and cart.

The cart usually arrived at the foot of the drills some time before it was necessary to start up and it spent on an average 3.25 minutes per trip waiting till the pickers were ready, while the tractor spent only .61 minutes per trip waiting for pickers.

Pits. 3 men were employed here and carts and tractor emptied the loads by backing in end on to the side of the pit.

Farm F.

The labour staff used was as follows:-

Digger:	1 man and 1 boy or youth with tractor and elevator digger.
Carting:	2 men with a tractor and trailer each. 3 loaders.
Pits:	3 men.
Pickers:	26 women and youths.
Overseer:	1 man.
Total:	4 regular and $32\frac{1}{2}$ casual workers.

Digging. On all other farms visited the potato haulms had either died down or been burnt off but on this farm they had not been burnt - and were in fact still growing strongly - because the maximum yield of Kerr's Pink potatoes for ware was wanted. This was the only farm at which an elevator digger was observed at work. The tractor was driven by a farm hand with a youth to stand on the front of the digger and clear it of shaws. The digger was trailed from the tractor drawbar. At the end of each drill the digger had to pause while the elevating mechanism was run to ensure that the potatoes all fell within the bit. The driver had also to dismount and disengage the digger at the ends and put it in at the beginning of each drill; and the digger itself was heavy.

Picking. This was done on two sides of a break. It was greatly impeded by the presence of the strong shaws. Usually, most of the pickers pulled the shaws in each drill before the digger came round, leaving the drill bare. If this was not done, the digger dug up the potatoes with the shaws still adhering, so that many of them had to be pulled off the shaws. When pulling the shaws, it seemed best to pull only one or two rows at a time and throw the shaws on to the dug land. Some of the pickers pulled the shaws from so far across their bit that they had to carry them in bundles across the drills and deposit them on the dug ground.

Carting. There were two tractor carts, each with trailer and hydraulic tip. The practice was to drive the cart up the side of the drills on the dug land, so that the driver was not able to dismount and empty baskets. Three rounds of the drills were made before the cart was full. The cart waited at the pit till the other cart was ready to leave the drills. The total time taken for a complete round journey was 36 minutes of which 16 minutes was spent in waiting, either at the pit or at the drills, so that the effective time for a trip was only 20 minutes. Had the round trip taken 4 minutes less, it is possible that one tractor and trailer would have been sufficient. The system of loading was different from that of other farms. Three men were available to load the cart while the driver drove the tractor. These three took turns to rest for each circuit of the cart round the break, so that there were always two men loading and one resting. Thus each man would load for two circuits and rest for one. It was believed that the work of loading was too hard for two men to carry out continuously and it was considered that this system worked satisfactorily.

Pits. There were 3 men working at the pits normally but on the second day of the observation 2 men only were there and did not seem to be falling behind with the work.

Hours of Work. The squad worked from 8 a.m. till 12 noon with a quarter-of-an-hour break for tea. They had half-an-hour only for dinner and worked again from 12.30 to 4.30 with a quarter-of-an-hour tea break. The tea breaks were included in the time paid for.

ANALYSIS OF OPERATIONS.

Various aspects of the operations of digging, picking, and carting potatoes must now be considered. An attempt will be made to isolate the factors which affect the rate of operation and which contribute to the effective use of labour and equipment. Although the effect of each factor must first be considered separately, it is the combined effect of all factors taken together which ultimately controls the efficiency of the operation - and consequently the daily output, so that in practice, any single factor must be considered in relation to the job as a whole. In the course of discussion, ways of increasing the speed of one operation may become apparent, but these will increase output only if the factor which is to be altered is the limiting factor. For instance, an increase in the digging rate would be of little use, if the pickers could not keep pace with the new digging speed; but if it happened that the digger was unable to keep the pickers reasonably busy, then an increase in the digging rate might be expected to lead to greater output per day.

If the amount of labour and equipment in use were perfectly integrated, so that no one had to wait for anyone else and there was no idle machine time, then an improvement in one factor would lead to greater output, only if all other factors were improved at the same time. In practice, however, the ideal degree of integration is seldom achieved, so that one or more factors tends to limit the efficiency of the operation. For example, if there were not enough carts to clear the baskets when the potatoes were picked, then the delay in waiting for empty baskets might slow down the whole operation. Once the limiting factor is removed the tendency is for another factor to become the limiting one. In other words, one improvement leads to another till a stage is reached where no further improvement is possible without altering the physical conditions.

In practice, the rate of lifting potatoes is usually governed by the operation of picking and on account of the waste of labour if pickers are held up, it is usual to ensure that digging and carting facilities are adequate, and

TABLE II

Digger Performance

1	2	3	4	5	6	7	8	9	10	11
Farm No.	Average Digger Cycle- (Actual Minutes)	Digging - per cycle		Turning - per cycle		Idle Time per cycle. (Minutes)	Actual Working Time. (Minutes)	Speed of digger when digging . (miles/hour)	Turning Time as percentage of Actual Working Time.	Total time taken per acre. (Minutes)
		Time spent. (Minutes)	Distance travelled. (yards)	Time spent. (Minutes)	Distance travelled. (yards)					
					Two Way Digging					
B	5.84	3.58	137	1.23	33	1.03	4.81	2.61	25.3	132
C	5.98	4.30	178	1.42	30	.26	5.72	2.81	24.8	105
E	8.48	4.36	204	2.33	45	1.79	6.69	3.19	34.9	130
F	6.43	3.92	180	2.20	35	.31	6.12	3.13	36.0	112
					One Way Digging					
A	6.30	2.69	184	3.32 x		.29	6.01	2.34	55.6	212
D	8.52	4.31	269	3.06 x		1.15	7.27	2.12	42.1	197

sometimes more than adequate, to keep the pickers fully employed. To some extent picking and carting may be regarded as providing the necessary conditions for the pickers to do their work.

Although picking is the key operation it will be convenient to discuss digging first, because picking is dependent on the digger cycle.

Digging.

An analysis of the performance of the diggers is shown in Table II.

The average digger cycle is the time taken for a complete round of the digger from the time it starts to dig one drill until it is back again at the start and begins to dig the next drill. It includes all time spent in waiting. It is governed by the following factors:-

(1) Length of the drill.
(2) Speed of travel of the digger.
(3) Time spent in turning at ends.
(4) Time spent in waiting.

The average time taken to dig a drill on each farm is shown in column 3 of Table II and the average length of the drill is given in column 4. The time taken to dig a drill is, of course, the product of the length of drill and the digger speed. (The latter is shown in column 9). This represents the time during which the digger is doing effective work.

The time spent in turning at the end and the distance travelled along the end-rig (headland) are shown in columns 5 and 6 respectively, for two way digging and for one way digging this also includes the time taken to return to the start.

For both, it includes time taken in clearing the digger of potato shaws where this was necessary. While the time spent on these tasks was unavoidable, no effective work was accomplished, and therefore the shorter this turning time is, in relation to the digging time, the more efficient is the use of the digger.

The longer the drills to be dug, the fewer are the drills per acre harvested and consequently the less is the time wasted per acre in turning at the ends. Thus it may be expected that if there are no delays due to other causes, harvesting will be quicker where the drills are long than where they are short.

In column 7 the time lost by waiting is shown. This is made up of time spent by the tractor waiting at the ends of the drills and waiting in the drills for pickers, for carts to move out of the way, or for the removal of a basket, stone, or some other obstruction. Clearly, to make the most effective use of the digger such time should be reduced to a minimum.

In column 8 the average time per digger cycle spent in working is shown. This is the total cycle time less the time lost in waiting, and is the same as digging time plus turning time. In column 10 the turning time is shown as a percentage of the working time of the digger and is a measure of the effectiveness of the use of the digger during that time. For two way digging, it varies from 25 to 36 per cent while for digging one way only the percentages for the two farms are 42 and 56. This suggests that more effective use was made of the digger when digging was done by circular travel round the break than when it was on one side only.

This is further confirmed in column 11 which shows the digging rate or the time taken to dig an acre. (The drills were all 28 inches wide). For one way digging, the average time taken on two farms was 205.5 minutes per acre, while on 4 farms where digging was in both directions, the average time was 120 minutes per acre.

Picking.

Table III shows an analysis of the performance of the pickers. Time did not permit of observing every picker, but as far as possible the pickers chosen for study were representative of good, bad and indifferent workers. Each picker was studied for three or four rounds of the digger. Column 5 of Table

TABLE III

Performance of Pickers

1	2	3	4	5	6	7	8	9	10
Farm No.	No. of Pickers.	Average actual picking time per round of digger. (minutes)	Average waiting time per round of digger. (minutes)	Total picking cycle. (minutes)	Percentage of total time spent waiting. (minutes)	Length of drill picked per cycle. (yds.)	Average length of bit. (yds.)	Average speed of picking. (min./yds.)	Acres picked per day per picker.
A	16	3.01	3.69	6.70	55.0%	184	12.5	.273	.125
B	26	2.06	3.92	5.98	65.5	274	10.5	.171	.138
C	34	2.38	2.98	5.36	55.6	356	10.5	.247	.106
D	18	4.25	4.07	8.36	48.6	269	15.0	.303	.195
E	32	3.77	3.61	7.18	50.5	408	12.75	.257	.175
F	26	ǂ 4.06	2.74	6.80	40.4 x	360	13.8	.178	.154

ǂ This includes 2.70 minutes picking and 1.36 minutes pulling shaws to make ready for picking

x Picking includes clearing shaws.

III is the total of columns 3 and 4. Actually, the picking cycle is the same as the digger cycle but the figures differ from those shown in Table II column 2 because the observations on digging and picking were made at different times.

The total time of the pickers was made up of the time actually spent in picking potatoes and the time spent resting, waiting for the next round of the digger (columns 3 and 4). The average picking time on the six farms was 3.26 minutes, while the average waiting time was 3.50 minutes. Thus more time was spent waiting than picking. In a 7½ hour day, (i.e. working time exclusive of breaks), on an average, only 3 hours 37 minutes were spent at work, while for 3 hours 53 minutes the pickers were idle. The percentage of total time spent in waiting is shown in column 6. There seems to be room for improvement in this performance and suggestions as to how this might be done are made later.

Area Picked. The total area of potatoes picked depends on the following factors:-

(1) Length and width of drill.
(2) Number of pickers.
(3) Length of digger cycle (i.e. the time the digger takes to make a complete round of the drills).

The width of the drills was the same on all farms but the length of drill picked varied on each. (See column 7). The length of drill is fixed in any part of a field, but the farmer has the choice of digging in either one or two directions, and, if the drill is a long one, of dividing it. The farmer wishes to choose the method which will enable him to pick the greatest length of drill per day.

The number of pickers needed is closely bound up with the length of drill to be picked. They should, in principle, be sufficient to keep the digger constantly at work. If there are too many pickers, their waiting time will be long and the consequent cost per acre of potatoes dug will be high because the farmer will be paying for much idle time. If the number of pickers is too few, the digger will have a long waiting time, and while this is not so serious from the point of view of wasting man power, the output per day will be lowered. The length of drills divided by the number of pickers available (subject to adjustments for young children) gives the average length of bit per picker (column 8).

The length of the digger cycle determines the amount of the pickers' waiting time and possibly, to some extent, the speed at which a bit is picked. It is usually fixed so as to allow pickers what they regard as a reasonable time to pick the bit and to rest. It seems possible, however, that the resting time allowed is really excessive.

The effect of speeding up the digger cycle would be that pickers would have to work harder, or take a shorter rest, or both, and this might be expected to result in a greater output per day and also a greater output per picker. Output per picker could be increased by maintaining the existing digger cycle but reducing the number of pickers so that each has a longer bit. Again the picker would have to work harder, or take a shorter rest, or both, during each cycle of operations. This would reduce the cost and provided the digger was not delayed, the output should remain the same as before.

Picking Time. The factors which affect the time required for the actual picking must now be examined. The average speed of picking on each farm is shown in column 9 and is seen to vary appreciably from farm to farm. The average speed on all farms is .234 minutes per yard. Generally speaking, the speed of picking will be affected by the following factors:-

(1) Length of bit.
(2) Yield of crop.
(3) Skill of pickers.
(4) Attitude of pickers to work.

It is quite clear that, as would be expected, the longer the bit the longer the time taken to pick it; but there is also some indication from the figures in columns 8 and 9 that the longer bits are picked at a slower

speed than the shorter ones, which can easily be accounted for by increasing fatigue. It follows, therefore, that if the length of the bit were to be increased, a point might be reached, beyond which it was not economic to increase its length further.

It would not be unreasonable to suppose that the bigger the yield of the crop, the longer it would take to pick, but comparison of the picking rates with the crop yields (Table I column 4) does not suggest that this is the case. A possible explanation is that the heavier crops may be due to larger tubers rather than to a greater number of tubers per plant, and that the larger tubers do not take any longer to pick than the small ones. Thus it seems that the time required to pick a bit depends more on the number of tubers than on the weight of potatoes.

The pickers showed varying degrees of skill and ability in the work. Farm workers' wives and families were among the most skilful, but some of the experienced pickers from the towns were equally skilled. Many of the town pickers, however, were slow and easily tired. While no attempt was made to study in detail the methods of picking, the impression was gained that the less skilled pickers were slower in their movements and less systematic in covering the ground than the best pickers.

The attitude of the pickers to their work affects, in no small degree, the speed of picking. Some pickers were diligent and conscientious, finished their work quickly and cleaned up their bit satisfactorily. At the other end of the scale were a few pickers who were careless and slovenly and required constant supervision.

Waiting Time. The most vulnerable point at which to attack the picking time is the waiting period. If this could be shortened, more effective use would be made of the labour available. The general opinion of the farmers and merchants consulted seemed to be that pickers to-day expect a longer rest than they used to do fifteen or twenty years ago. If they are not given what they regard as an adequate rest they may fail to turn up for work the following day or may seek work in a squad where easier conditions prevail. Hence the farmer is afraid to hurry the pickers in case he finds himself with too small a squad the following day.

It is difficult to decide objectively how long the resting period should be. Some of the farmers and merchants consulted considered a minute to a minute and a half to be sufficient in each cycle. Taking the picking cycle as 6.76 minutes (the sum of the average picking time and waiting time shown on page 13), 1½ minutes would be 22.2% of the total time. Compared with normal time study practice this is a generous allowance for fatigue, but it is considerably less than the 50 to 65 per cent shown in Table III (column 6).

In any given picking or digger cycle the waiting time could be reduced by increasing the length of the bit so as to increase the time required to pick. Thus in a digger cycle of 6¾ minutes, to allow a rest of 1½ minutes, the picking time would have to be increased to 5¼ minutes. At an average picking speed of .234 minutes per yard this would entail increasing the length of the bit from about 12½ yards to 23 yards. In this way the number of pickers required could be cut down to just over half, which would considerably reduce the cost per acre of picking as well as easing the problem of obtaining pickers. There seems to be no reason to regard longer bits as a hardship, because bits of 40 yards and over are found both in Scotland and in England.

Incentives. However desirable from the employers' point of view shorter rest periods may be, it is unlikely that workers would agree to them unless they were given some incentive to do so. It is therefore in the interests of the industry that suitable methods of piece-work or incentive payment should be devised and put into practice to induce pickers to improve their output. A form of piece-work has been tried in the North of Scotland in which the potatoes, when picked, are filled into barrels and the worker is paid at a fixed rate per barrel (1). In some parts of England potato picking is paid on piece-work by the ton, in other parts by the acre. It has been suggested that a group payment according to the number of acres lifted per day might be suitable in Scotland. Such a

(1) V. Baker. Potato Lifting, 1950. North of Scotland College of Agriculture. Economics Dept. Feb. 1951.

payment would probably be most effective if in addition to the pickers, the tractor drivers and other workers were included.

In working an incentive scheme it is essential to ensure that there are always potatoes dug ready to pick, so that the fastest workers are not held up by the digger. Some two-row potato diggers have an elevator which delivers the potatoes clear of the path of the digger and this enables the next row to be dug before the previous one has been picked. It is reported that there are on the market attachments for the ordinary spinner which enables this to be done.

Cost of Picking. Pickers were normally paid 16/- a day and they picked approximately from 1/10th to 1/5th acre per day (Table III column 10). Thus the cost of picking varied from about £4 to £8 per acre.

Effectiveness of Picking. A measure of the labour efficiency of picking may be seen in column 10 of Table III which shows the area picked by a picker in a day. Farm D has the best results with just under 1/5th acre picked by each picker in a day. It will be noted that this farm had the greatest average length of bit and was the only farm (except Farm F, which is not comparable with the rest) in which more time was spent in picking than in resting. It happens that the average speed of picking was the slowest of all farms. This might be caused by the longer bit, but it is more likely to be due to the fact that the picking squad consisted predominantly of schoolboys who were unaccustomed to the work.

Method of Picking. Other methods from that described may be found on farms. The pickers may gather the potatoes into aprons tied round their waists, the baskets may be emptied into sacks instead of carts, or each bit may have two pickers instead of one. These different methods will affect the output of the pickers, but they are not discussed here because they were not seen on the farms studied.

Carting.

Carting is a subsidiary or servicing operation which is necessary, in the first place, to remove the potatoes from the place where they are picked, and in the second, to take them to the place where they are to be stored. Its speed is dependent on the output of potatoes, and although it might be possible to speed up the operation by more effective methods or equipment, unless the rate of picking were also accelerated, this would only result in more idle time.

In Table IV the carting operation is divided into its various components. It was, unfortunately, not possible to ascertain the weight of potatoes removed in each cart load. The number of baskets lifted is shown, but, as many of them were only partly filled, the average weight could not he determined. In column 4 the time spent loading the cart is the total time taken irrespective of the number of persons loading.

The rate at which potatoes are removed from the field is affected by the following factors:-

(1) Yield of crop.
(2) Speed of lifting.
(3) Length of drills dug.
(4) Distance from drills to pit.
(5) Nature of ground covered.
(6) Type and capacity of equipment used.
(7) Efficiency in organisation of man power.

The first three factors are the same as those discussed under these heads in Picking; together they determine the quantity of potatoes which have to be carted. It is clear that the greater the quantity of potatoes harvested, the more the carting capacity that must be provided. In theory, capacity can be increased by providing more carts or larger carts, but in practice, any increase in capacity is usually limited by the type and quantity of equipment which the farmer has available. Only where very large acreages are grown would it be worth while buying special equipment for this purpose.

TABLE IV

Average Time Spent per Cycle, Tractor Carting

1	2	3	4	5	6	7	8	9	10	11	12
Farm No.	Travelling to and from drills and pit.		Loading Cart		No. of baskets Collected.	Turning at ends. (min.)	At pit. (min.)	Lost Time at drill. (min.)	Lost Time at pit. (min.)	Total Cycle Time. (min.)	Working Time. (min.)
	Time taken. (mins.)	Distance travelled. (yards)	Time taken. (mins.)	Distance travelled. (yards)							
A	1.83	61	7.48	207	75	.68	3.56	2.67	.78	17.00	13.55
B	2.45	243	9.96	616	110	.59	5.29	.06	.70	19.05	18.29
D	4.08	383	7.22	269	96	-	6.45	.80	.57	19.12	17.75
E	3.02	280	9.13	235	78	.51	2.77	1.04	.11	16.58	15.43
F	2.18	242	13.37	924	151	1.56	2.57	2.28	14.09	36.05	19.68
				Horse Carting							
C	3.00	360	9.60	208	89	.72	2.17	5.73	.65	21.87	15.49
E	5.30	430	6.00	201	37	-	2.15	3.48	.30	17.23	13.45

It is obvious that the distance between the pit and the drills must affect the time taken to carry out a cycle of carting. On the farms observed the time spent in so travelling varied from 10 per cent to 21 per cent of the total cycle time for tractor-drawn carts, and up to 30 per cent for horse-drawn carts. The average speed of travel to and from pits and drills varied remarkably little between farms. It was just under $3\frac{1}{2}$ miles per hour for tractor carts and a little more for horse-drawn carts. The nature of the ground over which the cart has to travel might (e.g. on heavy wet soil) affect the speed of the operation, but adverse conditions of this kind did not exist on the farms observed.

The time taken for carting is affected by the type of equipment used. Tractor trailers vary in size, and the weight they can carry may depend to some extent on the horse-power of the tractor. The figures in column 8 of Table IV show the time spent discharging the load at the pit. Farms E and F had trailers fitted with a hydraulic lift while the trailers on farms B and D were of similar size but were tipped by means of hand-screw. The trailers with a hydraulic lift took less than half the time to empty than the hand-tipped trailers. While it cannot be stated that the hydraulic lift was the only reason for this difference, it was clear from observation that it was very largely responsible. On some farms it was convenient to set the tractor in the furrows and let it travel up the drills with no one on the driving seat, thus releasing the driver to load the trailer. To do this it is necessary that the wheel tracks should be the same width as two drills, (on these farms 4 ft. 8 in.), or, that it should be possible to set them to this width.

The number of men used for carting and emptying baskets on each of the farms is shown in Table V, together with figures showing their output.

TABLE V

Carting and Loading.

1	2	3	4	5	6
Farm	No.of men used	Acres of potatoes harvested per day	Acres carted and loaded per man day	Production in tons per day	Tons handled per man day.
A	2	2.0	1.0	20	10
B	4	3.6	.9	44	11
C	5	3.5	.7	39	8
D	2	3.5	1.75	36	18
E	6	5.6	.9	76	13
F	5	4.0	.8	46	9

Farm D shows the most effective use of labour in this operation - 1.75 acres carted per man day - and because this is associated with a reasonably good yield, it also has the greatest tonnages handled per man day. It is clear from the table that the provision of a relatively large number of men for carting does not necessarily result in handling a big tonnage.

There is a wide variation in the effectiveness of the labour use on the different farms. The differences in the distance from the drills to the pits or in the length of the drills is not sufficient to account for this. The more effective use of labour on some farms than on others must be due to better organisation of the work and better integration of equipment and manpower with the job to be done. For example on farm D two men and a tractor and cart were able to keep the baskets empty, while on farm F one tractor and cart was work/ apparently not sufficient, but there was not nearly enough/to keep two tractors fully employed. Thus the most effective use of carting labour is made where the work to be done is nearly equal to, or a multiple of, the capacity of one carting unit.

Comparing horse carting and tractor carting, there is no evidence that one is more efficient than the other. The time taken by the horse carts to collect and discharge a load, i.e. the total cycle time, is not appreciably different from that of the tractor carts, and although the capacity was about

half that of the tractor carts, only one man was required to drive and load a horse cart compared with two or more per tractor cart. Thus the quantity of potatoes handled per man per day using horse carts was much the same as when tractor carts were used.

Storage Pits.

Although detailed observation of the work at the storage pits was not made, it is necessary to consider how this work fits in with the other operations. Table VI shows the number of men employed at the pits on each farm and the amount of potatoes they handled.

TABLE VI

1	2	3	4	5
Farm	No.of men employed	Estimated weight of potatoes pitted per day. (Tons)	Weight of potatoes pitted per man per day. (Tons)	Width of Pit. (Feet)
A	2	20.3	10.2	6
B	4	44.3	11.1	$6\frac{1}{2}$
C	3	39.0	13.0	$7\frac{1}{2}$
D	$1\frac{1}{2}$	36.3	24.2	7
E	3	76.4	25.5	7
F	3	46.4	15.5	$7\frac{1}{2}$

The measure of effectiveness of labour here is the number of tons of potatoes pitted per man employed (column 4). Farms D and E show the best performance, the one, because a small labour force was able to deal with an average production of potatoes and the other, because an average-sized labour force pitted a large daily production. It might be expected that wide pits would be associated with large tonnages per man day, but, although the smallest tonnages per man were found where the pits were narrowest, a definite relationship cannot be assumed from the figures. The differences in performance between the best farms and the others cannot be accounted for without more detailed observations on the work.

EFFECTIVENESS OF LABOUR IN HARVESTING.

The farmer's objective is to harvest his potatoes in the shortest possible time at as low cost as possible, with the resources he has available. To achieve this, the total labour force required must be low, or the area harvested per day large, or both of these conditions must obtain. Together they can be summed up in a low number of man hours per acre. Reference to Table I column 6 shows that a wide variation exists in the effectiveness of the labour on different farms, and Farm D, with 51 man hours per acre appears to have been the most efficient in this respect. It has attained this because a small number of workers have handled an average acreage of potatoes in a day.

Examination of the individual operations shows how this performance was achieved.

1. The pickers on this farm worked a long bit so that they had less waiting time and were able to pick a bigger acreage per day than on other farms. Consequently relatively fewer pickers were needed to carry out the job.

2. The amount of carting to be done was nearly equal to the capacity of one carting unit - consisting of a tractor, trailer and two men. Thus, a relatively large area of potatoes was carted per man day, and little time was lost.

3. The weight of potatoes pitted per man day was high, because one man with some assistance was able to handle the crop.

It is interesting to note that on this farm the digging performance had little effect on the efficiency of the over-all performance. The time taken to dig an acre, 197 minutes, was the second highest recorded, but as the digger usually had to wait for the pickers, it was not being used to its full capacity. Only one worker was involved in this operation, so that the loss of total man hours was small. It must be seldom that all operations can be perfectly integrated, and where one of a number of operations must work below capacity, it is clearly of advantage that this should be one which requires as few workers as possible.

Although the farmer's immediate object is to get the potatoes lifted, in the long run he is also concerned with producing a heavy crop at the lowest possible cost per ton. On Farm E the labour requirement was 61.2 man hours per acre and a heavy crop of over 13 tons per acre gave the low figure of 4.50 man hours per ton. Low man hours per ton results in a low cost of harvesting per ton, and thus helps to lower the cost of production per ton of potatoes.

Acknowledgments.

The writer wishes to express his gratitude to the farmers and potato merchants who so kindly allowed him to make observations on their crops. Acknowledgment is also due to members of the College staff who have assisted with information.

---------oOo---------