THE USE OF LABOUR IN FARM-SCALE VEGETABLE PRODUCTION

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FOREWORD

The main purpose of this study was to provide some guidance to producers of vegetables on a farm-scale with respect to the most profitable use of labour. This led us to investigate and compare different production practices and techniques in common use with a view to finding the most profitable methods to be recommended to growers.

We hope that this report will provide growers with some assistance in making managerial decisions, but we realise that there are still many gaps in the information available regarding the production of these crops. These gaps must be filled before the right choice between different production methods can be made with complete confidence.

In many instances in this report we were unable to reach final conclusions regarding the most profitable methods of production, due to the absence of data from controlled experiments with respect to such technical matters as the effect upon crop yields and quality of different methods of weed and pest control, and of different levels of plant population.

Without information of this type growers have to rely too much on tradition and intuition in cases where the results of controlled experiments could offer a better guide to management. Surveys of the present type, however valuable in their own sphere, cannot be expected to provide the type of information here required.

It is hoped that in addition to providing some of the answers to the many problems facing vegetable growers, this study will also draw attention to the need for more research into the primarily technical aspects of vegetable crop production.

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August, 1957

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An equal debt of gratitude is owed to the farmers and others who supplied the records on which the results of this work are based. We appreciate that much time and trouble was expended in keeping these records.

Finally, special thanks are due to those farmers who enabled us to make direct observations of field operations, and to the farm workers who at least tolerated our presence and at best materially assisted us by their lively interest in our activities.

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OBJECTIVES AND METHODS

CHAPTER I

INTRODUCTION

UP TO THE PRESENT time the economic problems of vegetable production have received scant attention in this country. Consequently, there is a dearth of the factual information needed to guide the vegetable grower to confident policy and management decisions, and thereby to more profitable systems and methods of vegetable crop production. Far too little is known, for example, about optimum seeding rates and plant populations, about the economic aspects of different methods of controlling pests, diseases and weeds, and about yield responses to fertilisers. However, for three main reasons it would seem that the greatest need is for information which will guide the grower of vegetable crops towards a more efficient use of labour.

Firstly, whilst the prices of most of the resources used in vegetable production have risen, none has increased faster than that of labour. Thus whereas the prices of farm machinery and buildings have trebled between 1938 and the present time, and fertiliser prices have risen somewhat less than this, the unit cost of labour has increased fourfold in the same period. Furthermore, so long as the present high level of demand for labour in other industries is maintained, it seems probable that this tendency for the price of farm labour to increase relative to the costs of other resources will continue.

Secondly, the rising price of labour is of particular significance in vegetable production because expenditure on labour commonly constitutes the largest single item, and often a major proportion, of total production costs. For example, a recent analysis of financial accounts relating to holdings where the main source of income was from the sale of outdoor vegetable crops, showed wages accounting for 47 per cent of total expenses.[1] Further evidence of the primacy of labour costs has been provided by several investigations into the costs of producing particular vegetable crops; these have shown expenditure on labour to account for up to 70 per cent of total "farm gate" costs.[2]

Thirdly, the necessity for making efficient use of labour has become increasingly urgent because whereas wage rates have risen steeply and consistently in post war years, vegetable prices have not risen apace, and have moreover, been highly unstable. This is evident from Table 1.

Objectives

For these reasons the general objective of this present study was to describe and appraise the use made of labour in vegetable production,

1 *Horticultural accounts scheme, results for accounting year* 1954–55; National Farmers' Union Information Service; Vol. II, No. 4; October, 1956. Unpaid family labour, including that of the operator and his wife, was not included as an item of expense, so that total labour *costs* would have been higher than 47 per cent.

2 See, for instance:
COLE, H. M.; *Broccoli cost investigation in Cornwall* 1952–53; University of Bristol, Department of Agricultural Economics; May, 1954.
RADFORD, M. A.; *Brussels sprout cost investigation* 1953–54; University of Bristol, Department of Agricultural Economics; June, 1955.
Preliminary Reports Nos. 1 and 8 *Autumn Cauliflowers* 1953–1954; 2. *Brussels Sprouts* 1953-54; 3. *Savoy Cabbage* 1953-54; 4. *Carrots* 1953-54; 6. *Vining Peas* 1954; and 7. *Pulling Peas* 1954; University of Nottingham, Department of Agricultural Economics; issued between March, 1954 and February, 1955.

with a view to obtaining information which would enable growers to achieve greater efficiency in labour organisation and management.

TABLE 1 RELATIVE TRENDS IN WAGES AND VEGETABLE PRICES

	1946	1947	1948	1949	1950	1951	1952	1953	1954	1955
Farm wage index*	100	112	121	126	128	137	148	156	162	171
Vegetable price index†	100	145	96	116	110	112	129	104	123	136

* Based on *Some indicators of general price and cost movements affecting agriculture in the United Kingdom*; Farm Economist; Vol. 8, No. 6; (Weighted average minimum weekly wage for ordinary adult male workers).

† Based on *Agricultural products price indices, England and Wales*; Annual Abstract of Statistics 1956. (Prices realised by primary and secondary wholesalers in certain representative urban markets).

The specific objectives of the enquiry were threefold. A primary aim was the derivation of standard labour requirements, both by groups of operations and by months, for each of six selected vegetable crops. Such standards are of well-proven value to farmers and their advisers in performing such management functions as the planning of future cropping programmes and the execution of particular tasks, in devising soundly based incentive schemes, and in appraising past results. The second objective was to focus attention upon the most labour consuming operations entailed in the production of these crops, and in particular, to ascertain the extent to which labour requirements could be reduced by the adoption of alternative production practices and techniques. But since financial success is dependent upon the grower making the best use of *all* the resources he commands and the mere saving of labour cannot be regarded as an economic end in itself, the third objective of the study was to examine all possible devices by which labour requirements could be reduced, with a view to determining the circumstances in which their adoption would result in greater total farm profits.

Selection of Crops

Since it was clearly not possible to bring all vegetable crops within the ambit of the study, the first step was to determine which of the vegetable crops grown in the East Midlands Province[3] were of greatest importance.

The Agricultural Returns covering the period from June 1950 to June 1953 showed that of an average of approximately 26,000 acres of outdoor vegetable crops[4] then being grown annually in the area, nearly 16,000 acres, or more than three fifths of the total acreage, were accounted for by six crops, namely maincrop carrots, pulling peas, green peas for canning or quick freezing, brussels sprouts, savoy cabbage and autumn cauliflowers, in that order of importance. Furthermore, estimates made of the value at the farm gate of all the outdoor vegetable crops grown in this area during the same period, showed that of an average total value of some £2.5 millions per year, £1.5 millions, or nearly 60 per cent was accounted for by the six above mentioned crops.[5] It was therefore decided to confine the study of labour usage to these six crops, since in terms both of acreage and of value, they were clearly of predominant importance.

3 The area comprising the counties of Leicestershire, Rutland, Derbyshire, Nottinghamshire, and the Kesteven and Lindsey Divisions of Lincolnshire.

4 All vegetable crops grown for human consumption with the exception of potatoes and peas harvested dry.

5 The estimates of farm gate values were made by relating crop acreages to net yield estimates made by local Horticultural Crop Intelligence Committees, and to data concerning average market prices and marketing costs supplied by the Ministry of Agriculture, Fisheries and Food. See, INGERSENT, K. A.; *High value and low value crops in East Midlands horticulture*; University of Nottingham, Department of Agricultural Economics; February, 1954.

Selection of Holdings

An analysis of the 4th June Agricultural Returns for 1947 showed that by far the largest proportion of the total acreage of outdoor vegetable crops grown in the East Midlands at that time was located on large holdings. Thus 64 per cent of the total acreage was grown on holdings of 100 acres or more. Furthermore, 71 per cent of the total acreage of the six selected vegetable crops was grown on holdings having at least five acres of one or more of these crops. On the other hand the holdings were, for the most part, non-specialist in respect of vegetable production, being farms with a relatively small proportion of their land devoted to vegetable crops.

There was no apparent reason to suppose that this pattern of production had materially changed since 1947, and so it seemed that the best representation of the total volume of vegetable production in the area would be obtained by concentrating attention upon farm-scale producers growing five or more acres of one or other of the six crops listed above.

The areas in which the production of each of the selected crops was most concentrated were located with the aid of a list of growers who had grown five or more acres in 1952. As far as possible the subsequent survey was confined to holdings lying within these main producing areas. However, with some crops, notably savoys and autumn cauliflowers, the survey sample was regarded as being too small even when all the growers in the main producing areas had been visited. Some records were therefore sought, and obtained, from holdings lying outside the main producing areas. Moreover, a few records were obtained from holdings in the county of Northamptonshire, which lies outside the boundaries of the East Midlands Province though geographically contiguous with it.

Each of the co-operating growers was asked to supply information in respect of one field of one or other of the selected crops, but although each had grown five or more acres of that crop in 1952, the survey could not be strictly confined to fields of this minimum size, for two reasons. Firstly, there were holdings with less than five acres at the time of the survey; secondly, there were holdings where although the total acreage of a surveyed crop exceeded five, there was no individual field of the crop as large as this. However, with the exception of the survey of brussels sprouts which included a number of crops grown on market gardens, the number of surveyed fields which were less than five acres in extent formed a very small proportion of the total.

Characteristics of Surveyed Holdings

(a) *Location*

The survey of *vining peas* embraced a total of 30 holdings, all of which were situated in the Lindsey and Kesteven Divisions of Lincolnshire. Until recently vining pea production in the East Midlands has been confined to the immediate vicinity of the canneries and quick freeze factories, and 23 of the holdings covered by this enquiry were in close proximity to factories at, or near, Lincoln, Grimsby, Boston and Louth. Lately, however, there has been a move to install viners on farms and this has resulted in the crop being grown over a much wider area, and in fact, the seven remaining farms were not in the immediate neighbourhood of factories. Five of these were in a compact area just south of Skegness, to which portable viners were brought from Norfolk when the season in that county was nearing completion.

It is evident that vining pea production was not confined to particular soil types or to areas enjoying peculiar climatic conditions, for they were grown under conditions as diverse as those afforded by the thin calcareous loams of the Wolds, the rich silts bordering the Wash and the heavy loams around Grimsby.

Records were obtained from 35 holdings during the course of the survey of *pulling peas*. All but one of these were situated in one or other of the two main producing areas in the East Midlands—north Nottinghamshire, where records were obtained from 16 holdings, and the Isle of Axholme where records were obtained from 18 holdings. One Lincolnshire farm, lying outside the Isle of Axholme was also included.

The location of pulling pea production in the area appears to be influenced by the proximity of towns. This is due partly, no doubt, to the fact that urban areas are the main source of the casual picking labour which is virtually indispensable for the harvesting of the crop, and there is, of course, the further advantage of having a ready market for a bulky crop near at hand. Most of the surveyed holdings were in reasonable proximity to a town from which casual labour could be obtained, and the main markets supplied were those in the nearby industrial regions of the West Riding of Yorkshire, and Lancashire.

Although the two main producing areas lie very close together geographically, there is a marked difference between them in soil type. Whereas the soils in north Nottinghamshire were characterised by light Bunter sand, the typical soil type in the Isle of Axholme was warp, or other moderately strong land. There was a tendency for the crops on the lighter land to be earlier sown and earlier harvested than those grown in the Isle.

Survey records of *autumn cauliflower* crops were obtained from a total of 24 holdings. Of these 18 were situated in the main producing area, a triangular coastal region bounded by Skegness to the north, Spilsby to the west and Boston to the south.[6] However, production of the crop in the East Midlands is not confined exclusively to this region, and the remaining six farms from which survey records were obtained were widely scattered; one was near Lincoln, two were in the Woodborough area of Nottinghamshire and three in Northamptonshire.

The soils of the main producing area are fertile silts well suited to vegetable production, and in addition, the mild climate induced by proximity to the sea makes autumn cauliflower a particularly favoured crop. Moreover, this is a region of early potato production, and on many farms autumn cauliflowers are grown as a catch crop after the potatoes are cleared.

The survey of *brussels sprouts* embraced a total of 32 holdings. Of these, 15 were situated in one or other of two areas where the crop is grown under intensive market garden conditions, the Melbourne area of Derbyshire and the Woodborough area of Nottinghamshire. On the other hand, production of the crop on farms is not markedly localised, and the remaining 17 holdings comprised six in the Lindsey Division of Lincolnshire, five in Nottinghamshire, four in Northamptonshire and two in Leicestershire.

Soil and climatic conditions do not appear to be prime factors determining the location of this crop in the East Midlands. Surveyed crops were grown on soils as varied as the heavy clays of Northamptonshire and the Nottinghamshire sands, and in situations ranging from the exposed Lincolnshire Wolds to more sheltered regions further inland.

Records of *savoy cabbage* crops were obtained from 30 holdings. Production of this crop on a farm-scale is concentrated mainly on and in

6 Although the two former towns mark the limits of this producing area to the north and west, in the south it extends into the Holland Division of Lincolnshire.

the vicinity of the Lincolnshire Wolds, and 23 of the farms were situated east of a line running from Scunthorpe to Woodhall Spa. The crop is also grown south of the Wolds in the area bordering the Wash, and a further three holdings were in this region. Records were also obtained from two holdings in the Isle of Axholme, and from two in central Nottinghamshire.

The savoy crop was, therefore, grown under diverse physical conditions, and there was some tendency for these and the seasonality of production to be associated. Thus, the exposed situation of farms on the Wolds makes them well suited to the production of very late winter savoys. In contrast, the more sheltered location and milder winter conditions of farms in south-east Lindsey are less suitable for the production of the really late crop, so that growers in this region cater for an earlier market.

The main producing area for *maincrop carrots* in the East Midlands lies on the alluvial sands of the Trent Valley, and all the 41 holdings to which the survey extended lay on the east bank of the River Trent. They were, however, in two distinct areas. One was south of Scunthorpe and centred on Messingham and Scotter, the second was due west of Lincoln and centred on the parishes of Collingham and Clifton ; 15 of the holdings were in the former area, and 26 in the latter.

(b) *Types*

Details of how the surveyed holdings were cropped were obtained in each year of the enquiry. Table 2 shows the average proportionate acreage of crops on the holdings included in the survey, and illustates the type of farm from which records were obtained, and the importance (in terms of land use) of the surveyed crops in their cropping programmes.

TABLE 2 AVERAGE CROPPING PATTERN ON SURVEYED HOLDINGS

Acres

Surveyed crop	Average size of holding*	Average area per 100 acres crops and grass								
		Surveyed crop	Other vegetables	Cereals	Potatoes	Sugar beet	Other arable	Temporary grass	Permanent grass	TOTAL
Vining peas	553	6.4	1.4	44.9	9.8	6.8	4.2	15.0	11.5	100.0
Pulling peas	293	8.7	1.7	44.9	12.9	7.6	1.6	10.5	12.1	100.0
Autumn cauliflower	399	6.2	9.0	32.1	18.4	9.4	2.4	7.2	15.3	100.0
Brussels sprouts:										
(i) on farms	252	5.8	10.1	33.1	6.7	7.4	2.9	13.5	20.5	100.0
(ii) on market gardens	64	20.5	51.9	6.5	8.6	1.0	7.9	1.5	2.1	100.0
Savoy cabbage	509	3.4	2.7	48.2	12.4	8.8	2.7	9.9	11.9	100.0
Maincrop carrots	201	7.4	0.9	36.8	11.8	13.1	0.8	21.1	8.1	100.0

* Average superficial area, including the area occupied by roads, buildings, dykes, etc.

With the exception of the market gardens on which brussels sprout crops were surveyed, and which are, by definition, specialist vegetable producing holdings, it is evident from Table 2 that the holdings covered by the enquiry were general farms of a predominantly arable type. On the average, none of the six groups had less than two thirds of their total acreage in arable crops, and a high proportion of these were cash crops such as wheat, cash roots and vegetables. However, only a relatively small proportion of the total acreage was devoted to the production of the surveyed vegetable crops.

Although there were differences between the surveyed crops in respect of the average size of farm on which each was grown, overall, the farms included in the enquiry were relatively large. This bias towards larger holdings is, at least in part, a reflection of the fact that the enquiry was mainly restricted to holdings growing a minimum of five acres of one or other of the crops concerned. It must therefore be stressed that whilst the results obtained and presented in subsequent pages are appropriate to the conditions, practices and methods found on the larger holdings, they may not be applicable without modification to smaller farms and market gardens.

(c) *Coverage of the Surveyed Crops*

Table 3 gives the main characteristics of the survey sample for each crop, and indicates the adequacy of the sample in terms of the coverage afforded to the total acreages of the surveyed crops grown in the East Midlands during the period.

Although the samples were neither randomly drawn, nor yet strictly stratified, there is little doubt that they constitute a reasonably representative cross section of East Midlands producers and embrace the main production systems, practices and techniques employed on farms in the area.

Form of the Enquiry

The study was carried out in two main phases. Firstly, the survey method was used to obtain information about the amounts of labour used on individual holdings at all stages in the growing and harvesting of the six selected crops. Co-operating growers supplied details of the date and duration of all operations performed, together with details of the numbers, types and payment of the workers engaged on each task. Details of the use made of tractors and mechanical appliances were also recorded, together with information relating to material requirements, such as fertilisers, seeds, pesticides and weedicides. Particulars were also sought about row spacings, plant populations, soil characteristics and the succession of crops. Furthermore, information was recorded about the marketed yields of the surveyed crops, marketing methods and channels used, and realised sale values.

Thus whilst the survey records were designed primarily to determine rates of labour usage, a good deal of supplementary data were also obtained. This latter information has been extensively used in subsequent pages in examining, by the budgetary method, the probable overall effects on farm profits resulting from the adoption of alternative production practices and techniques.

A final feature of the survey was a questionnaire designed to identify the periods when work on the surveyed crops clashed most severely with work elsewhere on the farms, and to elucidate growers' opinions of how peaks of labour demand might be (or had been) reduced. As a corollary to this, their opinions were sought concerning the scope existing for further mechanisation of field operations, and conversely, of the obstacles which had deterred them from carrying this into effect in instances where suitable equipment could have been purchased.

A preliminary analysis of the information contained in the survey records enabled the more labour consuming operations entailed in the production of the crops to be identified, and three of these were chosen for the second phase of the enquiry. This consisted of detailed field observational studies of the cutting and loading of vining peas, the mechanical transplanting of autumn cauliflowers, and the mechanical harvesting of maincrop carrots.

The information obtained in the survey showed that there were

TABLE 3

THE SAMPLES

	Vining peas	Pulling peas	Autumn cauliflowers	Brussels sprouts: Farms	Brussels sprouts: Market gardens	Savoy cabbage	Maincrop carrots
Number of records obtained							
(i) 1st season	20	28	20	14	15	19	40
(ii) 2nd season	26	25	12	6	8	17	18
Combined	46	43	32	20	23	36	58
Average acreage of surveyed crop per holding							
(i) surveyed	17.2	10.3	8.5	10.0	5.5	10.8	7.0
(ii) grown	20.4	20.4	11.8	17.0	10.6	12.9	12.1
Total acreage surveyed							
(i) 1st season	314	314	166	162	87	195	288
(ii) 2nd season	476	233	105	39	40	194	120
Combined	790	547	271	201	127	389	408
Total East Midlands[1] acreage[2]							
(i) 1st season	4,027	3,467	745	3,127		1,344	4,395
(ii) 2nd season	4,697	3,699	687	2,474		1,364	3,405
Combined	8,724	7,166	1,432	5,601		2,708	7,800
Total acreage grown on surveyed holdings as a proportion of total East Midlands acreage	% 15	% 15	% 26	% 10		% 17	% 9
Total acreage surveyed as a proportion of:	%	%	%	%		%	%
(i) total acreage grown on surveyed holdings	59	51	72	56		84	58
(ii) total East Midlands acreage	9	8	19	6		14	5

1 Including the county of Northamptonshire.
2 Source, Agricultural Statistics, 4th June Returns.

very wide variations in the amount of labour used in the performance of the above operations between one farm and another, even where the same general methods, and the same types and sizes of equipment, were employed. However, the reasons for these variations were not apparent from the survey records. The primary aim of the field studies was therefore to obtain by direct observation and measurement more reliable labour requirement standards than those available from the survey records. Furthermore, the results obtained enabled comparisons to be made of the labour saving and higher profit potentialities of alternative methods of performing the various tasks, with a greater degree of confidence than would have been possible had survey records been the only source of data.

Basically the field studies involved spending at least one day on each of the farms visited, observing the methods in use, timing the major elements of the operations performed and measuring the amount of work accomplished. As a rule no attempt was made to suggest improvements to the methods or techniques in use on a particular farm, or to measure the results of putting such improvements into effect. In this respect the field studies were not comprehensive method studies in the generally accepted sense. Nevertheless, as a result of making the observations, improved techniques were detected, and their probable effects on labour requirements and costs have been evaluated. In addition, certain qualitative characteristics of the work accomplished were examined, and related to apparent weaknesses in the design and operation of the various machines in use.

Timing of the Enquiry

The *survey* was started in the autumn of 1953 and continued until the end of the summer of 1955. Each of the six crops included in the study was surveyed for two consecutive seasons. In the first season four of the crops were, in part, surveyed retrospectively. Thus, the surveys of the 1953 autumn cauliflower crop, and of the 1953-54 brussels sprout, savoy and carrot crops were started in the autumn of 1953 when all growing operations had been completed and when harvesting had commenced on most farms. On the other hand, the first season's survey of vining and pulling peas, and the second season's survey of all six crops were carried out with the aid of "crop diaries" in which the co-operating growers recorded the required information concurrently with the performance of the various operations. The completed diaries, therefore, related to vining and pulling peas grown in 1954 and 1955, and to autumn cauliflowers, brussels sprouts, savoys and carrots produced in the 1954-55 season.

The *field study* of autumn cauliflower transplanting was carried out in the early summers of 1954 and 1955, that of carrot harvesting in the autumn and winter of 1954-55 and again in 1955-56, and the study of vining pea harvesting was undertaken in the summer of 1955.

It was perhaps unfortunate that the enquiry happened to be carried out at this particular period. The autumn and winter of 1953 saw vegetable prices falling to very low levels, and for this reason the harvesting of some of the autumn cauliflower, brussels sprout, savoy cabbage and carrot crops surveyed in the first season was either not undertaken at all, or was severely curtailed. The consequence of this was that less information was obtained about harvesting operations, yields and returns, than had been expected. There followed the exceptionally wet summer of 1954 which especially affected pea crops. In some crops of pulling peas the pods rotted on the straw before they could be harvested, whilst the wet weather made the harvesting of vining peas very difficult, and increased the labour needed for cutting and loading to much above normal requirements. In the survey area 1954 was also a bad growing year for carrots, and yields were much below average.

However, by drawing heavily upon the results of the field studies which were, for the most part, carried out under more normal conditions, and by adjusting recorded harvesting labour requirements to correspond with standardised yields, the major distortions attributable to extreme seasonal effects have been eliminated from the labour requirement standards presented in subsequent pages.

Analysis of Records

In deriving labour requirement standards all manual labour has been expressed in terms of "worker" hours without reference to the age or sex of the workers actually employed on the crops. When primary interest centres on labour requirements (as opposed to labour costs) the validity of the alternative and commonly used practice of reducing all types of labour to "man equivalent" hours by the use of conversion factors based on relative wage rates, rests on the assumption that wage differentials accurately reflect differences in rates of working and output. While this may be true of many farm operations it was not regarded as appropriate in respect of those tasks for which youths, women and girls were employed on the surveyed crops. In the main, these were operations for which neither physical strength nor long experience were particularly important, and conversely, for which the greater nimbleness and dexterity of young and female workers might well be advantageous, for instance in hand weeding and in the operation of mechanical transplanters.

Similarly, all tractor work has been expressed in terms of "tractor" hours without distinction between the varying powers and work capacities of the models actually used. On the other hand, on a small minority of farms, some field operations such as seed drilling and side hoeing were performed with the aid of horses rather than tractors, but in order to make the standards more closely reflect the practices of the majority of producers, the hours of horse work shown in individual records were converted to "tractor equivalent" hours, and, where appropriate, a corresponding adjustment was made to the hours worked by the operators. The following is a list of the conversion factors used.

OPERATION	TRACTOR HOUR EQIVALENT OF ONE HORSE HOUR
Harrowing	0.7
Applying fertilisers	0.8
Drilling	0.5
Side hoeing	0.5

With operations for which a horse is equally as suitable as a tractor, for instance, light carting, horse hours were entered directly as tractor equivalent hours without adjustment.

Some survey records gave details of the labour used in the application of farmyard manure and lime. However, since the performance of these operations was far from being the universal practice, and since there was reason to believe that on many farms the application of manure and lime was not specific to the production of the surveyed crops but was undertaken as part of a general policy of fertility maintenance at any convenient point of the crop succession, all labour expended on these operations was excluded from the standards. On the other hand, all labour used in the application of artificial fertilisers has been treated as being specific to the surveyed crops and no part has been carried forward to succeeding crops. Similarly, no adjustment has been made to the standards in respect of other cultural residues which might benefit following crops. Further, the standards include only that labour directly utilised in the performance of operations on the surveyed crops and make no allowance for the labour of supervisory and office workers, or for general maintenance work.

Standard labour requirements have been evolved both from the information contained in the survey records and from that obtained in the field studies.

In analysing survey records, the labour usage shown in individual records was first expressed on a per acre basis, and then broken down both into its main components by groups of operations and in terms of the months in which it was used. Standard operational and seasonal labour requirements were then obtained by taking simple averages of all the figures of per acre labour usage obtained from the individual records pertaining to both seasons. Thus each record bore equal weight in the averages, but these latter were weighted with respect to the number of records obtained in each year.

The extent to which the per acre labour usage recorded for individual crops was dispersed about the averages so calculated has been indicated in each case by giving the "standard deviation"[7] and the range. Where two averages or standards relating to alternative practices or methods of performing an operation have been compared and the difference discussed, the "standard error"[8] of the difference has been shown.

Labour requirement standards obtained from the field studies were derived in some cases from a synthesis of the average times recorded for individual work elements including rest periods, and making an arbitrary allowance for other non-working time such as that spent in travelling to and from fields and in preparing tractors and materials for the job.

Standard harvesting labour requirements were computed, for all crops except vining peas, on the basis of a standardised yield per acre. The reasons for adopting this procedure were that the harvesting of vegetable crops is a manual process absorbing a major part of the total amount of labour required for their production, and furthermore, that total labour requirements are closely correlated with the size of the harvested yield. Hence, in the formulation of realistic planning standards it is important that these should relate to normal yields. Consequently, because, for the reasons indicated previously, the average harvested yields of the surveyed crops were below the long term averages expected by growers in this area, a proportionate upward adjustment was made to the average harvesting labour requirements actually obtained from the survey records. This involved an element of oversimplification in so far as it was necessary to assume that the labour requirement *per unit quantity* harvested was independent of the size of the total yield. This may, in fact, not be the case, though no evidence of any other relationship could be established from the data available.

The distribution of seasonal labour requirements was derived, in the first instance, from the simple monthly averages of the actual per acre labour usage shown in the survey records. In instances where the employment of different production practices and techniques had a detectable effect

7 This is a statistical concept which, on the assumption that the sample was taken from a population which was "normally distributed", indicates the limits on either side of the average within which about two thirds of the individual results would fall.

8 This is similar to the standard deviation of the sample, being, in effect, the standard deviation of the difference between the means, and indicating on the basis of the same assumptions, the limits within which two thirds of the differences between means calculated from a very large number of samples would be expected to fall.

on the seasonal pattern of labour usage more than one distribution was derived. However, the actual monthly totals were adjusted on a *pro rata* basis in such a manner that the seasonal totals corresponded with the labour requirement standards. In this way seasonal labour requirements were also made to reflect the improved accuracy of the standards secured by drawing on the results of the field studies and from the standardisation of yields. Seasonal labour requirements derived in this manner should, therefore, be of greater value in management planning than if a single crude average distribution had been evolved from all records without taking account of variations in production methods and yields.

PART B

VINING PEAS

CHAPTER II

STANDARD LABOUR REQUIREMENTS

THE INFORMATION presented in this section was derived from two sources; firstly, from records kept by growers of the labour used in the production of 46 vining pea crops, and secondly, from an *ad hoc* field study of the labour used in harvesting. The standard labour requirements for growing operations have been drawn from the first source, whilst the information on the labour required for harvesting was obtained mainly from the special study.

The three variants in growing and harvesting methods of which account has been taken in arriving at standard operational and seasonal labour requirements are the use of chemical weedicides, the equipment used in cutting the crop, and the method of loading.

Operational Labour Requirements

The following table summarises the information obtained from the survey about vining pea growing labour requirements.

STANDARD GROWING LABOUR REQUIREMENTS

TABLE 4 Per acre

	Worker hours		Tractor hours
	Sprayed crops	Unsprayed crops	
Preparatory cultivations	4.4		4.3
Growing	3.2	5.8	2.4
Total growing	7.6	10.2	6.7

Preparatory Cultivations

The operations included under this head, comprised ploughing, cultivating and discing, harrowing, rolling and the application of artificial fertilisers.[1] On average preparing the land required 4.4 workers hours[2] and 4.3 tractor hours[3] per acre. These figures are based on the labour usage for all 46 crops.

The range in per acre labour usage was from 1.5 workers hours on a field which was shallow ploughed with a five furrow plough, after oats, and harrowed down just before drilling, to 9.6 worker hours on a farm where the peas followed a ley, and where cultivations were of necessity much more extensive, comprising deep ploughing, repeated discing and harrowing, and the application of artificial fertilisers.

Growing Operations

These included drilling the seed, and harrowing and rolling it in,

1 Except in the case of 10 crops which were combined or placement drilled; for these the labour requirement of fertiliser application was included with drilling under "growing operations".
2 Standard deviation, 1.8 worker hours.
3 Standard deviation, 1.9 tractor hours.

spraying the crop after emergence with insecticides to control weevil and with dinoseb to control weeds, and hoeing the crop both by hand and with tractors.

The simple average per acre labour requirement for these operations, based on 45 records[4] was 4.3 worker hours and 2.4 tractor hours. There was, however, a significant difference in the amount of labour required to grow crops which were sprayed to control weeds and those which were cleaned solely by hand and mechanical cultivations. On average, the former group required 2.6 workers hours[5] less labour per acre for cleaning operations.

GROWING LABOUR REQUIREMENTS. OF SPRAYED AND UNSPRAYED CROPS

TABLE 5 — Worker hours per acre

	No. of records	Average	Standard deviation	Range
Sprayed crops	26	3.2	1.2	1.7 to 5.9
Unsprayed crops	19	5.8	2.7	1.9 to 11.4

As shown in the table, the highest labour requirement for a sprayed crop was three times the lowest for an unsprayed crop, showing that the cleanliness of individual fields, the degree of weed control which growers adjudge to be desirable, and the methods used in achieving this state, are factors which may have a larger effect on the total growing labour requirement of individual crops than whether they are sprayed are not. However, other things being equal, the adoption of the spraying technique for weed control can be expected to reduce the labour requirement of cleaning operations by *at least* 2.6 worker hours per acre.[6]

Table 6 shows standard labour requirements for harvesting operations.

STANDARD HARVESTING LABOUR REQUIREMENTS

TABLE 6 — Per acre

	Worker hours	Tractor or lorry hours
Cutting		
Cutter-rower	1.2	1.2
Mower	4.8	2.4
Loading		
Hand	9.6*	1.6
Green crop loader	4.7†	1.6

* Assuming factory vining, a team of five loaders, and a lorry driver.
† Assuming factory vining, a team of two loaders, and a lorry driver.

Cutting

Two distinct types of equipment were used for cutting the surveyed crops, specialised cutter-rowers and general purpose mowers.

(*a*) *Cutter-rowers*

The average labour requirements obtained from survey records relating to the use of specialised cutter-rowers, were of limited use in

4 Due to quite exceptional circumstances the labour used on one farm was very high; it was decided to exclude this record from the analysis.
5 This difference is significant at the five per cent level; standard error ± 0.7 worker hours.
6 For a discussion of this result, see Chapter III.

arriving at standards for this method of cutting. There were two main reasons for this. Firstly, the almost continuous rain in the 1954 harvesting season made working conditions exceptionally difficult, and added greatly to labour requirements. Secondly, there was reason to think that in some cases where vining was done on the farms, the total time spent on cutting was determined by the speed of vining and loading, rather than by the capacity of the machines. However, a study of the use of specialised pea cutter-rowers, made on six farms in the 1955 season, suggested average labour requirements of from 1.1 to 1.3 worker and tractor hours per acre, depending upon the size of the machine. A median figure of 1.2 hours per acre is shown as a standard in Table 6.

(*b*) *Mowers*

The ways in which mowers were used for cutting peas were highly variable. The most usual method was to have a team of two men, with a windrowing device hitched in tandem behind the mower. But on farms where windrowing was a separate operation up to four men were employed where this was done mechanically, and as many as eight where it was done by hand. In these circumstances a simple average of the labour used on all farms without reference to the method employed is of limited value. However, information obtained from two farms during the course of the field study suggested that where a mower is used with tandem hitched windrowing equipment by a team of two workers, 4.8 worker hours and 2.4 tractor hours per acre is a reasonable estimate of the labour and power requirements of this method.

Loading

The operations included under this head comprise all work done in loading the crop and leading it to the field gate. The standards shown in Table 6 do not include time spent in taking the loads to the viners, whether these were on the farm or at a factory. The time so occupied is dependent upon the distance from the field to the vining station, and more important, on the speed with which loads are put through the viners. No generally applicable standards for the time and labour required to lead the crop can be given here, but as growers well know, at the height of the season it is not unusual for lorries to be delayed for several hours at the factories, and the total labour requirement can be greatly increased as a result.

Loading was accomplished both by hand and with the aid of green crop loaders. By both methods the average amounts of labour used in loading the surveyed crops were again abnormally high on account of the exceedingly difficult working conditions in the wet 1954 season, and cannot be accepted as satisfactory standards. The figures presented in Table 6 are therefore based upon information obtained from a field study of loading in the more typical 1955 season.

(*a*) *Hand Loading*

A labour requirement of 9.6 worker hours per acre is suggested as a standard for the hand loading of crops vined *at the factory,* and where the loading team consists of four men forking from the ground, a fifth on the load, and a sixth driving the vehicle being loaded. A range of from 11.8 to 9.2 worker hours per acre can be expected for loading teams having from four to seven workers.

The amount of labour used in the hand loading of crops vined *on the farm* was highly variable, and even in the 1955 survey ranged from

5.9 to 25.0 worker hours per acre. Such differences were mainly attributable to the way in which the size of the loading gang was balanced with transporting and vining capacity. It was not uncommon for the number of men in the field to be such that loading could be done much faster than the peas could be fed to the viners, with the results that the loading gang was only partly occupied and total labour usage much higher than was strictly necessary. Direct observation on two farms where this was not the case showed that the labour requirement for loading farm-vined crops can be as low as 6.2 worker hours per acre where the loading team consists of two men engaged full-time on loading horse-drawn trailers.

(b) Mechanical Loading

The labour requirement standards for the mechanical loading of vining peas are based on field observations made on four farms in 1955. A figure of 4.7 worker hours per acre is suggested for a loading team of three men, two on the load and a lorry or tractor driver, assuming that the green crop loader is picking up a swathe of the width left by a medium sized cutter-rower. A range of from 4.2 to 8.4 worker hours per acre can be expected, depending upon the number of workers in the team and the width of swathe being loaded.

Total Labour Requirements

The method of weed control adopted and the equipment used in cutting and loading, are factors affecting the total labour requirement of the vining pea crop. Chemical weed control can be expected to reduce labour requirements by at least 2.6 worker hours per acre, and cutting with specialised machines as opposed to the use of general purpose mowers may effect a further reduction of from 3.5 to 3.7 worker hours per acre. The position with regard to loading is more complex, the labour requirement depending upon the size of the team employed and whether the peas are loaded for farm or factory vining. Mechanical loading can be expected to require up to six worker hours per acre less labour than hand loading for factory vined crops, but under the special circumstances of farm vining, hand loading may require little or no extra labour. Under typical conditions the lowest total labour requirement is likely to be 13.5 worker hours per acre for a sprayed crop, cut by a large cutter-rower and loaded mechanically by a team of three men, and the highest, 24.6 worker hours per acre for an unsprayed crop, cut by a mower and hand loaded for factory vining by a team of six men.

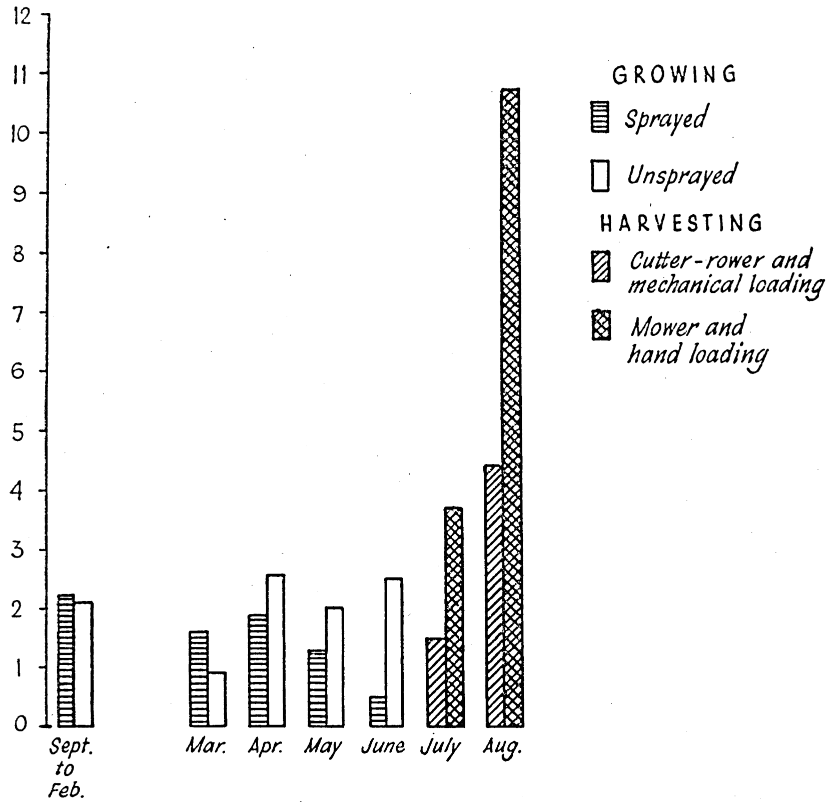
Seasonal Labour Requirements

In examining the seasonal pattern of labour usage on the surveyed crops, the average amount of labour used in each month was determined separately for growing and harvesting operations. Further, the seasonal distributions of the labour used for growing operations were obtained separately for crops which had been sprayed with dinoseb, and for those which had only been hoed.

These seasonal distributions were then related to the standard labour requirements presented in the previous section, by distributing the appropriate standards for growing and harvesting operations over the months and in the same proportions as labour was in fact used on the surveyed crops. The result of treating in this manner the standard total labour requirements for sprayed crops, cut with a cutter-rower and mechanically loaded

(13.5 worker hours per acre), and for unsprayed crops, cut with a mower and loaded by hand (24.6 worker hours per acre) are depicted in Fig. 1.

FIG. 1. VINING PEA SEASONAL LABOUR REQUIREMENTS
(Worker hours per acre)



Preparatory cultivations started in the autumn with ploughing, and this operation was performed in every month from September to February amongst the group as a whole, but most frequently in the November and December period. The land was worked down, fertilisers were applied and successional sowings were made during March and April. May and June were the months when hand and tractor weed-killing operations were performed, and when insecticidal and weedicidal sprays were applied. Harvesting began in early July with the earliest varieties, but was continued through to the end of August, when the last of the late crops were cut; but, in the main, harvesting was concentrated in the last fortnight in July and the first two weeks of August.

Considering the seasonal pattern of labour usage in vining pea production as a whole, the salient feature is that the peak demand for labour is for harvesting in late July and early August. Otherwise, the demands made on the labour force are, in the main, both evenly distributed throughout the year and small in total in any one month.

From the answers given by co-operating growers to specific questions directed at discovering the status of the vining pea crop in relation to the seasonal pattern of labour demand on the farm as a whole, it emerged that the fact that the peak labour requirement falls when it does is regarded as one of the most attractive features of the crop. This is because, in most years, it comes between haymaking and the harvesting of cereal crops, and provides highly productive employment for the regular staff at an otherwise relatively slack period.

The demands for labour made between drilling and the point of harvest similarly seem to have presented no serious problems, and it was interesting to find that no grower in the survey specifically attached importance to the fact that the use of chemical weedicides saved labour in the late April, May and June period.

CHAPTER III

CHEMICAL WEED CONTROL

IT HAS BEEN SHOWN that on average, 2.6 worker hours per acre less labour was used in cleaning crops which had been sprayed with dinoseb, than on those cleaned entirely by harrowing and hoeing.

It would be wrong to conclude from this that spraying will reduce the labour required to clean pea crops by no more than 2.6 worker hours per acre, since there is reason to believe that whilst some of the growers who sprayed their peas did so as a matter of routine, others sprayed only because their crops were exceptionally dirty. In other words, there is no means of knowing what the labour requirement would have been on the sprayed crops if they had been cleaned solely by means of hand and mechanical cultivations.

There is no doubt that chemical weed control involves a relatively high outlay. Contract rates vary from £4 0s. to £4 10s. per acre depending on the acreage, and even where a grower possesses suitable equipment and does his own spraying, the materials alone will cost from £1 5s. to £2 7s. per acre, according to the rate of application. To recoup this outlay there must either be a substantial reduction in the labour requirement of hand and mechanical cultivations, or an increase in the value of the peas.

To recover the costs of contract spraying at £4 10s. per acre, labour would need to be released from cleaning operations at the rate of about 28 man hours for each acre sprayed. To recover the cost of materials where spraying was done by the grower's own sprayer, the corresponding figures would be approximately 14 and 8 man hours per acre for high and low rates of application respectively. If the amount of labour released was greater than that indicated by these figures, and if the labour released could either be employed on alternative tasks where it could earn as much as its wage rate, or if the wage bill could be reduced by a commensurate amount, then spraying would be more profitable than cleaning in other ways.

The amount of labour released will, of course, depend upon the state of cleanliness of individual crops, the dirtier the crop the more labour will be saved. At present no independent evidence exists about the frequency with which the degree of weed infestation in pea crops is such that the labour requirement of hand and tractor hoeing is likely to be greater than the figures cited above. However, the fact that the *highest* labour requirement amongst the 19 unsprayed crops included in this survey was only 11 worker hours per acre, would strongly suggest that opportunities for saving sufficient labour to make spraying profitable will but rarely present themselves.

Evidence about the effect of spraying on the yield of peas is scanty and conflicting. One series of experiments on *harvesting peas* showed that even under good conditions, hoeing gave slightly better yields, despite a somewhat poorer control of weeds, than spraying with the usual preparations of dinoseb.[1] On the other hand, one writer has stated that "weed

[1] HOME GROWN THRESHOLD PEAS JOINT COMMITTEE: *Report for* 1954; p.37-39. Also PROCTOR, J. M. *Weed control in peas*; Farmers' Weekly; Vol. XL, No. 12; p.71; March 19th, 1954.

control by spraying carried out with proper regard to makers' recommendations, can be expected to increase yields by 25 per cent or so on average; often it will be more".[2] No supporting evidence was presented for this claim. Similar experiments on varieties of peas grown for vining do not appear to have been carried out.

However, if the practice of spraying does result in a yield increase it may come about in two ways; either the individual pea plants may grow and yield more heavily by reason of reduced weed competition, or spraying may facilitate the adoption of other cultural techniques having the same result. In particular, the ability to drill the rows closer together will result in the plants being more uniformly distributed over the land area, and because they will compete less with each other, growth and yield may be enhanced.

An American experiment[3] designed to test the relationship between yield and spacing gave the following results.

EFFECT OF SPACING ON YIELD AND RETURNS
TABLE 7

Row width (ins.)	Yield (cwts. per acre)	Returns per acre* £	s.
7	29.6	70	9
14	13.1	28	10
21	8.9	19	6

* This column has been added to the original table. The estimated crop values are based on U.K. canners' basic price for early varieties, 43s. 6d. per hundredweight.

In this particular experiment the variety was Thomas Laxton, an unbranched variety; as the authors point out, "a branched variety might have reacted differently". Certainly such large yield differences as those shown in the table would be exceptional under our conditions. However, they illustrate that the ability to drill on close rows, might easily repay the additional costs of spraying. An additional yield of about two hundredweights of shelled peas to the acre would be sufficient to recoup the cost of contract spraying; an additional yield of about one hundredweight would be sufficient to cover the cost of materials where the grower did the spraying himself.

If spraying resulted in improved weed control, the value of the crop might be increased even without an improvement in yields because some canners' schedules of prices are based partly upon the number of weed seeds in the shelled peas. For instance, one cannery in this area pays a graduated bonus of up to 4s. 2d. per hundredweight for peas free from weed seeds, extraneous matter and diseased or maggot infested peas. Thus, on a 30 hundredweights crop a grower stands to gain up to £6 5s. per acre by ensuring that his crop is weed-free at harvest. Moreover, if the crop is badly infested with particular weed species which can cause tainting in the cans, e.g. mayweed, the cannery may reject the whole of the crop.

Any one of the factors outlined in the previous paragraphs may act in isolation or all may act together to offset the additional costs of

2 SHORROCKS, R. W.; *Peas and sprays*; Farmers' Weekly' Vo.l XLIV, No. 12; p.95; March 23rd, 1956.

3 MURPHY, H. J. and TERMAN, G. L.; *Fertiliser, liming and seeding practice for processing peas in Maine*; University of Maine, Agricultural Experimental Station; Bulletin No. 496; p.13; March, 1952.

chemical weed control. Until more information is available—about the reduction in labour requirements which results, the effect of row spacing on yields, and the effect of weeds on yields and quality—then the extent to which these factors can, in practice, be expected to offset the costs of spraying must remain a matter for individual assessment.

It may finally be noted that on some soils stones brought up by hoe blades may cause trouble at harvest by jamming the cutter bar. Under these circumstances chemical methods of weed control may be obligatory.

CHAPTER IV

A STUDY OF VINING PEA HARVESTING

THREE CONSIDERATIONS led to a detailed study being undertaken, in the summer of 1955, of the operations of cutting and loading vining peas.

(i) The harvesting of vining peas is the most labour consuming process in the production of the crop, and hence it is at this stage that the greatest potential for reducing labour requirements exists.

(ii) The reasons for the considerable differences in the amount of labour used by individual growers to cut and load an acre of peas, were not apparent from the records obtained in the general survey.

(iii) Although some growers had invested considerable sums in specialised equipment, it was not apparent that this investment had invariably resulted in a marked reduction in labour requirements, or an increase in the profitability of the crop.

The objectives of the study were to identify the factors affecting labour requirement of harvesting operations, to derive acceptable standard rates of performance for the more common of the different methods in use and to use the standards to investigate the circumstances in which the purchase of specialised equipment would lead to greater profits.

THE CUTTING OPERATION

It will be convenient to present and discuss the information relating to the use of specialised pea cutter-rowers separately from that for the use of general purpose mowers.

Cutter-rowers

Two distinct elements are involved in cutting pea crops; firstly the haulm must be severed, and secondly it must be windrowed in order that pods shall not be crushed by the tractor wheels in subsequent rounds. Specialised machines accomplish these in one operation. Three types of cutter-rowers were studied. They differ in size, flexibility and versatility, and as a result in price, but are essentially similar in working principle, consisting of a cutter bar equipped with lifting fingers over which a linkage reel is fitted. This lifts the peas over the knife and on to a cross conveyor canvas which deposits the cut haulm in a windrow. The larger cutter-rowers have longer cutter bars and linkage reels, are capable of a wider range of reel adjustment to suit the crop condition, are more robust in construction, and can be used on a wider variety of crops. Throughout this section these machines are designated by the letters A, B and C, cutter-rower "A" being the smallest and cheapest, and cutter-rower "C" being the largest, most versatile, and most expensive of the three.

Individual Results

The average total time required to cut an acre of peas on each of the six farms on which cutter-rowers were used, and the manner in which overall time was distributed between its elements, are shown in Table 8.

TABLE 8 CUTTING RATES ON SIX FARMS USING CUTTER-ROWERS

Machine minutes per acre

Farm No.	Type of cutter	Cutting and windrowing	Turning and travelling	Clearing blockages	Repairs and maintenance	Other time	Total
1	"A"	24	5	9	4	1	43
2	"A"	27	32*	7	2	4	72
3	"A"	36	3	28	3	—	70
4	"B"	35	5	21	5	1	67
5	"B"	45	6	14	4	2	71
6	"C"	35	25*	7	5	6	78
Average		34	13	14	4	2	67
Percentage		51	19	21	6	3	100

* Cutting was in one direction only.

The two determinants of *net cutting* time are the speed of the outfit whilst actually cutting, and the width of cut. These are shown for each machine in the following table.

TABLE 9 VARIATIONS IN THE FACTORS AFFECTING NET CUTTING TIME

Farm No.	1	2	3	4	5	6	Average
Average tractor speed whilst working (m.p.h.)	3.7	3.0	2.5	2.2	1.8	2.1	2.6
Proportion of cutter bar used (per cent)	86.2	77.0	86.2	86.7	73.3	80.0	81.5
Net cutting time (mins. per acre)	24	27	36	35	45	35	34

Other things being equal, the larger machines should cut faster than the smaller. The main reason for this not being observed in practice was that different tractor speeds were used. These ranged from 3.7 to 1.8 m.p.h. and the smaller machines were driven faster than the larger, despite the fact that the latter were in all cases mounted on more powerful tractors. The proportion of the cutter bar which was actually used was also variable, but less so than tractor speed, and this factor played a minor role in determining net cutting times.

The speed at which the tractor is driven is influenced by the interaction of numerous factors, of which the state of the crop is probably the most important. The state of maturity, the thickness of the stand, and whether the crop is laid or erect all have their effect on the speed at which the tractor can be driven. An attempt was made to relate tractor speed and width of cut to both quantitative and qualitative measures of the bulk and the degree of laying of the crops, but this proved fruitless, indicating that the reaction of the individual tractor drivers to the conditions of the crops on which they were working was an additional important variable.

Turning and travelling time includes turning on the headlands, and on Farms Nos. 2 and 6 where cutting was in one direction only the time spent in running from one end of the field to the other.

Cutting round the field is the general rule, and one-way cutting is normally only resorted to in exceptional circumstances. The extent to which non-productive travelling time is thereby increased is apparent from Table 8. On average, one-way cutting increased travelling time about sevenfold, and is obviously best avoided whenever possible. It may be necessary, however, in badly laid crops, where cutting against the direction in which the crop is laid will help to reduce the frequency of stoppages and may result in shorter stubbles and fewer severed pods.

Although there can be no doubt that the modern specialised pea cutters are less subject to *blockages* than are mowers, this problem is by no means solved. The average amount of time lost through this cause, was 14 minutes on each acre, with a range from 7 to 28 minutes. This may not be the most serious consequence. Driver fatigue is increased as a result of continuously having to dismount, and so is wear on the tractor. Moreover it was noticed that when an attempt was made to clear an accumulation of haulm by reversing the tractor, lifting the cutter and then returning to a forward gear, the treatment given to the cutter when re-lowered was frequently harsh.

Observations showed that blockages were mainly attributable to one or more of four causes. Firstly, the lifting fingers tended to ride over haulm lying in depressions, such as those left by the wheels of heavy spraying tackle, thereby causing the haulm to accumulate under the knife. It would seem advisable to confine the use of heavy equipment strictly to dry soil conditions, and where this is not possible, e.g. when spraying contractors are available only for limited periods, to remove the wheelings by subsequent cultivations. Secondly, when cutting across undulating land, particularly land which lay in ridge and furrow, there was a tendency for the knife to ride over the haulm when the machine breasted a ridge. Again haulm accumulations formed under the knife and resulted in stoppages. A partial solution may lie in cutting along the length of the undulations rather than across them. Thirdly, laid crops were less easily lifted by the fingers and reels than erect crops. This difficulty can be partly overcome by cutting only in the direction in which the peas are lying, but this will result in a substantial increase in non-working time. Fourthly, it was constantly observed that haulm tended to accumulate under and around the divider points which are fitted to these machines; so much so that the divider had been removed on two of the six machines and replaced by an additional lifting finger. On Farm No. 3 this step was taken at the observers' suggestion with the following effect on the cutter's performance.

RESULT OF REMOVING DIVIDER POINT
FARM NO. 3

TABLE 10 — Per acre

	With divider point	Without divider point	Difference
Net cutting time (minutes)	38	33	5
Clearing blockages (minutes)	42	14	28
Total time in row (minutes)	80	47	33
No. of stops	44	11	33

The number of stoppages caused by haulm accumulations was reduced by 75 per cent, and the total time in the row by two fifths. The border between the cut and uncut crops was somewhat less neat, but this had no adverse effect on the width of cutter bar which was utilised. If the use of divider points does confer advantages, it would seem that some alternative design is necessary; the experience of some growers would suggest that in their present form they are a distinct hindrance.

Making *running repairs and adjustments* accounted for only four minutes per acre, on average. Activities included under this head include routine oiling of the knife drive and bed, replacing thrown driving chains and belts, and replacing or straightening broken and bent lifting fingers.

Other time was all non-working time, consisting of talking with other workers, smoking, and similar occupations.

Estimated Labour Requirement

This study did not give a direct measure of the comparative performance rates of the three types of cutter-rower, since the machines observed were not working under uniform conditions and the numbers were too small to permit averaging of the results by types. Nevertheless the information obtained can be used to that end by combining the *recorded* average total non-cutting time for all machines (33 mins.), with the *computed* net cutting time for each machine at the average forward speed of 2.6 m.p.h. and when using an average of 81.5 per cent of the cutter-bar.[1] The estimated totals so obtained are shown in the fourth column of Table 11. An allowance may also be made for time spent in moving to and from fields, sharpening and changing knives, changing canvases, reel bats and tines, and similar tasks which must be done from time to time. An arbitrary figure of 10 per cent of the estimated total time for the medium sized machine (7 mins.), has therefore been added to each total to give the adjusted totals shown in the right hand column of Table 11.

ESTIMATED CUTTING RATES FOR THREE CUTTER-ROWERS

TABLE 11 Machine minutes per acre

Cutter-rower	Computed net cutting time	Average non-working time	Total	Adjusted total
"A"	37	33	70	77
"B"	32	33	65	72
"C"	28	33	61	68

In this manner it is estimated that the comparative average rates of performance of the three machines are an acre cut and windrowed in 1.3, 1.2 and 1.1 hours by the cutter-rowers "A," "B," and "C," respectively.

Since only one operator is required, the comparative average per acre labour requirements when using these machines, would similarly be 1.3, 1.2 and 1.1 worker and tractor hours per acre respectively.

Mowers

The use of ordinary mowers was studied on two farms. On both a 5 ft. mower was used, and windrowing was accomplished with the aid of a side delivery rake. On one farm the rake was hitched behind the mower, but on the second windrowing was a separate operation.

Two men were employed on the first farm, the tractor driver and an additional worker whose task was to clear mower blockages and fork trailing haulm from the border between the cut and uncut crop. Four men were employed on the second farm, two driving the tractors drawing the mower and side delivery rake, a third with the mower, and a fourth with the rake.

1 The uninterrupted cutting time in machine minutes per acre is given by,

$$\frac{43{,}560 \times 60}{5{,}280 \times \text{speed (m.p.h.)} \times \text{actual width of cut (feet)}}$$

Individual Results

The total amount of labour used on the two farms, and the way in which it was occupied, is shown in the following table.

CUTTING-WINDROWING RATES ON TWO FARMS USING GENERAL PURPOSE MOWERS

TABLE 12 Man minutes per acre

Farm No.	No. of workers	Cutting, rowing, forking	Turning and travelling	Clearing blockages	Repairs and maintenance	Other	Total
7	2	97	83	113	21	7	321
8	4	269	132	17	7	59	484

For Farm No. 8, where cutting and windrowing were done by two independent teams, each of two men, a separate analysis of the way in which each team was occupied is set out in Table 13.

LABOUR USAGE ON FARM NO. 8

TABLE 13 Man minutes per acre

Team	No. of workers	Cutting, rowing, forking	Turning and travelling	Clearing blockages	Repairs and maintenance	Other	Total
Cutting	2	122	80	17	6	17	242
Windrowing	2	148	51	—	1	42	242

Amongst the farms supplying survey records the most common method of using a mower and windrower was to have these hitched in tandem and operated by a team of two men. It is doubtful whether there is any advantage in having the cutting and windrowing done by two separate teams, and the owner of Farm No. 8 agreed with this view. It so happened that the peas were being harvested at a time when there was very little other work on this farm and it was agreed that the two men windrowing were being "found" work.

This being the case, as a first approximation it may be assumed that had the side delivery rake on Farm No. 8 been attached directly behind the mower, two men would have sufficed and the total labour requirement would have been that of the cutting team. The labour usage of the cutting team on this farm can then be compared with that of the cutting team on Farm No. 7 ; this is done in Table 14.

COMPARATIVE CUTTING RATES

TABLE 14 Man minutes per acre

Farm No.	Cutting, rowing, forking	Turning and travelling	Clearing blockages	Repairs and maintenance	Other	Total
7	97	83	113	21	7	321
8	122	80	17	6	17	242
Average	109	81	65	13	12	281

Cutting was in one direction only on both farms. This is usual with mowers, which having no linkage reel are obliged to cut against the direction in which the peas lie in any but the most erect crops. The effect of this is seen in the large amount of travelling time on both farms. The difference between the net cutting times on the two farms was mainly attributable to the faster tractor speed on Farm No. 7, which more than offset the fact that a narrower width of cut was taken.

It will be seen that the time lost through *blockages* was very much greater on Farm No. 7 than on Farm No. 8. This was due to the different crop conditions. Whereas on Farm No. 7 the crop was laid and stoppages were frequent, on Farm No. 8 the crop was erect and cutting proceeded much more smoothly.

As with the specialised cutters, *repairs and maintenance* consisted of replacing bent and broken lifting points, oiling the knife drive and similar operations. The remaining time was occupied in talking, taking short rests, etc.

Estimated Labour Requirement

By adding to the average performance figures shown in Table 14, the same figure of 7 minutes per acre as was used for the cutter-rowers to allow for travelling to and from the field, making major repairs, etc., the figure of 288 man minutes or 4.8 man hours per acre is obtained as an estimate of the amount of labour required to cut and windrow an acre of vining peas with a 5ft. mower, a tandem hitched side delivery rake and a team of two men.

Cutting Rates

The rate at which peas can be cut with different kinds of equipment is of some importance. Where vining is done on the farm the cutting capacity must be such that the output of the viners is not limited by the rate at which the peas can be cut. Where vining is done at the factory, the rate at which the peas can be cut must be such that it does not limit the number of loads which can be sent at any one time. With farm vining the demands made on the cutting equipment are unlikely to vary from day to day, and balancing cutting capacity and vining capacity will be a relatively simple matter. With factory vining, it is not unusual for the number of loads which may be sent in any one day to vary throughout the season, and cutting capacity must be adequate to deal with the maximum rate of sending.

It has been shown that under average conditions a 5 ft. mower can be expected to cut an acre of peas in 2.4 hours, whilst cutter-rowers would take from 1.1 to 1.3 hours, depending upon their size. Examination of five survey records showed that the average through-put of farm viners was of the peas from one acre being vined in 2.7 hours. No doubt some of these viners were not working at full capacity and the fastest rate recorded is a better guide to the potential capacity of farm viners; this was two viner hours per acre of peas. Thus it would seem that a mower would need to work for only one to two hours longer each day than the viner, in order to keep the latter working at full capacity. Cutter-rowers would easily keep a single viner supplied with peas, and would need to work for only a short time longer than the viners in order to maintain a supply of peas to two viners.

Judging from the experience of growers included in this enquiry, it is unlikely that limited cutting capacity will restrict the number of loads which can be sent to factories in any one day. The limiting factor is more usually the rate at which the factories can cope with the crop, particularly in short vining seasons.

Effectiveness of Cutting

A limited study of the efficiency of cutting was made on six of the eight farms, by collecting the pods and loose peas which were left on or in the stubble, and weighing the shelled peas. The peas from a total area of 24 square yards were collected and weighed on each farm, the samples being taken from 24 one yard squares spaced regularly along the row of stubble in the path of the cutter.

It was found that the losses of peas which occurred were of an unsuspected magnitude, and represented a substantial loss in the potential value of the crops. On average, the wastage recorded was equivalent to 218 lbs. of shelled peas per acre. At the canners' basic price of 39s. 6d. per hundredweight for maincrop varieties, this represented a financial loss of £3 17s. per acre.

The range in such losses was from 88 to 554 lbs. per acre, but the number of each type of machine was too small and the conditions under which they were working too variable, to permit any conclusions being drawn about their relative efficiencies in this respect.

It was also observed that the loose peas and pods were unevenly distributed over the full width of the path cut by the machines. On each farm half the samples were taken in the centre of the swathe, and half at the edge. It was found that the average weight of peas left at the inside end of the knife, i.e. in the region of the junction between cut and uncut crop, was twice that in the centre of the swathe. As is shown in Table 15, this positional relationship was observed on each of the six farms.

DISTRIBUTION OF PEA LOSSES

Table 15 Ounces per sq. yd.

Farm No.	Edge of swathe*	Centre of swathe*	Combined†
1	0.5	0.2	0.3
2	0.5	0.2	0.3
3	0.9	0.1	0.5
4	1.5	0.6	1.0
5	1.9	1.7	1.8
6	0.4	0.2	0.3
Average	1.0	0.5	0.7

* Averages of 12 samples on each farm.
† Averages of 24 samples on each farm.

Several features of the design of the cutter-rowers and mowers may have contributed to this result. It was noted that the stroke of the reciprocating knife on mowers and cutter-rowers carried it beyond the end of the bed and a short distance into the peas of the succeeding swathe. In so doing the end segment of the knife tended to sever pods on haulm which was neither lifted clear by the outer lifting finger, nor by the reels of cutter-rowers. Moreover the presence of the divider point on cutter-rowers resulted in the peas in this region being pressed down rather than lifted clear, thereby accentuating the tendency for the floating end of the knife to sever pods. In addition, haulm frequently accumulated round and under the knife at its inner end, and there may have been some tendency for the pods on this haulm to be severed by the knife at this point.

It would seem, therefore, that an effort should be made to improve the design of machines so that losses due to this cause are obviated.

THE LOADING OPERATION

A study of the loading of vining peas was made on eight farms. On four farms green crop loaders were used, and on the remaining farms loading was entirely by hand.

Mechanical Loading

All the green-crop loaders observed at work were of the type hitched to the rear of the vehicle being loaded.

The number of workers employed in building the loads varied, on two farms there were two men on the load and on the other farms three men were so occupied.

The number of men required on the load depends, in part, upon the state of the crop; two workers are sufficient on lightish crops, but a third man may be added where a bulky crop is being loaded. In addition the dimensions of the vehicles being loaded play a part; building the load may be accomplished with two men (or even one) when short-bodied lorries are used, but with the rear-hitched loaders of the type observed, an additional worker may be necessary with long-bodied vehicles. To some extent also the number of workers on the load may be a reflection of the lack of alternative work at this time of the year.

If the forward speed of vehicles was infinitely variable then the rate of picking up could be adjusted to suit the bulk of the crop and the ease of building the front half of the load. But in practice forking peas is such an arduous task that even in relatively thin crops the actual forward speed is usually the lowest that is possible without excessive stalling. Consequently variations in the state of the crop and the length of the load tend to be reflected in varying numbers of workers rather than in varying forward speeds.

Individual Results

On the four farms where green crop loaders were used, the total working times per acre, and the way in which these were made up, were as shown in Table 16. Waiting time and other non-working time is excluded at this stage.

LOADING RATES WITH GREEN CROP LOADERS

TABLE 16 — Minutes per acre

Farm No.	Net loading time	Turning and travelling	Stoppages	Time between loads	Total
3	86	—	2	10	98
4	59	2	1	5	67
5	69	4	4	8	85
7	122	16	4	16	158

Net loading time is determined by the forward loading speed of vehicles, and the width of swathe contained in each windrow. Each of these factors was variable between farms, and together resulted in the different net loading times shown in Table 16.

The overall average forward speed of the vehicles loaded on the four farms was 1.2 m.p.h. The study of cutting showed that on average 81.5 per cent of the overall length of the knife was used in cutting. Knowing average forward speeds and the average width of swathe, the average uninterrupted net loading times may be computed for the mechanical loading of crops cut by each of four methods. These are as follow:

Loading after 5 ft. mower	......	101 minutes per acre
,, ,, cutter-rower "A"	......	78 ,, ,, ,,
,, ,, ,, "B"	......	68 ,, ,, ,,
,, ,, ,, "C"	......	59 ,, ,, ,,

As will be seen from Table 16, the actual results on the four farms were very similar to these calculated figures. On Farm No. 3 the peas had been cut with a cutter-rower of type "A", type "B" had been used on Farms Nos. 4 and 5, and a 5 ft. mower had been used to cut the peas on Farm No. 7.

The average time spent in *turning* on the headlands was five minutes per acre. The range was from 16 minutes on Farm No. 7 where the rows were somewhat shorter than on the other farms, and where considerable manoeuvring of the combination of loader and vehicle was occasionally found necessary, to nil on Farm No. 3 where, since the cutter had been taken round all four sides of the crop, loading was continuous. On Farms Nos. 4 and 5 loading was continuous over most of the area loaded.

Stoppages due to mechanical breakdowns were infrequent, but were occasionally the result of the chain driving the rakes being thrown off, or by the loader coming adrift from the towing vehicle. On average, three minutes per acre were lost from these and similar causes.

The time spent *between loads* was occupied by workers getting on and off the vehicles, hitching and unhitching the crop loader from the towing vehicle, and shaping and securing the loads of peas. These took an average of 10 minutes per acre.

It was found that there was a marked difference in the extent of *non-working* time between farms with their own viners and those from which the peas were sent to factories for vining. Considering for the moment all eight farms together without reference to the loading method used, waiting and other idle time averaged eight minutes per acre for the four teams loading peas for factory vining, and the corresponding average figure for the teams loading peas for vining on the farm was 30 minutes per acre.

Average non-working time was higher on the farms with their own viners by reason of the vining being a continuous operation. Although there were intervals between the dispatch of full loads and the return of empty vehicles, the loaders remained in the field between loads. With factory vining, on the other hand, all the vehicles available were loaded in the early morning and sent off to the factory, and since several hours commonly elapsed before their return, the loaders were able to leave the field and undertake work elsewhere on the farm. The average non-working time of eight minutes per acre per team in the latter case, represented legitimate rest periods. The average non-working time for the farm vining teams—30 minutes per acre per team — included both legitimate rest periods and enforced idleness, the latter being due either to slowness at the viner or inadequate arrangements for transporting peas from the field to the viner and returning empty vehicles to the field, or both.

While the organisation of an integrated process such as on-the-farm vining is obviously fairly complex, it is the business of management to balance the size and capacity of interdependent units of the organisation so that the process flows smoothly without any unit or worker being over or underemployed. This purpose will best be served if the standards available for use in management planning are based on good practice rather than bad. It is proposed therefore to use the figure of eight minutes per acre to cover non-working time for teams loading peas for both farm and factory vining. However, not all the workers were engaged in the performance of the operations included under the heading "between loads," and a major proportion of this element can, in practice, be regarded as an additional opportunity for resting.

Estimated Labour Requirement

The amount of labour required to load an acre of vining peas will depend upon the number of men employed and the time they take for the job. Two or three workers on the load was the most common practice on farms in the general enquiry and in the field study, but as has been pointed out, the time required to load a given area does not necessarily vary directly with the number of men on the loads because of the tendency for the forward speed of vehicles to be kept as low as possible.

Information obtained from this study about the average swathe widths left by various cutters, the forward speeds of vehicles being loaded, and the average composition of all non-loading time, permits loading labour requirements to be estimated.

For instance, it is estimated that peas which had been cut with the smallest of the cutter-rowers would be loaded at an average rate of an acre in 1.7 hours. This figure is obtained by adding the calculated net loading time at the average forward speed, to the average amount of time spent in activities other than actually loading, in the manner shown in Table 17.

ESTIMATED MECHANICAL LOADING RATE

TABLE 17 — Minutes per acre

Calculated net loading time	Turning and travelling	Stoppages	Time between loads	Other time	Total
78	5	3	10	8	104

If a total of three men were employed, one driving the tractor or lorry and two on the load, the estimated total labour requirement would be about 312 man minutes or 5.2 worker hours per acre. Similarly the estimated total labour requirement for loading crops which had been cut with the other types of cutter-rower or with a 5 ft. mower, would be as follow:

Loading after 5 ft. mower	...... 6.3	worker hours per acre
,, ,, cutter-rower "B"	...... 4.7	,, ,, ,, ,,
,, ,, ,, "C"	...... 4.2	,, ,, ,, ,,

The assumptions made are that the loading team consists of three men, that vehicles being loaded travel at an average rate of 1.2 m.p.h., and that the swathe width is 81.5 per cent of the full length of the knife on the cutter-rower or mower. If a third worker were on the load, bringing the total number to four, the labour requirements would be increased by about one third.

Hand Loading

The number of workers employed for hand loading on the four farms where this method was used, varied from two to six.

On Farm No. 9 vining was done at a factory and loading was onto lorries. Four men forked from the ground, a fifth was on the load and a sixth drove the lorries. On the remaining farms vining was on the farm. Loading was on to horse or tractor-drawn trailers and was accomplished entirely from the ground since there was no necessity for building large loads.

On each of Farms Nos. 1 and 6 two workers accomplished the loading, and a third man was solely engaged in towing loaded trailers to the farm viner and empty trailers back to the field. During loading in the field the trailers were drawn by a well trained horse.

On Farm No. 8, three men were engaged full time on loading; two tractor-drawn trailers were loaded alternately. The tractor drivers divided their time between moving the trailers as loading proceeded, assisting with the forking, taking the loaded trailers to the farm viner, and there unloading them.

Individual Results

Other things being equal, the net time required to load an acre of peas is directly dependent upon the number of workers actively engaged in forking the peas from the ground. Since the number of forkers employed on these four farms ranged from two to four there is little of value to be derived from a simple average of the individual net loading times. On the other hand, the total labour input, i.e. the product of the number of men involved and the time they were forking, should have been approximately the same on all farms. This was in fact the case as is shown in the following table.

NET HAND LOADING LABOUR REQUIREMENT ON FOUR FARMS

TABLE 18

Farm No.	Worker mins. per acre
1	279
6	310
8	401*
9	316
Average	326

* Includes the time spent by the tractor drivers in assisting with forking peas on to the loads.

The *net loading* time for any sized loading team may be estimated by dividing the average net loading labour requirement of 326 worker minutes per acre by the number of workers employed in forking from the ground. Thus with two forkers the estimated net loading time would be 163 minutes, with three forkers 109 minutes, and with four forkers 82 minutes per acre.

The times occupied by the remaining elements of working time were as shown in Table 19.

NON-LOADING TIME ON FOUR FARMS

TABLE 19 Minutes per acre

Farm No.	Turning	Between loads
1	6	10
6	10	6
8	—	6
9	—	2

On Farms Nos. 8 and 9 loading was continuous even when the vehicles were turning at the ends of the rows. But on Farms Nos. 1 and 6, where horses were used to pull the trailers, loading was periodically interrupted to move and turn the trailers. On average eight minutes per acre were so occupied on these two farms.

Hitching and unhitching trailers, removing loose haulm from the sides of loads and similar tasks required six minutes per acre, on average, for all teams.

Estimated Labour Requirement

Total labour requirement may be estimated for various situations by using the information presented in the previous paragraphs.

The total labour requirement is given by the product of the number of workers employed and the time that they are in the field. Total time is composed of net loading time and other time. Net loading time for any sized team may be estimated by dividing the average net loading labour requirement (326 worker minutes per acre) by the number of workers actually forking peas from the ground. The average time spent in activities other than loading is given in preceding paragraphs and as previously explained eight minutes per acre may be allowed for legitimate rest periods.

For example, if vining is at the *factory* and loading is by a team of six—four forking, one on the load and a lorry driver—the estimated overall time would be 96 minutes per acre, made up as in Table 20.

ESTIMATED HAND LOADING RATE WITH A SIX-MAN TEAM
(Factory Vining)

TABLE 20 — Minutes per acre

Net loading time	Time between loads	Other time	Total
82	6	8	96

Hence the estimated total labour requirement would be 576 worker minutes per acre, or 9.6 worker hours. The corresponding figures if two, three or five workers were forking from the ground would be 11.8, 10.2 and 9.2 worker hours per acre.

With *farm* vining it is not necessary for a man to be on the load. Moreover, where a horse is available and is used to draw the trailers in the field, the system employed on Farms Nos. 1 and 6 can be used. With two men loading for a single viner, the estimated overall time required to load the peas from one acre would be 185 minutes, made up as shown in the following table.

ESTIMATED HAND LOADING RATE WITH A TWO-MAN TEAM
(Farm Vining)

TABLE 21 — Minutes per acre

Net loading time	Moving trailers	Time between loads	Other time	Total
163	8	6	8	185

The total labour requirement would then be 6.2 worker hours per acre.

Loading Rates

On the basis of the information obtained in this study it is estimated that the average rates at which peas can be loaded by *green crop loaders* following the various types of cutter-rowers or a 5 ft. mower are as follow.

Crops cut with 5 ft. mower	2.1	hours per acre
„ „ „ cutter-rower "A"	1.7	„ „ „
„ „ „ „ "B"	1.6	„ „ „
„ „ „ „ "C"	1.4	„ „ „

Estimated *hand loading* rates with from two to four men loading for farm viners, and with from four to six men (including the driver) loading peas for factory vining are as shown in Table 22.

ESTIMATED HAND LOADING RATES

TABLE 22 Hours per acre

No. of workers in loading team	2	3	4	5	6
Farm vined crops on to horse-drawn trailers	3.1	2.0	1.6	—	—
Factory vined crops on to lorries	—	—	2.9	2.0	1.6

With factory vined crops a high loading rate is often important because of the need to get the lorries loaded and away to the factories as early in the day as possible, so that they are not unduly delayed in the congestion which is frequently found at the factories at the height of the vining season. In addition a quick turn-round is essential where transport facilities are limited in relation to the area of peas to be cleared. It would seem that where only three or four workers are available, mechanical loading is the faster method, except where very narrow swathes are being loaded. With six or more workers hand loading can be equally as fast, or faster.

With farm vining, where the need is to keep the viner fully occupied, there is little to choose between mechanical loading and hand loading on to horse-drawn trailers, so long as four workers are available. But with less than four men pitching up, hand loading would probably be slower.

Without more information on vining rates any conclusions about the ability of different numbers of workers using the two methods to keep a viner fully occupied must of necessity be tentative. But taking as a rough measure of viner capacity the fastest average rate recorded in the general survey—i.e. of the peas from one acre being vined in two hours—it would seem that with only two men hand loading (as on Farms Nos. 1 and 6) it would be difficult to keep a viner working at full capacity; three men loading would seem to be a more suitable team. The rate of loading where a green crop loader was used would be adequate under most circumstances, even when narrow swathes were being picked up.

CHAPTER V

THE PURCHASE OF SPECIALISED PEA CUTTERS

A MAJORITY OF THE growers covered by the enquiry owned specialised cutters, and several of those who were still using mowers indicated that they were considering investing in one or other of the several machines on the market. The purpose of this section is to examine the conditions under which the purchase of specialised cutter-rowers will add to farm profits.

Cost Reduction

It has been established that cutter-rowers will cut an acre of peas faster, and require less labour than a mower. Further, the larger cutter-rowers will, other things being equal, cut faster and with a lower labour requirement than smaller machines of the same type. Hence the use of specialised machines will result in a reduction in the variable costs of pea cutting, i.e. labour, fuel and oil, and the larger the machine the greater the saving on these items will be.

On the other hand, growers who invest in specialised cutter-rowers incur the depreciation and interest charges ascribable thereto. Since on the vast majority of farms, a mower will need to be retained for the task of grass cutting, there will be no opportunity of offsetting the fixed costs of specialised cutters by disposing of the farm mower. The purchase of a specialised cutter will therefore result in a net addition to fixed costs.

The problem is to determine the minimum annual amount of work which specialised cutters must do before the savings in variable costs, due to more speedy cutting with fewer workers, are sufficient to cover the additional annual depreciation and interest charges on the investment.

The magnitude of the fixed and variable costs involved are shown in Table 23. Interest on the investment is charged at six per cent per annum and the machines are written off alternatively over six or ten years.[1] Variable costs are based on the standard labour and tractor hour requirements given in previous pages, labour being charged at 3s. 3d. per hour and tractor running costs at 2s. 9d. per hour. Repair charges of 5s. 0d. per acre for each of the cutter-rowers, and 2s. 0d. per acre for a mower and windrower, are also included. These repair charges are based upon information supplied by the manufacturers of cutter-rowers about their sales of replacement parts.

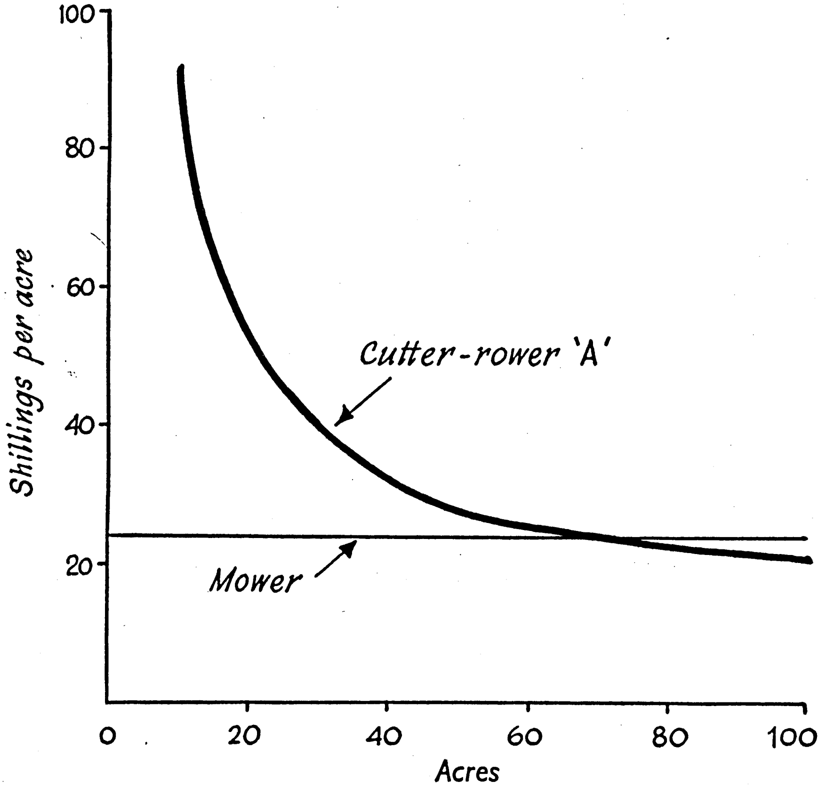
The capital and annual fixed costs of each machine, and in particular the differences in these costs between machines, will be considered small by growers for whom such factors as the satisfaction and prestige to be derived from owning the most advanced types of equipment may be more important than cost minimisation. Such attitudes will not, however,

[1] Throughout this report the combined annual depreciation and interest charges on capital investments are calculated by the annuity formula

$$A = \frac{Cr\ (1+r)^t}{(1+r)^t - 1}$$

where A is the annual charge, C the capital cost of the machine purchased, r is the interest rate, and t the amortisation period.

FIG. 2. PER ACRE COSTS OF VINING PEA CUTTING



be shared by growers with more limited capital resources. Moreover, if profit maximisation is the primary objective then any investment must be subjected to the same close scrutiny as that given to the purchase of cutter-rowers in the following pages.

TABLE 23

THE COSTS OF PEA CUTTING

Machine	Capital cost	Annual fixed costs		Variable costs
		6 year life	10 year life	
	(£'s)	(£'s per year)	(£'s per year)	(shillings per acre)
5 ft. mower	—	—	—	24.2
Cutter-rower "A"	195	39.7	26.5	12.8
,, "B"	325	66.1	44.2	12.2
,, "C"	385	78.3	52.3	11.6

For any one machine, variable costs per acre are about the same for each acre of peas cut, regardless of the total acreage involved. On the other hand, the incidence of the fixed costs on each acre falls as the number of acres cut increases. Consequently, the combined or total cost per acre falls as the machine is used on an increasing acreage. If total cost per acre is plotted against the acreage on which the cutter is used, a falling cost curve of the form shown in Fig. 2 is obtained.

Since the purchase of a specialised cutter would not in most cases allow the farm mower to be sold, the fixed costs of the mower could not be escaped, and hence may be left out of account in deciding the amount of work a specialised cutter has to do before it will result in lower total costs. The only mower costs which need to be considered are the variable costs of using it, i.e. labour, fuel, oil and repairs. Since the *per acre* incidence of these does not vary they are shown as a horizontal line in Fig. 2.

At the acreage represented by the point where the cost curves intersect, the per acre costs (and hence total costs) of the two methods are equal. That is, at this acreage the reduction in variable costs resulting from using a specialised cutter instead of an existing mower are just sufficient to counterbalance the increase in annual fixed costs attributable to the cutter-rower. This may be designated as the "break-even cost acreage".

As can be seen from the diagram the purchase of the smallest and cheapest specialised cutter could not be justified on the grounds of cost savings unless used on at least 70 acres of peas.

The exact location of the point of intersection of the curves, and thereby the calculated break-even cost acreage, depend upon the rates of working, factor prices, and interest rates which are used in the calculation, and the number of years over which the machines are depreciated. Fig. 2 is based upon the assumptions already listed, but Table 24 gives the calculated[2] break-even cost acreages not only on this basis, but also on the basis of an assumed repair charge of 2s. 6d. per acre and a working life of 10 years.

BREAK-EVEN COST ACREAGES IN CHANGING FROM A MOWER TO EACH OF THREE CUTTER-ROWERS

TABLE 24

Life (years)	Repairs (shillings per acre)	Cutter-rower		
		"A"	"B"	"C"
6	2.5	57	91	104
	5.0	70	110	124
10	2.5	38	61	69
	5.0	47	74	83

It will be seen that even under the most favourable assumptions, namely, a 10 year life and a repair charge of only 2s. 6d. per acre, the calculated break-even cost acreages for the three machines are quite large, at 38, 61 and 69 acres, and very much higher under the more realistic assumptions of a six year life and a 5s. 0d. repair charge.[3] To write off cutter-rowers

2 The diagrammatic method of locating break-even cost acreages is laborious. The annual acreage on which the use of any two machines results in equal per acre and total costs may quickly be found from the formula

$$X = \frac{Fm_1 - Fm_2,}{Vm_2 - Vm_1}$$

where, X is the break-even acreage, Fm_1 and Fm_2 are the combined interest and depreciation charges of the more expensive but lower labour requirement machine, and the less expensive but higher labour requirement machine respectively, and Vm_1 and Vm_2 are the variable costs of their use.

In this particular example the fixed costs of the mower are inescapable and may, therefore, be left out of account; the formula then becomes

$$X = \frac{Fm_1}{Vm_2 - Vm_1}$$

where the suffixes 1 and 2 refer to the cutter-rower and mower respectively.

3 Unless otherwise stated, all subsequent calculations are based on the assumptions of a six year life, an interest rate of six per cent per annum, and repair charges of 5s. 0d. per acre for cutter-rowers, and 2s. 0d. per acre for mowers and windrowers.

in six years is not to take a too pessimistic view, firstly, because the imminent introduction of mobile viners may radically change existing pea harvesting techniques and render existing equipment obsolete, and secondly, because as several growers in this area have recently learned to their cost, there is no guarantee that contracts once granted will be indefinitely renewed. The risk of being left without a contract, and without peas on which to use specialised equipment, would be an additional inducement for growers to write their investment off over a short period.

It may further be noted that because the combined depreciation and interest costs of machine ownership are high in relation to the costs of their use, except when used on very large acreages, large variations in machine performance would have a proportionately smaller influence on the break-even cost acreages. For instance, if the performance on a particular farm of cutter-rower "C" was an acre cut and windrowed in 0.5 hours instead of the 1.1 hours suggested as a standard, the break-even cost acreages above which its purchase would result in lower total cutting costs than the use of an existing mower cutting an acre in 2.4 hours, would still be considerable (84, 97, 56 or 65 acres instead of the 104, 124, 69 and 83 acres shown in Table 24).

It is therefore apparent that although cutter-rowers reduce the labour requirement by about 75 per cent and the tractor work requirement by half, these savings can only offset the fixed charges of depreciation and interest if used on a considerable acreage of peas each year.

It is of interest to compare the actual amount of work available on the 30 farms covered by the survey with the calculated break-even cost acreages shown in Table 24 in relation to the cutting equipment owned. For this purpose, it is assumed that peas grown for harvesting dry would be cut with the same equipment as was used for vining peas, and that the variable costs of cutting both types of peas would be the same.

ACREAGE OF PEAS GROWN IN RELATION TO EQUIPMENT USED

TABLE 25

Method of cutting the vining peas	No. of farms	Average acreage of peas grown annually			Range in total acreage of all peas grown
		Vining peas	Harvesting peas	Total	
Cutter-rower "A"	7	35	21	56	22 to 79
,, "B"	3	22	17	39	20 ,, 98
,, "C"	7	40	43	83	35 ,, 153
General purpose mower	11	19	14	33	7 ,, 120
Contractor	2	26	18	44	41 ,, 48

Taking the most optimistic view of the probable life of cutter-rowers and of the amount to be spent on repairs—that is, assuming a 10 year life and a repair charge of 2s. 6d. per acre—the calculated break-even cost acreages would be 38, 61 and 69 acres for cutter-rowers "A", "B" and "C" respectively (see Table 24). It will be apparent from the right hand column of Table 25 that some of the growers included in this enquiry were using specialised pea cutters on acreages considerably below those which would justify their ownership of these machines on the grounds of reducing cutting costs. And in fact, two of the seven users of cutter-rower "A", one of the three using cutter-rower "B", and three of the seven users of the largest machine, were in this position. If costs are calculated on the basis of what are in the writers' opinion more realistic assumptions, namely a six year life and a repair charge of 5s. 0d. per acre, then it would appear that five of the seven users of cutter-rower "A", all three of those using cutter-rower "B", and five of the seven with cutter-rower "C" were using these machines on less than the break-even cost acreages. If in fact the machines were purchased specifically for, and used solely on, vining peas, then very few of the surveyed farms could have provided a large enough volume of work to bear the interest and depreciation charges of specialised pea cutting equipment.

Output Expansion

Cost reduction is only one way of increasing productivity and profit. This objective may also be achieved by increasing the value of output by means which involve a less than commensurate increase in costs. The use of cutter-rowers instead of general purpose mowers could lead to improved profits by increasing the value of peas in either of two ways, or both in combination.

Firstly, it is conceivable that specialised cutters are technically more efficient than mowers; the presence of a linkage reel which lifts the haulm on to the knife may result in fewer severed pods and a shorter stubble, and thereby the securing of a higher proportion of the potentially saleable crop. Secondly, the faster rate of cutting possible with a cutter-rower might enable the peas to be cut closer to the point where the combination of yield and quality result in their highest sale value.

Table 26 shows the magnitude of the additional per acre costs of owning and using cutter-rowers rather than an existing farm mower, on less than the break-even cost acreages of peas. The figures shown are a measure of the additional value which would need to be added to *each acre* of the pea crop by more effective or more timely cutting, over and above the savings in variable cutting costs, in order that the investment in cutter-rowers should be profitable.

ADDITIONAL COSTS OF USING CUTTER-ROWERS ON LESS THAN BREAK-EVEN COST ACREAGES

TABLE 26 — Shillings per acre

Annual acreage	10	20	30	40	60	80	100
Cutter-rower "A"	68	28	15	8	2	—	—
" "B"	120	54	32	21	10	5	1
" "C"	144	66	40	27	14	7	3

The *additional yields* due to more effective cutting which would just be sufficient to offset these extra costs are shown for each machine in the following table. The canners' basic price for maincrop varieties, 39s. 6d. per hundredweight, has been used throughout.

ADDITIONAL YIELDS OF SHELLED PEAS NEEDED TO RECOUP ADDITIONAL COSTS OF USING CUTTER-ROWERS ON LESS THAN BREAK-EVEN COST ACREAGES

TABLE 27 — Cwts. per acre

Annual acreage	10	20	30	40	60	80	100
Cutter-rower "A"	1.7	0.7	0.4	0.2	0.1	—	—
" "B"	3.0	1.4	0.8	0.5	0.3	0.1	..*
" "C"	3.6	1.7	1.0	0.7	0.4	0.2	0.1

* Less than 0.1 cwts. per acre.

The study of the comparative cutting efficiency of the various machines was inconclusive, and failed to establish whether cutter-rowers are more efficient than general purpose mowers in respect of the weight of peas left in the stubble. The question of whether the additional costs of owning and using cutter-rowers on less than the break-even cost acreages can be recouped by more effective cutting therefore remains unsettled

Precise information on the way the value of vining pea crops changes with increasing maturity under the conditions found in this country is not available. This is to be regretted since the way in which yield increases and quality changes interact to produce changes in sale value is a matter of constant concern to growers, and essential to the solution of the second aspect of the problem in hand, namely how far *more rapid cutting* can be expected to result in the value of the crop being enhanced.[4]

The following table is based on an authoratative estimate of the interaction between yield and quality changes, and their effect on sale value when the peas are bought at the sliding scale of prices shown. The estimate of the percentage of the maximum crop at the various tenderometer readings is based on observations made on maincrop varieties in the 1952 season. For the purpose of converting these percentages into actual yield estimates the maximum yield was assumed to be 34 hundredweights to the acre.

ESTIMATED CHANGE IN YIELD AND GROSS RETURN PER ACRE
MAINCROP VARIETIES

TABLE 28

Tenderometer reading	Percentage of maximum yield	Actual yield (cwts.peracre)	Price scale (shillings per cwt.)	Gross return (£'s per acre)
86 - 90	68	23.0	47.5	55
91 - 95	75	25.5	47.5	61
96 - 100	81	27.6	47.5	66
101 - 105	85	28.9	45.5	66
106 - 110	88	30.0	43.5	65
111 - 115	91	31.0	41.5	64
116 - 120	94	32.0	39.5	63
121 - 125	96	32.6	39.5	64
126 - 130	99	33.7	37.0	62
131 - 135	100	34.0	34.5	59
136 - 140	98	33.4	32.0	53
141 - 145	96	32.7	29.5	48

Source: ADAM, W. B. and HOLT, R.; *Experiments with the Tenderometer and Maturometer*, 1953; Fruit and Vegetable Canning and Quick Freezing Research Association; Tech. Memo. No. 4 (new series); Table V.

It will be seen that on this particular scale of prices[5] the gross return rises to a maximum of £66 per acre with tenderometer readings between 96 and 105 and then falls off rapidly as yield increases fail to offset losses in quality, the fall in value being from £1 to £6 per acre for each step of five points on the quality scale. Since it has been shown that at the practical canning stage[6] the daily increase in tenderometer reading is commonly five or more units,[7] and since beyond this stage quality

4 The relationship between value and harvesting date will vary with season, variety and the scale of quality payments, as well as with the degree of maturity at which the crop is cut.

5 The scale agreed by the canners for the 1953 crop season.

6 This is a mainly qualitative concept, defined as the point where deterioration in quality is detectable by tasting. In general, it marks the stage beyond which delay in harvesting will result in an inferior pack. For the grower, it marks the onset of the final stages of maturity acceptable to the canners.

7 ADAM, W. B.; *Experiments with the Tenderometer and Maturometer*, 1954; Fruit and Vegetable Canners and Quick Freezing Research Association; Tech. Memo. No. 7, p.7; February, 1955.

usually deteriorates at an increasing rate, it will be apparent that a day's delay in cutting might easily result in the gross value of the crop falling by several £'s per acre.

In addition, if quality deteriorates too far, the proccssors may not accept the peas for canning and quick freezing, and the sale value of the crop when cut for seed will normally be lower than when it is vined.

It would seem, therefore, that the fact that peas can be cut about twice as fast with specialised cutters as with mowers, might conceivably result in increases in value of the crop sufficient to offset the extra costs of using the former on less than the break-even cost acreage. This would be particularly true in a season such as 1955 when prolonged hot weather caused the peas to mature at an abnormally fast rate.

A Second Mower

Where the acreage of peas is large, and the peas are not sown in small blocks to mature over an extended season, a grower may find that the individual sowings are too large and mature too closely together for his existing mower to cut them all at the optimum time.

The alternatives before him are the purchase of a specialised cutter, or provided a sufficient number of workers are available, the purchase of an additional mower and windrower.

The combined capacity of two mowers is sufficient to cut an acre of peas in 1.2 hours, a slightly faster rate than can, on average, be expected from the smallest cutter-rower, and only slightly slower than the largest specialised machine. Moreover, the additional investment and consequent annual fixed costs would be lower. A 5 ft. mower and a swinging windrower can be bought for a combined outlay of £110, as opposed to £195, £325 and £385 for the three common types of cutter-rowers. On the other hand, the operating costs of two mowers would be higher, since two tractors and four men would be required instead of one tractor and one man.

The problem, then, is to determine the acreage of peas which would have to be cut annually before the reduction in operating costs associated with the use of specialised cutters was sufficient to offset the difference in depreciation and interest charges. Whereas it is permissible to leave the annual fixed costs of an *existing* mower out of account, since it is needed for other tasks, the depreciation and interest charges on the *second* mower and windrower must be included. The calculated acreages below which the purchase of a second mower would prove cheaper than buying a cutter-rower are shown in the following table.

ACREAGES BELOW WHICH THE PURCHASE OF A SECOND MOWER WOULD BE CHEAPER THAN THE PURCHASE OF CUTTER-ROWERS

TABLE 29

Life (years)	Cutter-rower		
	"A"	"B"	"C"
6	30	73	88
10	23	49	59

It would seem, therefore, that growers who find that the rate at which peas can be cut with a general purpose mower is inadequate, would obtain approximately the same cutting capacity as that provided by specialised cutter-rowers by purchasing a second mower and a swinging windrower, and that this would in many circumstances prove cheaper.

Hiring a Contractor

It has been shown that unless a substantial acreage of peas are grown the purchase of specialised cutting equipment is likely to increase the cost of cutting. The use of an existing mower, and if necessary the purchase of a second mower will usually prove to be cheaper. A third alternative is to have cutting done by a contractor.

Current contract rates for pea cutting vary from £2 10s. to £3 per acre for the hire of the cutter and its operator. Growers could always cut their own crops with an existing mower cheaper than this, but it is calculated that with annual acreages of peas smaller than those shown in Table 30, the hiring of a contractor would be less expensive than the purchase and use of any of the three cutter-rowers.[8]

BREAK-EVEN COST ACREAGES BETWEEN HIRING A CONTRACTOR AND THE PURCHASE OF CUTTER-ROWERS

TABLE 30

Per acre contract rate	Cutter-rowers		
	"A"	"B"	"C"
£ s.			
2 10	21	35	41
3 0	17	27	32

Thus growers with less than about 20 acres of vining peas each year would get their peas cut cheaper by a contractor than by purchasing their own cutter-rowers. However, because quite short delays in cutting can result in serious losses in the value of this crop, growers would need to assure themselves of the reliability of the available service before entrusting this job to a contractor.

8 These break-even acreages are given by the formula, $X = \frac{Fm}{C - Vm}$ where X is the break-even cost acreage, *Fm* and *Vm* are, respectively, the annual fixed ownership costs and the variable costs of using a cutter-rower, and *C* is the contract charge.

CHAPTER VI

FINANCIAL INCENTIVES

ONLY A LIMITED USE was made of output incentives in the production of the surveyed crops, and furthermore the payment of piece rates and bonuses was confined exclusively to the operations of harvesting.

Piece rates were paid on only one farm and for only one operation: two workers loading lorries with the aid of a mechanical crop loader were paid at a joint piece rate of 10s. 0d. per load. On the other hand, three systems of bonus payments were in operation, and a brief description and comment on these follows.

Firstly, on a farm where loading was done mechanically, a bonus of 1s. 0d. per load was paid to each of the two men building the loads. Secondly, on the farms in one area, overtime rates were paid to all the men engaged on the harvesting of vining peas, irrespective of the number of hours worked. The third example was of a farm where every man employed on cutting, loading and operating the farm viner was paid a bonus of 2s. 3d. per ton of shelled peas.

If bonuses of this type were intended as incentives to greater effort they are open to the serious criticism that their payment was not directly linked to the rate of working. In the first example, the bonus payment was made irrespective of the speed with which each load was completed. In the second, there was a direct incentive for the workers to work slowly rather than quickly, since the longer the harvesting season was prolonged the longer they would be paid at overtime rates. Similarly in the third example, the slower the harvesting proceeded the more the crop would gain in weight and the greater would be the bonus payments, even though the gross value of the crop to the grower might be falling due to its greater maturity.

Moreover, the second and third systems (overtime rates and tonnage payments), suffered from a second limitation in that they benefited all workers equally without regard to differences in the effort, skill or responsibility required for the accomplishment of the separate tasks. Thus the drivers of the vehicles being loaded received the same additional payments as the men actually loading, but the former had an easy task, the latter a relatively arduous one. Similarly where vining is on the farm, the key worker who sets the pace for the whole of the cutting, loading and vining organisation, is the man forking the peas on to the viner elevator; but by neither of these systems did he receive any greater additional payment than workers having less responsible or heavy tasks.

The best that can be ascribed to bonuses of this type is that they are of a compensatory nature; they give an additional reward to the men, *some* of whom have unusually fatiguing or responsible tasks. They are unlikely to provide direct incentives to greater effort, and they have the additional disadvantage in being inequitably awarded. It is hoped that the standards of performance presented in this report will enable growers to devise more soundly based incentive payments than those which were encountered in this survey.

CHAPTER VII

SUMMARY AND CONCLUSIONS

ALL STAGES OF THE production of vining peas have been extensively mechanised, and the total labour requirements of the crop with existing management practices are low, both in relation to many general farm crops, and to most other vegetable crops. This study has not disclosed any ways in which this labour requirement could be still further reduced. Indeed, the main conclusion which emerges is that the zeal for reducing labour requirements by the employment of chemical methods of weed control and by the mechanisation of harvesting operations, may in some cases have been carried too far.

Weed control falls mainly in May and June, and it is probable that the competition for labour between vining peas and other crops reaches its greatest intensity at this time, for it occurs when a variety of other row crops are requiring singling or cleaning. This may be one reason for the frequency with which growers sprayed their peas with dinoseb, despite the increased direct outlay which the adoption of this practice seems likely, under most conditions, to entail. It has been shown that if the costs of spraying are to be recouped by savings in the labour required for cleaning operations, then substantially more labour must be released than the difference in average labour requirements between sprayed and unsprayed crops recorded in this survey. However, the recorded difference may not be a reliable guide to the savings in labour which can be expected under particular conditions, because in surveys of this type the extent of weed growth and the efficacy of weed control are largely unknown.

Nevertheless the magnitude of the labour savings required to recoup spraying costs have been indicated. So too, have the circumstances under which additional yields (arising from more effective control of weeds in the rows or from the adoption of closer row spacing), or an improvement in the value of the pea crop (due to the quality bonuses earned for a reduced proportion of weed seeds in the shelled peas) could make chemical weed control a profitable practice.

Each of these aspects of weed control is a fertile field for further research, and indeed, a precise analysis of the economy of spraying weedicides must await the results of husbandry experiments directed along these lines. At present, it would seem that there is little justification for growers to regard the use of dinoseb as anything other than an expensive emergency measure which may on occasions be profitably employed on exceptionally weedy crops.

The cutting and loading of vining peas are the operations absorbing the major part of the labour required for the production of the crop. However, they fall at a relatively slack period of the farming year, and imposed no great strain on the labour resources of the majority of the farms covered by this survey. Nevertheless, both operations have been extensively mechanised, and in particular, considerable sums have been invested in specialised cutter-rowers. Whether this investment has always been warranted, is open to question.

A field study of cutting was made with the primary objective of obtaining more reliable standards of performance than those provided by the survey records. These standards formed the basis of an examination of the circumstances under which the purchase and use of each of three common types of cutter-rowers would lead to greater profits than the use of an ordinary general purpose mower, which it may be assumed would form part of the standard equipment on most farms.

It is concluded that whilst the use of cutter-rowers reduces tractor labour requirements by about half, and man labour requirements by three quarters, compared with the use of a mower and tandem-hitched windrower, the savings in operating costs are small in relation to the additional depreciation and interest charges incurred by the purchase of specialised equipment. It is calculated that at least 38 acres of peas must be cut annually before the purchase of even the cheapest cutter-rower would result in lower total costs. Moreover, the acceptance of this figure involves taking a rather optimistic view of the probable repair charges and the useful life of the machines. A more realistic figure would be 70 acres. A comparison of the acreages of peas grown on the surveyed farms with the various break-even cost acreages raises doubts as to whether many growers would not have accomplished their cutting more cheaply with a mower.

It is possible, however, that the ownership of cutter-rowers and their use on less than the break-even cost acreage of peas might be warranted on the grounds that they were technically more efficient than mowers and led to a lower rate of wastage. Whether this situation does in fact exist is not as yet known, and this aspect warrants further examination.

The fact that peas can be cut with a cutter-rower at about twice the rate possible with mowers, may have been an important factor leading many growers to invest in the specialised machines. However, they could obtain the same cutting capacity at lower capital cost by buying a second mower and a swinging windrower. It is calculated that with up to 30 acres of peas to cut annually, this practice would be cheaper. Similarly, as an alternative to the ownership of a cutter-rower the hiring of a contractor would be profitable for all acreages less than about 20. But, the use of an existing mower would be cheaper than paying current contract rates.

In general, it would seem that growers should adopt a cautious approach to the purchase of specialised pea cutting equipment. Only those growers with considerable acreages of peas can expect to find the use of cutter-rowers profitable on the grounds of cost reduction, and unless it can be established that cutter-rowers reduce wastage by a sufficient amount (in relation to the acreage of peas cut), many, if not most, growers would be better advised to use an existing mower, and if necessary, to buy a second.

Growers who already possess a cutter-rower which is being used on an uneconomically small acreage might be able to profit by cutting neighbours' crops at contract rates; and co-operative ownership by a group of neighbouring farmers would similarly seem to be one way in which a sufficient volume of work could be provided. In this latter respect it may be noted that loans are available from the Conditional Aid—Revolving Loan Fund to assist farmers to acquire field machinery for joint use.

A study of the effectiveness of cutting, in terms of the quantity of loose peas and pods left in the stubble, revealed that wastage is a factor of considerable importance. Several features of the design of cutter-rowers are thought to contribute to this undesirable situation and require further investigation.

Many farmers already possess green crop loaders which are used primarily for loading crops other than peas; their use on peas involves little additional expenditure apart from that on repairs, and confers some advantages. The main advantages are firstly, that it makes loading a far less fatiguing task, and secondly, that with a loading gang of limited size a faster rate of loading can be achieved. This last is important in relation to the rapid changes which occur in the value of pea crops where harvesting is for any reason delayed. However, with a sufficiently large number of hand loaders forking from the ground, loading by hand can be as fast or faster than mechanical loading, though the total labour requirement will usually be higher.

PLATE I. Specialised machines cut and windrow peas in one operation, and require only one worker.

PLATE II. The use of a mower and tandem-hitched windrower is a more laborious method, but it is probably cheaper for many growers.

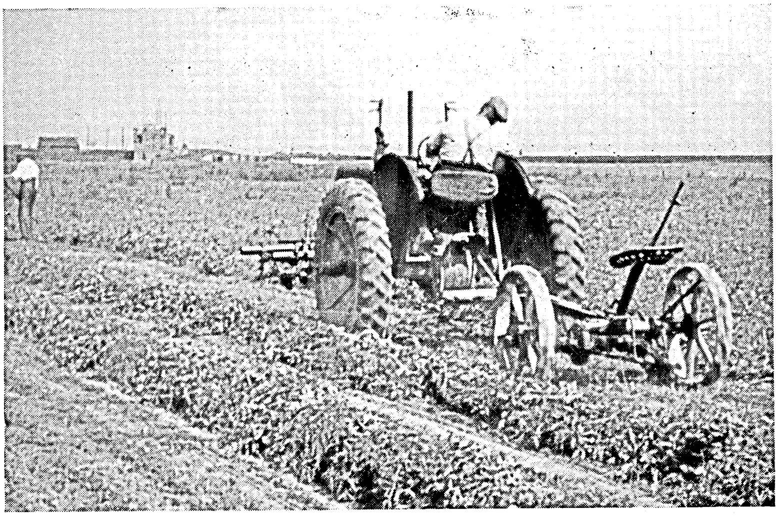


PLATE III. It is doubtful if there is any advantage in having cutting—

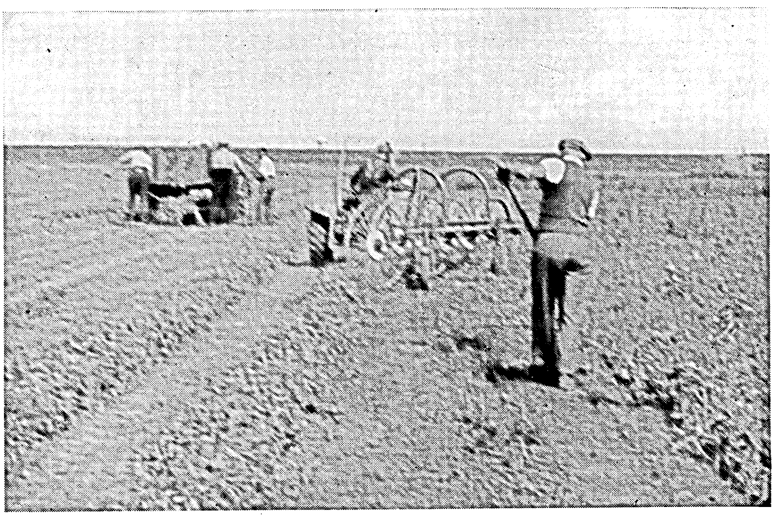


PLATE IV. —and windrowing done as separate operations.

PLATE V. When short bodied vehicles are loaded by rear-hitched crop loaders two workers on the load are sufficient.

PLATE VI. An additional worker makes the job easier when loading long bodied vehicles.

HARVESTING VINING PEAS

PLATE VII. When hand loading for factory vining one man builds the load.

PLATE VIII. With farm vining, smaller loads can be built from the ground.

PART C

PULLING PEAS

CHAPTER VIII

STANDARD LABOUR REQUIREMENTS

THE LABOUR REQUIREMENT standards for pulling pea production are based on survey records of 53 individual crops. In the presentation of the standard labour requirements by the main groups of operations, account has been taken of alternative weed control methods. However, the effect of this on the overall labour requirements of the crop do not appear likely to be large under average conditions, and the seasonal labour requirements presented at the end of the chapter presuppose the more usual practice of controlling weeds without recourse to spraying.

Operational Labour Requirements

Standard labour requirements by the main groups of operations are shown in Table 31. This is followed by an explanation of the derivation of the standards and details of the variations in labour usage recorded between individual crops.

TABLE 31 STANDARD LABOUR REQUIREMENTS Per acre

Operations	Worker hours		Tractor hours
	Sprayed crops	Unsprayed crops	
Preparatory cultivations	5.1		4.9
Drilling	1.9		1.0
Post-establishment cultivations	5.1	8.1	2.3
Total growing	12.1	15.1	8.2
Harvesting	260.0		—

Preparatory Cultivations

The operations included in this group were those undertaken in preparing the land for drilling, i.e. ploughing, discing, cultivating, rotovating, harrowing, rolling and the application of fertilisers, except where fertiliser was drilled with the seed.[1]

Based on a total of 53 crop records, the average labour requirements for preparatory cultivations were 5.1 worker hours[2] and 4.9 tractor hours[3] per acre. The range was from 1.9 worker hours per acre on a field where peas were grown after potatoes without further ploughing, to 10.6 worker hours per acre on a field where a late sown crop of peas was grown after wheat, and preparatory cultivations comprised twice ploughing, including deep ploughing with a single-furrow plough, numerous harrowings, and the application of fertiliser.

1 Only one of the surveyed growers used a fertiliser placement drill; one other used a combine drill.
2 Standard deviation, 1.8 worker hours.
3 Standard deviation, 1.7 tractor hours.

Drilling

In addition to the actual drilling operation, this also included harrowing where harrows were attached to the drill, and the application of fertilisers where these were drilled with the seed.

Based on a total of 50 crop records,[4] the average labour requirements for drilling were 1.9 worker hours[5] and 1.0 tractor hours[6] per acre. The range was from 0.9 worker hours per acre on a field where only two separate sowings were undertaken and the operation was performed by only one man, to 4.0 worker hours per acre on a field sown in four stages and where two men were employed to operate the drill.

Post-establishment Cultivations

The operations included in this group were those undertaken between drilling and harvesting the crop, i.e. hand and mechanical cultivations for the control of weeds, the application of chemical weedkillers, and the application of insecticides.

A total of 51 crop records was used for an analysis of labour requirements, and these were divided into two groups according to whether or not the crop was sprayed with a chemical weedkiller.[7] The average labour requirement for post-establishment operations amongst 13 crops that were sprayed was 5.1 worker hours,[8] and amongst 38 crops that were not sprayed, 8.1 worker hours[9] per acre. On average, therefore, crops that were sprayed required 3.0 worker hours less labour for cleaning than crops that were not sprayed.[10] The average tractor labour requirement based on all 51 records, was 2.3 tractor hours[11] per acre.

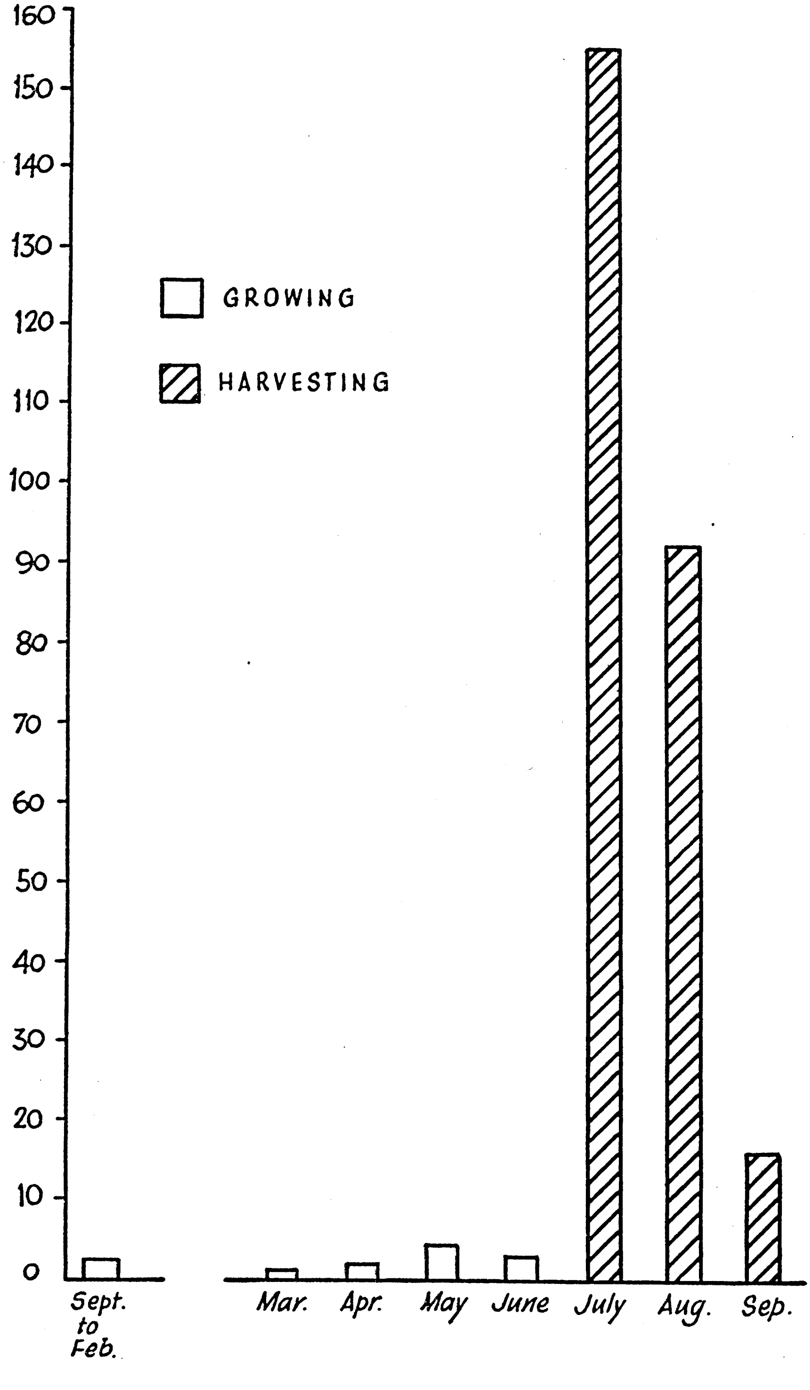
Amongst sprayed crops the range in labour usage was from 1.2 worker hours per acre on a field where, apart from spraying, the only post-establishment operations were a single harrowing and rolling, to 11.9 worker hours per acre on a field where spraying was supplemented by tractor and hand hoeing. Amongst unsprayed crops the range was from 0.3 worker hours per acre on a field where apart from a single harrowing the crop received no attention between drilling and harvesting, to 31.4 worker hours per acre on a field where the crop was steerage hoed twice and, in addition, an exceptionally large amount of hand hoeing was done.

Harvesting

This group of operations included picking, weighing and loading. The computation of standard harvesting labour requirements per acre was complicated by great variation in the marketed yields recorded for individual crops. Furthermore, because in both seasons a proportion of the crops were harvested by produce merchants, and also because a number of the 1954 season crops were not harvested due to the extremely wet weather prevailing at the time, only 30 crop records were available which gave details both of harvesting labour usage and the quantity picked. The average manual labour usage per 40 lbs. bag was computed for each of these, and an overall average of 1.3 workers hours[12] per bag was arrived at

4 Three crops sown by hand were excluded as being unrepresentative of the methods used by the majority of farm-scale growers.
5 Standard deviation, 0.3 worker hours.
6 Standard deviation, 0.6 tractor hours.
7 Two crops were excluded from this analysis since only part of their total acreage was sprayed.
8 Standard deviation, 3.4 worker hours.
9 Standard deviation, 6.7 worker hours.
10 This difference between means is significant at the five per cent level; standard error ± 1.4 worker hours.
11 Standard deviation, 1.3 tractor hours.
12 Standard deviation, 0.3 worker hours.

FIG. 3. PULLING PEA SEASONAL LABOUR REQUIREMENTS
(Worker hours per acre)



from the results so obtained. The marketed yield was then standardised at 200 bags per acre, and the standard labour requirement *per acre,* at this yield level, was obtained by multiplication. For individual crops harvesting labour usage ranged from 0.9 to 1.7 worker hours per bag.

Seasonal Labour Requirements

The overall picture of seasonal labour requirements for pulling pea production is shown in Fig. 3. The procedure followed in arriving at the monthly labour requirements was similar to that employed for other crops dealt with in this report, but it should be noted that this distribution relates to crops not sprayed with chemical weedkillers.

This is, of course, the average pattern for the surveyed crops considered as a whole. It is to be expected that the seasonal distribution of labour requirements for any individual crop would differ from this pattern to some extent, according to the exact timing of the sequence of operations.

Amongst the surveyed crops preparatory cultivations extended from September to June. The preliminary ploughing for 46 of the 53 crops was completed before February, and other types of preparatory cultivation were mostly done immediately prior to sowing during March, April or May.

Drilling extended from February to June. As is the normal practice amongst pea growers, the period of drilling was lengthened by successional sowings; even in individual fields sowings frequently extended over several weeks. For the group as a whole, sowings were almost equally numerous during March, April and May.

Post-establishment operations extended from March to August. Of these, inter-row cultivations made the heaviest demands on labour, and for these May and June were the peak months. The cultivation of the earlier sown crops naturally overlapped to some extent the preparatory cultivations for, and drilling of, the later sown crops, and for the group as a whole more labour was required for cleaning operations in May than in any other month.

The earliest crops from February sowings were harvested in the first two weeks of July, and the latest sown crops in September. But most crops were harvested in late July and early August.

Several salient features of pulling pea production are reflected in the seasonal labour requirements. The growing season is a relatively short one, the time elapsing between drilling and harvesting being, at the most, about four months. Moreover, when the crop reaches maturity, harvesting must be completed within a few days. Labour requirements are very unequally distributed over this short season. An exceedingly pronounced peak occurs during the short harvesting period (in July, August or September), and a very much smaller subsidiary peak during the period of inter-row cultivations (generally in May or June). In practice, successional sowings frequently extend the growing season for the entire crop by one or two additional months, and the harvesting season may be similarly extended. Successional sowings thus tend to spread the work more evenly over the season than would otherwise be the case. Even so, during the harvesting period labour requirements are so great, even on small acreages, that the regular farm staff cannot cope with the situation without the assistance of casual labour, and indeed, considering the surveyed crops as a whole, 95 per cent of the total worker hours used for harvesting were accounted for by casual labour. Female labour was exclusively employed for the actual picking.

CHAPTER IX

FERTILISER PLACEMENT

RECENT EXPERIMENTAL WORK at Rothamsted and elsewhere has shown that on soils where peas respond to fertiliser the response is better when the fertiliser is placed in a concentrated band near the seed than when it is broadcast over the whole of the seed bed. These experiments showed an average gain from fertiliser placement of approximately eight hundred-weights of peas-plus-pods per acre.[1]

The adoption of this practice enables productivity to be increased in two ways. In the first place, since a higher yield can be obtained without any increase in the labour requirement for growing the crop, output per man hour is inevitably increased. In the second place, since combining the application of fertilisers with drilling eliminates the application of fertiliser as a separate operation, the labour previously required to do this is saved.

Placement Equipment

Since the major additional cost of adopting this practice is attributable to the ownership and use of a drill of the type suitable for fertiliser placement, a brief survey of the types currently available and their costs may precede an examination of the circumstances in which fertiliser placement will add to profits. A number of *placement drills* suitable for sowing peas are now on the market. Amongst five different makes concerning which details have been obtained, prices range from £134 for a four-row machine, to £281 for an eleven-row machine. The more expensive machines tend to be more versatile in that they can be used for a wider range of crops and row spacings. A new drill will rarely be acquired solely for sowing peas, and hence choice will be determined not only by price but also by suitability for use in sowing one or more other crops such as corn, roots, or grass seeds.

Most firms offering new placement drills, however, will also supply fertiliser placement conversion kits for existing drills of the same basic type. The costs of conversion depend mainly on the size and type of drill and the number of rows it is desired to use for fertiliser placement. On the basis of a given number of rows, the *combined grain and fertiliser drill* is the cheapest to convert. On this type of drill the fertiliser box is already present, and, in the simplest design, conversion for fertiliser placement merely involves shutting off alternate conductor tubes for seed and fertiliser respectively, and strapping the seed and fertiliser coulters together in pairs to provide for the bands of fertiliser being sown the correct distance from the seed. The cost of this type of conversion ranges amongst three different makes from less than £1 to £2 10s. per row.

The conversion of an *ordinary grain drill* for fertiliser placement involves the addition of a fertiliser box and feed mechanism as well as

1 BULLEN, E. R., DADD, C. V. and COOKE, G. W.; *Fertiliser placement experiments on green peas*; Agriculture; Vol. LXI, No. 1. pages 19 to 22; April, 1954. The authors point out that these experiments were carried out on ordinary arable land where vegetable crops were only occasionally grown. On soils which have received regular heavy dressings of organic or inorganic manures it is unlikely that additional fertiliser will give any sizeable response. Under such conditions fertiliser placement would not have any special merit.

alterations to the conductor tubes and coulters. Hence the costs of conversion are generally considerably greater than for the combined grain and fertiliser drill. However, since the costs of fitting the fertiliser box and feed mechanism are approximately the same irrespective of the number of rows which are adapted for fertiliser placement, the costs of conversion *per row* tend to be higher for a small number than for a larger number of rows. With this type of drill, the costs of conversion to placement on a total of six rows range, amongst three different makes, from £15 10s. to £19 0s. per row. The most expensive of these conversions provides for the placing of two bands of fertiliser with each row of peas, instead of the single band provided for by the other makes. However, there is no evidence at present that the response to fertiliser sown in two bands is any greater than to the same quantity sown in one band.

The type of drill specially designed for sowing root crops in relatively wide drills is also used by some growers for sowing peas. The costs of conversion to fertiliser placement have only been obtained from one manufacturer of this type of drill. For a six-row drill the current cost of the conversion kit is the equivalent of approximately £11 per pea row.

Break-even Cost Acreages

It will be appreciated that the additional costs associated with the ownership of a placement drill will be the same irrespective of the acreage on which it is used. Hence the additional costs *per acre* will be higher on a small acreage than on a large one. By equating these additional (fixed) costs and the additional costs of picking labour, with the expected returns from the sale of additional peas and the saving in tractor running costs, the minimum acreage above which the practice of fertiliser placement is likely to be profitable can be calculated.

For the purposes of working out break-even cost acreages the number of conversion types has been reduced to two by assuming that the costs of conversion are the same both for the ordinary grain drill and the root drill. Hence consideration is confined to these two types of drill on the one hand, and the combined grain and fertiliser drill on the other. In both instances it is assumed that the drill is converted to place fertiliser with six rows of peas.

(*a*) *Conversion of ordinary grain and root drills*

The following assumptions have been made in calculating the break-even cost acreage above which the conversion of this type of drill would be likely to be profitable.

(i) Capital costs of conversion are £15 per row, i.e., £90 in all.
(ii) Working life of the fertiliser placement mechanism is eight years.
(iii) Interest on the investment is charged at six per cent per annum.
(iv) Repairs and the replacement of parts cost 6d. per acre.
(v) Picking costs are 3s. 6d. per 40 lbs. bag.
(vi) Combining operations saves one tractor hour per acre, and tractor running costs are 2s. 9d. per hour.
(vii) Fertiliser is applied at the same rate as before the adoption of the practice of placement, and fertiliser costs therefore remain unchanged.
(viii) Yield response to fertiliser placement is an extra eight hundredweights of peas per acre.
(ix) Net market value of peas at the farm gate is £1 per hundredweight.[2]

2 Based on the average prices received by growers participating in the enquiry.

With this type of drill, the annual fixed costs of the fertiliser placement equipment amount to £14 10s. The additional net revenue left after balancing additional picking and repair costs against tractor running costs saved and additional returns from the sale of peas, amounts to approximately £4 5s. per acre. Thus any grower with a drill of this type, and with more than about $3\frac{1}{2}$ acres of peas should profit by converting the drill to permit fertiliser placement. With relatively large acreages of peas the gain from so doing might be expected to be substantial. For example, on a farm with 20 acres of pulling peas the total additional profit would be of the order of £70 per annum.

(b) Conversion of combined grain and fertiliser drill

The assumptions made in calculating the break-even cost acreage above which the conversion of this type of drill for fertiliser placement would be likely to be profitable are the same as those made in the previous example, except that

(i) Capital costs of conversion are £1 10s. per pea row, i.e. £9 in all,

(ii) In view of the simplicity of the extra equipment and the absence of moving parts, no allowance is made for repairs and replacements.

With this type of drill, the fixed costs of the placement equipment amount to £1 9s. per year, and the additional net revenue left after balancing other additional (variable) costs against costs saved and additional returns from the sale of peas, amounts to approximately £4 6s. per acre. Thus any grower with a drill of this type, and with more than about a third of an acre of peas should profit by converting it to permit fertiliser placement. In practice this means that virtually all growers of peas on a farm-scale can profit from the adoption of this technique. On relatively large acreages the likely gains are again substantial; for example, on a farm with 20 acres of peas the total additional profit might be expected to be of the order of £85.

It is concluded, therefore, that the adoption of the practice of fertiliser placement in pea growing is a potential means of bringing about a substantial addition to profits on many farms. Although the greatest gains are likely to accrue to the farmer adapting a combined grain and fertiliser drill for this purpose, the conversion of an ordinary grain or root drill would be only slightly less profitable.

In view of the clear economic advantages of fertiliser placement it is a surprising fact that of the 21 growers taking part in this enquiry who applied fertilisers to their peas, only one used a placement drill.

CHAPTER X

SUMMARY AND CONCLUSIONS

AT THE GROWING STAGE, labour requirements for pulling peas are not high compared with those of some other vegetable crops dealt with in this report. Nevertheless, most of the required operations have to be performed during periods of the year when, on most farms, the labour force is working under considerable pressure due to the need for attending to other crops. Thus, except for the earliest sown crops, a high proportion of the labour required for preparatory cultivations and drilling has to be found at a time when land preparation and drilling is in progress for spring sown cereals and root crops. Similarly, during the period of post-establishment cultivations, pulling peas may again be competitive for labour with other crops. The majority of the surveyed farms had a relatively high proportion of their land in root crops—on average, approximately 20 per cent of the total acreage of crops and grass—and no doubt these required a good deal of attention during the period of pea cleaning operations.

Under these circumstances, when it seems likely that labour could be profitably employed elsewhere on the farm, any technique seeming to afford even a small reduction in growing labour requirements merits attention. Furthermore, any practice seeming to afford scope for increased production without increasing labour requirements is worthy of examination.

One practice deserving examination on both these counts is chemical weed control as an alternative to hand and mechanical cultivation. It has been shown that, on average, the practice of spraying to destroy weeds can be expected to save at least three worker hours per acre. However, the costs of spraying are comparatively high, especially on small acreages, or when the work is done by a contractor, and it cannot therefore be assumed that spraying is the most profitable method of weed control. The economic problems involved are almost exactly the same whether one is considering the spraying of pulling peas or vining peas, and the reader may refer to another part of this report for a full discussion of these problems.[1] The conclusions regarding the economic merits of spraying are much the same for both types of peas.

Another practice which offers scope both for saving labour and increasing production is fertiliser placement. On farms where fertilisers are applied to the crop, growing labour requirements per acre can be slightly reduced by the employment of a fertiliser placement drill since this enables the application of fertilisers to be combined with drilling. However, a much more important advantage of adopting this practice is that it can be expected to result in a substantial yield increase for a comparatively trifling addition to growing costs on all but the very smallest acreages.

At the harvesting stage pulling peas require more labour than any other commonly grown crop. Moreover, there seems to be little scope at present for reducing harvesting labour requirements, since a practicable

1 See Chapter III.

pea picking machine has yet to be designed. But since pea picking is almost invariably done by casual labour hired specifically for the task, harvesting labour requirements do not have to be closely integrated with the labour requirements of other crops. The main problem is not that of apportioning labour between pea harvesting and other farm tasks, but rather that of assessing casual labour requirements for getting the crop picked at the required time. It is hoped that the harvesting labour requirement standard given in this report will be of some assistance to the less experienced grower in this respect.

In the area of the survey, it is possible for the pea grower to relieve himself of the responsibility of recruiting picking labour by arranging for a merchant to harvest and market the crop. Although no factual information emerged from this enquiry concerning the profitability of this practice, a similar arrangement frequently entered into by growers of autumn cauliflowers is dealt with elsewhere in this report[2] and the discussion to be found there of the conditions under which it is likely to be profitable to a grower to make this type of arrangement, should be of interest to growers of pulling peas.

2 See Chapter XIII.

PART D

AUTUMN CAULIFLOWERS

CHAPTER XI

STANDARD LABOUR REQUIREMENTS

IN PRESENTING standard labour requirements account has been taken of four variants in the practices employed on the sample farms in growing and harvesting autumn cauliflower crops. Important differences existed in the rotational sequence, the acquisition of plants, the method of transplanting and in the methods used for the disposal of the crops.

Operational Labour Requirements

The labour employed in bringing the crop to the point of harvesting has been examined under five groups of operations, and the results are summarised in Table 32.

TABLE 32 STANDARD GROWING LABOUR REQUIREMENTS Per acre

Operations	After early potatoes		After other crops	
	Worker hours	Tractor hours	Worker hours	Tractor hours
Preparatory cultivations	2.5	2.3	7.0	6.6
Plant raising	3.4	0.6	3.4	0.6
Plant pulling	10.2	0.1	10.2	0.1
Transplanting	11.0	2.2	11.0	2.2
Post-establishment cultivations	14.7	3.7	27.8	3.7
Total growing labour	41.8	8.9	59.4	13.2

Preparatory Cultivations.

The operations included in this group comprise ploughing, discing, cultivating and harrowing, and the application of artificial fertilisers.

Autumn cauliflowers grown after early potatoes generally entailed substantially less labour in the preparation of the land for planting than when grown after other crops. This was because after potato lifting the land was left in such a condition that, in most cases, no more than a final harrowing was performed before the cauliflowers were planted.

The 10 crops which were grown after early lifted potatoes required, on average, only 2.5 worker hours [1] and 2.3 tractor hours [2] for preparatory cultivations, whereas the 22 which followed other crops required a full range of preparatory cultivations and absorbed, on average, 7.0 worker hours [3] and 6.6 tractor hours [4] per acre.

The average figures conceal wide differences between individual crops. Thus the highest labour requirement for preparatory cultivations for a crop grown after early potatoes (5.5 worker hours), was higher than the lowest

1 Standard deviation, 1.6 worker hours.
2 Standard deviation, 1.2 tractor hours.
3 Standard deviation, 2.7 worker hours.
4 Standard deviation, 2.4 tractor hours.

labour requirement amongst crops not following potatoes (2.9 worker hours). The first mentioned crop was grown on a small farm run by family labour. After clearing the potatoes the land was ploughed, cultivated and rolled, and a heavy application of fertilisers was given by hand; that is, this crop was treated essentially as if it were a maiden crop in respect of cultivations, and the hand application of fertilisers absorbed a relatively large amount of labour. In contrast, the second of the above mentioned crops was grown on a large, highly mechanised farm. It followed broccoli, and was preceded by ploughing, discing, harrowing, rolling and fertiliser application, but through the use of high powered tractors and large capacity implements, the labour requirement for accomplishing essentially the same operations was only slightly more than half that on the first farm. This indicates that although there is no doubt that the choice of preceding crop usually has a very strong influence on the preparatory labour requirement, other factors may either detract from, or supplement, the advantages that growing cauliflowers as a catch crop after early potatoes confers; and in practice, growers may not always exploit the potential advantages which exist. Nevertheless the difference in average labour requirements between these two groups was too great to be solely attributable to chance variations.[5] Hence growing autumn cauliflowers as a catch crop after early potatoes can be expected to result in an average reduction of 4.5 worker hours and 4.3 tractor hours per acre, compared with growing it after other crops.[6]

Plant Raising

The figures shown in Table 32 for this group of operations are not based solely on the 32 autumn cauliflower records, but on a combined total of 64 records of the labour used in plant raising by growers of autumn cauliflowers, brussels sprouts and savoy cabbage crops. The reason for adopting this procedure was that although there was no apparent reason for supposing that the labour requirement per acre of plant bed would differ materially between these crops, the raising labour requirement per acre established could be expected to bear an inverse relationship to the plant population. Since no consistent trend of this sort was shown by the records obtained for the three crops, despite marked differences in mean plant populations, it was decided to pool all the available information on labour usage in plant raising. The simple average labour re-requirement so obtained was 3.4 worker hours[7] and 0.6 tractor hours[8] per acre of brassicas planted. The operations included comprise preparation of the seed bed, seed sowing and all cleaning operations in the plant bed prior to lifting the plants for transplanting.

Among 27 autumn cauliflower crops the highest labour requirement for plant raising was 14.1 worker hours per acre planted, and the lowest 0.9 worker hours. Such differences as these are almost entirely attributable to varying degrees of cleanliness aimed at and secured in the plant bed. The high labour requirement on the first farm arose from the plant bed being situated on a relatively weedy site, with the result that a gang of men had to resort to crawling the bed with onion hoes in order to prevent the plants succumbing to weed competition. In contrast the plant bed on the second farm was on clean land, and twice through with a "Planet" type push hoe gave a sufficient degree of weed control.

In all cases, preparing the seed bed and sowing the seed absorbed less than half of all the work put into plant raising; hoeing the plant bed absorbed the

5 Differences between means significant at one per cent level.
6 Standard errors, ± 0.9 worker hours; ± 0.6 tractor hours.
7 Standard deviation, 2.8 worker hours.
8 Standard deviation, 0.2 tractor hours.

major part of the total labour input. Growers are well aware of these facts, and within the limits set by availability and suitability of land, and convenience, try to raise their plants on clean land. Nevertheless the examples cited above well illustrate the importance of choosing weed-free sites and timely control of the weeds which inevitably appear; neglect of these precautions can evidently result in a substantial increase in the labour requirement at this stage, most of which is hand work.

Plant Pulling

Only 22 of the 32 records were used for the derivation of the average labour requirement for the operations included under this head. Of the remaining 10 crops, four were grown from purchased plants, and in six records the labour expended on plant pulling was not shown as a separate item.

On average, the labour required for the operations involved in lifting the plants and transporting them to the planting site was 10.2 worker hours[9] per acre planted, with a range from 4.6 to 18.3 worker hours. Expressed another way and taking an average plant population of around 11,000 per acre, plant pulling required a little under one worker hour per thousand plants.

Apart from the actual lifting or pulling, other operations which were involved included sorting, packaging, and transporting the plants from the plant bed to the planting site. The importance of these associated operations differed widely between crops. Most growers insist upon a certain amount of plant sorting being done in the plant bed, so as to present the transplanting gang with a reasonably uniform and easily handled sample of plants. No quantitative measure of the influence of different degrees of sorting on labour requirements was possible, but it is probable that the wide range around the average labour requirement is mainly attributable to the varying amounts of sorting undertaken by individual growers.

On three farms where the plant beds and fields to be planted were at some distance apart, loading and transporting the plants was recorded as a separate item. The labour so expended was less than one worker hour per acre planted in each case. Generally the plants were raised in close proximity to their final stations and often in the same field. Transport of plants in these circumstances was of negligible importance, and was not separately recorded.

Planting

Of the 32 records used in the study of labour requirements, 17 related to crops planted by 3-unit machines, 12 to crops planted by 2-unit machines and the remaining three to crops which were hand planted.

The operation of transplanting was the subject of a field study in both years of the enquiry, and this study was the source of the figures shown in Table 32. Moreover the figures of 11.0 man hours and 2.2 tractor hours refer to a particular set of conditions, namely the use of a 3-unit transplanting machine, operated by a team of five workers transplanting at the rate of a little over 5,000 plants per machine hour, and achieving a plant population of 10,890 per acre.

A discussion of factors affecting the labour requirement of mechanical transplanting is given in some detail in Chapter XII.

Only three crops were transplanted by hand, and in two of the records obtained it was not possible to distinguish between the labour used for planting, and that for lifting the plants. Hence the survey added little to our knowledge of hand transplanting. However, information gathered from a number of

9 Standard deviation, 4.3 worker hours.

growers revealed that before mechanical transplanting was so widely employed, an output of 1,000 planted per hour of overall time by a team of two men – one laying the plants out, the second planting – was regarded as a satisfactory rate of working for men paid by the hour. Using this figure of 500 plants per man hour, an acre of 10,890 plants would require about 22 worker hours, or twice the labour required for mechanical transplanting with a 3-unit, machine[10].

Post-establishment Cultivations

The operations performed after the crops were planted included the filling of gaps, top dressing and hand and mechanical cultivations for the control of weeds.

Weed control operations absorbed by far the major proportion of all labour expended between planting and cutting the crop, but there was a substantial difference in the average amount of labour used to clean crops grown after early lifted potatoes, and those following other crops. Whereas the former absorbed, on average, only 14.7 worker hours[11],the latter required an average of 27.8 hours[12] per acre. That is, the substantial measure of weed control arising from the intensive cultivations associated with growing and lifting potatoes resulted in an average reduction of 13.1 worker hours[13] per acre on cleaning operations in the following crop of cauliflowers.

This saving was achieved in part through a reduction in the number of cleaning operations performed, and partly through the more speedy accomplishment of those operations which were undertaken. For example, one crop taken after early potatoes was brought to maturity without any hand hoeing, twice through with a tractor hoe being the only cultivations performed, and the total post-establishment cultivations absorbed no more than 2.0 worker hours per acre. At the other extreme, a crop grown after wheat was tractor hoed three times and hand hoed twice, and the labour requirement for cleaning was 57.4 worker hours per acre.

However, it is necessary to point out that the highest post-establishment labour requirement amongst crops following early potatoes (42.9 worker hours), was considerably more than the lowest labour requirement amongst those following crops other than potatoes (9.7 worker hours). So that other factors such as the speed and efficiency with which individual operations were performed, the quality of the workers employed, the types and capacities of equipment used, and the state of cleanliness adjudged by individual growers to be desirable, resulted in wide variations around the averages presented. Nevertheless, given the same types of workers and machines, following early potatoes can be expected to result in a reduction in man labour requirements of about 13 worker hours per acre at this stage.

Total Growing Labour Requirements

Table 32 shows that the total labour requirement for autumn cauliflower crops grown after early potatoes was 41.8 worker hours, and for those grown after other crops 59.4 worker hours: similarly the tractor labour requirements were 8.9 and 13.2 hours respectively. That is, compared with maiden crops the average reduction in the amount of labour required to bring catch

10 Records obtained in this study relating to the hand transplanting of ten brassica crops – one autumn cauliflower, three savoy and six brussels sprout crops – showed an average hand planting rate of 477 plants per man hour; the range was from 328 to 674 per man hour.
11 Standard deviation, 12.4 worker hours.
12 ,, ,, 14.6 worker hours.
13 This difference is significant at the five per cent level; standard error, ± 5.3 worker hours.

crops of autumn cauliflowers to the point of harvest was 17.6 worker hours and 4.3 tractor hours per acre.

Harvesting Labour Requirements

Again the 32 records obtained in the survey fall into two distinct groups: those where the crops were cut and marketed by the grower, and those sold standing and cut by merchants. The numbers in each group were 14 and 18 respectively. The operations involved comprised cutting and packing (which were carried out simultaneously in all cases), loading, and transporting the packed heads off the field. All these operations were undertaken by the growers of the 14 crops which were not sold standing. Loading and leading out were performed by the growers of only 12 of the 18 crops which were cut by merchants; in the remaining six cases the merchants not only cut but also undertook the carting off.

No information was obtained about the labour used in cutting and packing merchant-harvested crops; having sold the standing crops the growers took no part in their cutting and were able to supply information only about the labour used for carting the cut crops off the fields. Thus information on cutting was obtained for 14 grower-cut crops, whilst details of the labour required for loading and carting off were obtained from 26 records, i.e., the 14 grower-cut crops and 12 merchant-cut crops.

There were large differences in the marketed yields of crops covered by the survey. This was particularly true in the 1953 season when there was a glut of most autumn vegetable crops, and some growers in the survey had difficulty in finding a market for all the cauliflowers which were potentially saleable. In some cases, cutting had to be highly selective, in others cutting was abandoned before the whole of the crop was cleared. Consequently, the per acre harvesting labour requirement tended to bear a close relationship to the marketed yield, and since this was low, average harvesting labour requirements per acre were also lower than would normally be expected. On the other hand, the average labour requirement per unit number of packages showed less variation than yields. Growers in south-east Lindsey expect to harvest about 400 packages[14] per acre taking one year with another, and this figure was taken as a standard yield in converting the recorded harvesting labour requirements per unit number of packages into *per acre* terms.

On farms where the crops were cut by merchants' men, farm labour was used for loading and leading out at the average rate of 10.2 worker hours[15] per acre. For grower-cut crops, labour was used at the rate of 53.0 worker hours [16] per acre for cutting, loading and carting. This figure is based on 10 of the 14 records relating to grower-cut crops[17]. This high average harvesting rate – about 7.5 packages per man hour – may be attributable to the general employment of the piece work incentive, and to the negligible amount of grading undertaken by growers in the survey. On average, tractors were used at the rate of 4.8 tractor hours[18] per acre during loading and carting, and this figure is based on the records obtained for both grower-cut and merchant-cut crops which were led off by the growers' men.

14 The term "package" includes both mats, crates and boxes. Merchants' mats were by far the most common container, but a few growers marketed trimmed cauliflowers in crates and boxes.
15 Standard deviation, 5.2 worker hours.
16 Standard deviation, 15.9 worker hours.
17 Two records were not used in this analysis because some doubt existed about the exact yield from the recorded fields. Two further records which related to crops grown on market gardens were also excluded, since the crops were cut in small lots to meet a local trade, and the consequent high labour requirements (128.0 and 122.0 worker hours per acre) were not typical of farm-scale production.
18 Standard deviation, 2.5 tractor hours.

STANDARD HARVESTING LABOUR REQUIREMENTS

TABLE 33 Per acre

Worker hours		Tractor hours
Grower-cut crops	Merchant-cut crops	
53.0	10.2	4.8

Thus it would appear that selling a standing crop of cauliflowers, reduced the demands made on the grower's labour force at the rate of 42.8 worker hours, or about five man days, per acre.

Total Labour Requirements

It has been shown in the foregoing sections that the amount of labour used in the production of autumn cauliflowers by the growers in the survey was dependent upon the rotational sequence and the method of sale adopted. Hence any production standards to be used in management planning should take these factors into account, and this is done in Table 34 where four standards of growers' average labour requirements are shown.

STANDARD TOTAL LABOUR REQUIREMENTS

TABLE 34 Per acre

	Worker hours	Tractor hours
After Early Potatoes:		
(i) Crop cut by grower	94.8	13.7
(ii) „ „ merchant	52.0	13.7
After Other Crops:		
(iii) Crop cut by grower	112.4	18.0
(iv) „ „ merchant	69.6	18.0

Two further factors affecting total labour requirements, which though not shown in the tables may properly be brought into account, are the practices of purchasing plants and transplanting by hand. The former can be expected to reduce total labour requirements by 13.6 worker hours per acre: whilst it is estimated that hand transplanting requires about 11 worker hours per acre more labour than mechanical transplanting with a 3-unit machine.

Seasonal Labour Requirements

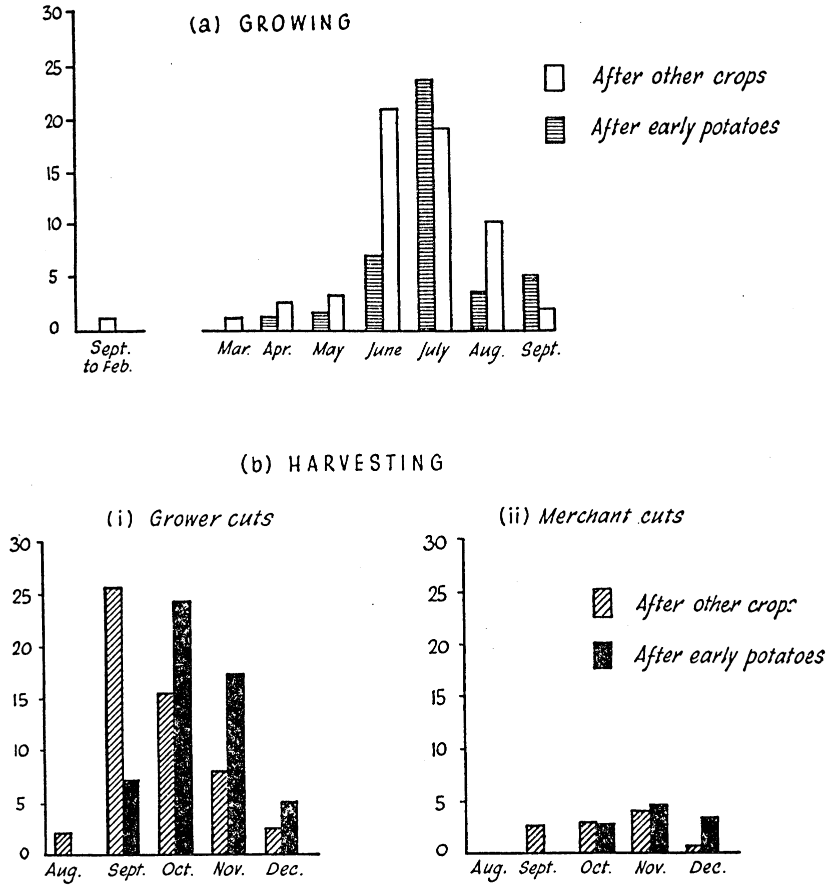
The procedure adopted in the analysis of seasonal labour requirements may be briefly outlined as follows.

Growing and harvesting labour usage were examined separately. All 32 records were first divided into two groups according to whether the cauliflowers were preceded by early potatoes or by other crops. For each group the average monthly growing labour usage was found by dividing the total of the per acre labour usages in each month by the number of records in the group. Within each of the above groups, two further sub-groups were made according to whether the crop was cut by the grower or by a merchant, and four sets of average monthly harvesting labour distributions were obtained. The second step was to distribute the labour requirement standards for growing and harvesting given above, over the months when, and in the same proportions as the first stage of the analysis had shown that labour had in fact been used on the surveyed crops. The results of this analysis are depicted in Fig. 4.

Preparatory cultivations started in the autumn for maiden crops but no

FIG. 4. AUTUMN CAULIFLOWER SEASONAL LABOUR REQUIREMENTS

(Worker hours per acre)



work was done for any crop which followed early potatoes until April. At this date preparation of the plant bed and seed sowing were common to both groups. Cleaning of the plant bed was mainly in May, but in addition some preparatory cultivations were still being done on those few crops which followed late cleared broccoli and spring greens.

Plant pulling and transplanting were mainly undertaken by the "after other crops" group in June, but these operations were delayed on those crops which were planted after early potatoes, until July. With this latter group the end of June was occupied by the few preparatory cultivations undertaken.

The delay of approximately one month in planting dates between the "after other crops" group and those where cauliflowers followed early potatoes, was traceable throughout the growing and harvesting season. Thus cleaning operations, which absorbed a major part of the summer work, were mainly in July and August for the earlier planted crops, and August and September for the catch crops. The diagrams also reflect the reduction in labour requirements associated with following early potatoes. Thus the labour requirement in July for the crops which did not follow early potatoes, was hardly less than the peak labour requirement of planting in June and this high level continued through into August. On the other hand the late planted catch crops required less hoeing, and the labour requirement after a comparable interval, i.e., in August, was substantially less.

Harvesting was spread over a considerable period, but it is apparent that the delay of approximately one month in planting those crops which followed early potatoes was still detectable at harvest. Most labour was used in October for cutting and packing those crops which followed early potatoes, whereas the peak of harvesting labour usage in maiden crops fell in September.

CHAPTER XII

A STUDY OF MECHANICAL TRANSPLANTING

THE TRANSPLANTING OF autumn cauliflowers is a key operation in that it requires a substantial amount of labour for its accomplishment, and has to be done at a busy time. The transplanting of maiden crops is undertaken in early June, when the demands on the farm labour force are already heavy, largely on account of sugar beet and potato hoeing. In addition the imminent onset of early potato harvesting makes the accomplishment of transplanting a matter of urgency. The transplanting of catch crops is no less urgent, for there is competition for labour between this and hay making in July, and further, it is necessary to establish the cauliflowers and other transplanted brassicas as rapidly as possible in order that they may have a sufficiently long growing season. Hence there is a real need to accomplish transplanting as quickly and with as little labour as practicable.

Mechanical transplanting has been widely adopted on this account, and is deservedly popular. But the records of labour usage kept by co-operating growers revealed that there were large differences between one farm and another in the time taken to plant an acre of cauliflowers, even where machines of similar design and size where being used. Moreover, some growers were using more men to operate a given sized transplanting machine than others.

It was with the intention of studying the reasons for these differences, and thereby to uncover information which would help growers to get the best out of their transplanting machines, that detailed observations were made on the mechanical planting of 14 autumn cauliflower crops. Seven farms were visited in 1954 and a further seven in the following year, and the combined results are presented in this chapter. Three different makes of machine were encountered in the study, but they all operated on the same principle and the minor differences in construction were not of such a nature as would affect their use or performance.

Much of the information here presented, and the conclusions drawn are equally applicable to the mechanical transplanting of a wide variety of crops; but it will be appreciated that the detailed results refer only to autumn cauliflowers and may not be applicable *in toto* to the mechanical transplanting of other crops, particularly non-brassicas such as leeks and lettuce. Further, the results are not directly applicable to the use of other types of transplanters differing fundamentallv in design or working principle.

RATE OF PLANTING

The overall time taken to cover a unit area is jointly determined by four major factors:

(i) distance between rows

(ii) tractor speed whilst the machine is in work

(iii) relationship between the time the machine is working, and the time "lost" through stoppages and turning on the headlands

(iv) size of the machine.

The first point needs little comment; clearly other things being equal, the wider rows are apart the faster will a unit area be covered.

Tractor Speed

Tractor speed is determined by the interaction of two factors:

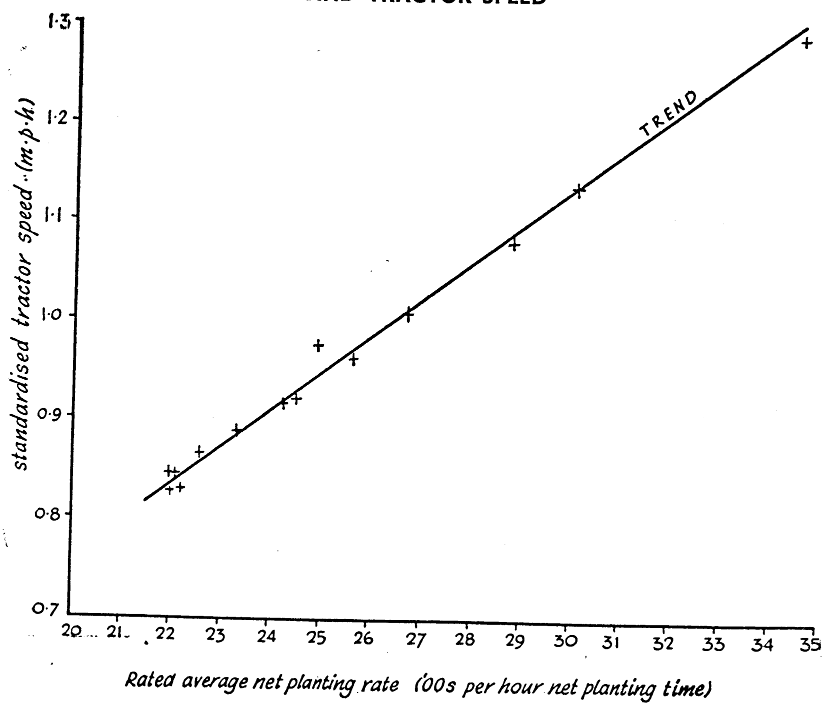
(i) the mean spacing which is required between plants in the row to give the desired plant population at the existing row width.

(ii) the rate at which the planters can handle the plants consistent with effective planting.

Because the operators on a transplanting machine work independently, each tends to develop his own rhythm or tempo in the performance of the repetitive actions involved in planting[1]. Within limits this rhythm is not affected by the speed at which the machine is travelling, and variations in tractor speed result in variations in the spacing of plants in the row. That is, tractor speed and the rate at which a unit area or number of plants is planted are directly proportional to the distance apart of plants in the row; but the rate at which the planters handle the plants is unaffected by variations in the spacing between plants.

It follows that the faster the team handle the plants the faster the tractor can travel. Hence when making comparisons between teams on different farms, a distinction must be made between differences attributable to varying

FIG. 5. RELATIONSHIP BETWEEN NET PLANTING RATE AND TRACTOR SPEED



1 Thus it was found that the fastest workers were planting from two to 20 per cent more plants per hour of net planting time than the slowest members of the team.

plant populations and those resulting from other factors such as differing degrees of skill and effort on the part of the workers. Clearly it is the latter type of differences which are of most interest. The influence of varying plant populations on tractor speed have therefore been eliminated by multiplying the observed mean tractor speed whilst working in the row, by the ratio of a standard spacing of 24 inches to the actual mean observed spacing.

It is then possible to seek a direct relationship between the rate at which the planters handled the plants and the tractor speed. That there was such a relationship is revealed by Fig. 5 where standardised tractor speeds are plotted against the average rate of planting per planter per hour of net planting time, for each of the 14 teams. It will be seen that as the rate at which plants were handled increased, the speed of the tractor was increased proportionately (over the ranges encountered).

At this point it may also be noted that since individual members of a team differ in dexterity, experience and effort, it is apparent that whatever the tractor speed, it cannot suit all workers equally well. If it is such that the slowest planter can just space the plants sufficiently closely so that his mean spacing will give the desired plant population, then the other, faster, planters must either be planting too closely, or planting at a slower rate than that of which they are capable, in order to place the plants at the correct mean spacing. Conversely, if tractor speed is such that the fastest planter is achieving the correct mean spacing, his slower companions will be planting at a spacing wider than that desired. In the former case the desired plant population may be achieved or exceeded; in the latter case a gain in the rate of planting a given area will be obtained at the expense of some loss in plant population. Hence in practice, it will be unlikely that each individual planter will be planting exactly at the mean desired spacing and discrepancies between the desired and the actual plant populations will be the rule rather than the exception.

Net Planting Rate

The rate at which the planters work is determined by a large number of factors, including their inherent dexterity, their experience, and the effort they apply to the task. For the purpose of arriving at a useful standard of performance for use in management planning an attempt was made to minimise the influence of this last factor by a simple system of "rating", whereby the observed planting rates for the teams were adjusted either upwards or downwards according to whether the observer judged a particular team was expending a "normal" or "abnormal" amount of effort. The "norm" was the rate at which effort would be applied by experienced and conscientious workers planting throughout normal length days, when paid at time rates, and with proper provision for rest periods. It will be appreciated that such an adjustment is highly subjective in its application, but this necessary defect was minimised by two observers making independent assessments of the rating factors to be applied. Since a substantial measure of agreement and uniformity was the result, it was concluded that the adjustments made to the actual figures for any one team were reasonably based.

Even after making these adjustments, considerable differences remained between the net rates at which the teams on different farms were planting; it is thought that these differences are mainly attributable to varying degrees of skill. As shown in Table 35, the highest rate of planting was on Farm No. 4, where the team was planting at an average rate of 3,460 plants per planter per hour of net planting time. The slowest rate was on Farms Nos. 13 and 14, where the teams were planting at an average rate of 2,200 plants per planter per hour of net planting time. The average for all farms was 2,530 plants planted by each planter per hour of net planting time.

TABLE 35

MECHANICAL TRANSPLANTING, INDIVIDUAL PERFORMANCES

Farm No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14
No. of units	TWO			THREE										
No. of workers in team	4	4	3	5	5	4	5	4	5	5	5	5	4	4
Rated average no. planted per planter														
(i) per hour net planting time	3,010	2,880	2,430	3,460	2,670	2,560	2,490	2,450	2,330	2,260	2,220	2,210	2,200	2,200
(ii) per hour overall time	2,190	2,370	1,790	2,130	2,140	2,140	1,920	1,970	1,670	1,470	1,490	1,680	1,430	1,770
Rated average no. planted per machine hour														
(i) per hour net planting time	6,020	5,760	4,850	10,380	8,010	7,680	7,470	7,350	6,990	6,780	6,660	6,630	6,600	6,600
(ii) per hour overall time	4,380	4,740	3,580	6,390	6,420	6,420	5,760	5,910	5,010	4,410	4,470	5,040	4,290	5,310
Rated average no. planted per worker hour														
(i) per hour net planting time	1,500	1,440	1,620	2,070	1,600	1,920	1,490	1,840	1,400	1,360	1,330	1,330	1,650	1,650
(ii) per hour overall time	1,095	1,190	1,190	1,280	1,290	1,610	1,150	1,480	1,000	880	890	1,010	1,070	1,330
Average no. of machine hours per acre at standard spacing	2.5	2.3	3.1	1.7	1.7	1.7	1.9	1.8	2.2	2.5	2.4	2.2	2.6	2.1
Average tractor speed at standard spacing (m.p.h.)	1.1	1.1	0.9	1.3	1.0	1.0	1.0	0.9	0.9	0.9	0.8	0.9	0.9	0.8
Per cent of each hour														
(i) planting	73	83	74	62	80	84	77	80	72	65	67	76	65	80
(ii) stopped in row	—	1	—	7	—	—	9	2	2	—	1	3	2	—
(iii) on headland	27	16	26	31	20	16	14	18	26	35	32	21	33	20

Overall Planting Rate

However, a high rate of working whilst actually planting will not ensure a high rate of planting per hour of *overall* time if a large proportion of each hour is spent in turning and loading the machine with plants on the headlands, or if time is lost through stoppages in the row. Therefore, as a measure of actual performance, and as a guide to a satisfactory standard rate of working, the average number of plants set by each planter per hour of overall time is to be preferred. This ranged from 2,370 to 1,430 plants per planter per hour of overall time, with an average for all teams of 1,870 plants per planter. Reference to Table 35 will show that although the planters on Farm No. 4 had the highest average rate of planting per hour of *net* planting time, they were engaged on planting for only 62 per cent of their total time in the field and their performance per hour of *overall* time was not the highest.

On average only 74 per cent of the total time the machines were in the field was occupied in actual planting; stoppages in the row accounted for a further two per cent of overall time, and the remaining 24 per cent was required for turning the machine on the headlands and refilling the plant boxes.

There were three main causes of stoppages in the row:

(i) Under damp soil conditions there was a tendency for moist soil to cling to the press wheels and eventually to stop them turning. This was observed even where the wheels were fitted with a scraping device, and the provision of a more effective scraper is a problem of design requiring attention.

(ii) Due to the low tractor speeds employed some time was lost through engine-stalling. The incidence of this was most noticeable where paraffin-burning tractors were in use; petrol and diesel fuelled tractors were more satisfactory in this respect, particularly the latter which have the ability to "hang-on" at low engine speeds. The provision of a reduction gear reduced stalling, and the use of tractors with self-starters made it less of a nuisance and hindrance.

(iii) Occasionally the supply of plants on the machines was exhausted before the end of the row was reached, and the teams had to wait until more were fetched from the headland. This is an organisational problem which could be avoided by ensuring that there were sufficient plants on the machine for the length of row to be planted.

Turning and associated operations occupied about one quarter of overall time. Other things being equal, the number of times it will be necessary to turn the machine will be lower for a given acreage, when the rows are long than when they are short. It follows that whenever possible the rows should run parallel to the longest side of the field.

Two other factors can help to reduce the time spent on the headlands. Firstly, the use of independent wheel brakes facilitates turning and manoeuvring of the tractor; secondly, by ensuring that the supply of fresh plants are positioned at convenient points along the headland the time spent in re-loading the planting machine may be minimised.

However, transplanting can be a fatiguing task, imposing strains on the backs and legs of the workers. The interval on the headland is properly regarded, in part, as an opportunity for a short rest, and for this reason it should not and cannot be drastically curtailed.

Size of Machine

The third factor jointly determining the speed with which transplanting proceeds is the size of the machine, that is, the number of units in use.

Three-unit machines were more commonly employed than 2-unit machines both on the farms visited for this special study, and also on those taking part in the enquiry as a whole. Other things being equal, planting with a 3-unit machine can be expected to proceed faster than with one of only two units. Moreover, the output per man hour will tend to be higher with a 3-unit transplanter, since the tractor driver's labour (and the time of the feeder where such a worker is employed), is spread over the output of three planters instead of two.

But "other things" rarely are equal, and it is interesting to note that the results include examples of 2-unit machines working under good conditions, achieving a higher rate of performance than 3-unit machines being used in relatively unfavourable circumstances. For instance, the number of plants planted per hour of overall time by the team on Farm No. 2 (4,740), was higher than the number planted by the team operating a 3-unit machine on Farm No. 10 (4,410). Two reasons for this were, firstly that the individual workers on Farm No. 2 were planting at a higher average rate per hour of net planting time, and secondly, because the rows on this farm were twice as long as those on Farm No. 10, the machine was making fewer turns and spending less time on the headlands per unit area planted. These advantages combined to give a higher planting rate per hour of overall time for the smaller machine, even though as a result of having the extra unit, the number planted per hour of net planting time was greater on Farm No. 10.

It is conceivable that in circumstances where the output of a 3-unit machine was limited by the slowness of one particularly unskilled planter, the speed of planting might be increased if this worker and his unit were dispensed with, thus enabling the remaining two planters to work at their optimum rates.

Standard Planting Rate

The average rate of planting was 1,870 plants set by each planter per hour of overall time, and this figure may be taken as a basis for a standard rate. "Overall time" includes all working time and short rest periods taken on the headlands between planting runs. If the figure of 1,870 is arbitrarily reduced by 10 per cent to allow for getting to and from the field, hitching tractors, breaks for refreshment, and unforeseen interruptions, the resultant figure of 1,680 plants set by each planter per hour of overall time may be used for several purposes in management planning.

The standard rate of transplanting can be used to estimate the *time required* to plant a given acreage with various sized machines and plant populations. For instance, with a population of 10,890 plants per acre[2], an acre of cauliflowers would be planted in about 2.2 hours with three units and 3.2 hours with a 2-unit transplanter. Or, the area covered in a day of eight and a half hours could be expected to be just under four acres with a 3-unit, and a little over two and a half acres with a 2-unit machine. Similarly, for a given sized transplanting machine the number of planting days required to establish any number of plants or acreage, can be computed.

The standard can also be an aid in the formulation of *incentive payments*. If the object of using the piecework incentive is to reduce the cost of transplanting, the piece rate must be lower than that rate at which the total labour cost is just equal to the cost when performed by hourly paid workers. This upper rate may be described as the break-even cost piece rate. Thus taking the figure of 1,680 plants per planter, the output of a 3-unit machine under average conditions would be 5,040 plants per hour of overall time, or 1,008 per man hour when the team consisted of five workers. Therefore at the current

[2] This was the plant population most frequently encountered in the enquiry: given by a spacing of 24 inches by 24 inches.

wage rate for adult male workers[3] the break-even cost piece rate per thousand plants is given by

$$\frac{£7\ 1s.}{47} \times \frac{1{,}000}{1{,}008} = 2s.\ 10d.\ \text{per } 1{,}000 \text{ plants.}$$

That is, if growers wish to reduce the labour cost of transplanting by having it done at piece rates, then under average conditions, they cannot offer rates higher than the above.

Finally, *standard labour requirements* may be estimated on the basis of the average performance of the transplanting teams on the 14 farms. Table 36 shows the estimated total labour requirements for the use of machines having from two to four units, with and without a feeder, and where the plant population is 10,890 per acre. This approach undoubtedly involves an element of over-simplification, for instance in assuming that operators work at the same rate when in larger gangs as when fewer workers are present, and also by taking no account of any relationship between turning time and the size of the machine. Nevertheless, it provides a reasonably accurate basis for management planning, and in particular for examining the circumstances in which the purchase of transplanters is likely to be profitable (see Chapter XIII).

MECHANICAL TRANSPLANTING ESTIMATED LABOUR REQUIREMENTS

TABLE 36

No. of units	Team output (plants per hour of overall time)	Machine hours per acre	Estimated labour requirements (worker hours per acre)	
			With feeder	Without feeder
2	3,360	3.2	12.8	9.6
3	5,040	2.2	11.0	8.8
4	6,720	1.6	9.6	8.0

ELIMINATING THE "FEEDER"

The most usual practice with the type of transplanting machine observed is to have a team consisting of a tractor driver, a planter to each unit, and a "feeder" handing plants from containers carried on the machine to those planting. Thus a 2-unit machine is commonly operated by four workers, and a 3-unit machine by five. As the number of units increases beyond three, it is sometimes necessary to have more than one feeder. Thus a 4-unit machine might have one or two feeders, and a total of six or seven workers.

Task analyses on three farms where feeders were employed on 3-unit machines, showed that the feeders were engaged in handing plants to the planters and taking more plants from the carrying boxes for only two thirds of the time the machines were at work in the row, and were simply holding plants for one third of the time. Feeders on 2-unit machines would be even less fully occupied.

However, the proportion of time actually engaged in directly productive movement is not in itself a sufficient criterion on which the need for a feeder can be assessed. If no alternative method of supplying plants to the planters exists, then the feeder's presence is essential regardless of the distribution of his time between performing the more obviously productive operations and the intervals between these. But the study revealed that some growers have succeeded in arranging for the planters to maintain their own supply of plants by a variety of simple adaptations to their machines, and have thereby eliminated the need for a feeder.

3 £7 1s. per week of 47 working hours, as from January, 1957.

One of the simplest yet most effective devices was that shown in Plate XI (Farm No. 6). Two canvas slings had been fastened between two of the units. The plants for the right hand and centre planters were carried on these slings. A simple angle-iron extension had been welded to the framework of the left hand unit and this carried a chitting tray holding plants for the left hand planter. All three planters inserted plants with their right hands, and it was easy for them to take more plants from the slings and tray with their left hands as the last plant from the previous handful was being inserted with the right (see centre planter in Plate XI.

In Plate XII is shown yet another simple innovation, where a small crate filled with plants was placed in front of each planter. Again the planters had no difficulty in maintaining their own supply of plants, though the relatively slow rate of planting on this farm (No. 13) may have concealed difficulties which could have arisen at faster rates of work. In particular, the relatively small space between the boxes and the press wheels for insertion of the planters' arms might be a distinct disadvantage at higher rates of planting.

Plates XIII and XIV illustrate equally simple but highly effective arrangements.

It is, therefore, quite clear that the presence of the feeder is not essential, and it would seem that his elimination by means of some such simple devices as those described is one of the most promising ways in which the costs of transplanting with this type of machine may be reduced, and the release of one person for work elsewhere on the farm secured. There is no evidence that the speed and quality of transplanting is adversely affected by so doing.

PLANTING EFFICIENCY

The study disclosed large differences in the number of cauliflowers that growers aimed to establish on each acre. The average theoretical plant population amongst 38 crops covered by the general enquiry and the special study of transplanting was 10,250. There was a range from 14,520 given by a spacing of 24 inches in the row and 18 inches between plants in the row, to 6,970 where the spacing was 30 inches each way: but the most frequently encountered population was 10,890, obtained when the rows were 24 inches wide and the plants 24 inches apart in the row. The distribution for all crops was as follows.

FREQUENCY DISTRIBUTION OF DESIRED PLANT POPULATIONS

TABLE 37

Desired plant population	No. of crops
Less than 7,000	1
7,000 to 7,999	4
8,000 „ 8,999	3
9,000 „ 9,999	8
10,000 „ 10,999	14
11,000 „ 11,999	3
12,000 „ 12,999	1
13,000 „ 13,999	3
14,000 or more	1

There appear to be very wide differences of opinion between one grower and another as to what constitutes the most profitable level of plant population, even where the same varieties are being grown on neighbouring farms with similar soils. It appears, however, that this problem has not been subjected to any extensive research. One limited observational study indicated that spacing broccoli at 36 inches square gave larger and better quality curds than planting on either 30 or 24 inch squares, but led to the comment ". . . it is doubtful from an economic viewpoint if the improved quality would compensate for the smaller number of heads per acre"[4]. On the other hand, an investigation into the economics of broccoli production in Cornwall found some slight evidence that the proportion of heads marketed tended to be higher with the wider spacings, and so did the absolute yield[5].

Because only a proportion of the potentially marketable heads were sold from some of the crops, and because of the absence of yield data from crops sold standing to produce merchants, no further light can be shed on this very important problem of what level of plant population is likely to yield the highest economic return, from information obtained in this enquiry. Instead the purpose of this section is to show how close the users of mechanical transplanters came to establishing the plant populations they desired, and to discuss some of the reasons for their frequent failure to achieve this object.

Desired and Actual Populations

Table 38 shows for each of the 14 farms where transplanting was studied, the discrepancy between the spacing and plant population at which the growers stated they were aiming, and those which were actually achieved. It will be seen that seven of the transplanting teams were exceeding the desired plant population and six were putting fewer plants on each acre than was intended: on only one farm were the intended and the actual mean populations the same. The average shortfall on the six farms where the plant population was lower than intended was 1,900 plants per acre, the average "excess" on the seven farms where the actual mean spacing was closer than that at which the planters were aiming, was 866 plants per acre.

Discrepancies between the desired and the achieved plant population may be due either to the distance between rows being greater or less than desired, or to the mean spacing between plants in the row diverging from that desired.

On the majority of farms the rows were accurately spaced and this was attributable to the general use of markers. The one important exception was on Farm No. 2, where the transplanter units were found on measurement to be two inches further apart than was the intention. This alone would have decreased the plant population by 400 plants had it been the only inaccuracy, illustrating that inadequate care in spacing the units on the tool bar can have a marked effect on the plant population.

Inaccurate spacing between plants in the row was by far the most important cause of discrepancies between intended and actual plant populations. Examination of Table 38 will reveal that on only one farm was the actual mean spacing between plants in the row exactly equal to the desired mean; on six farms it was greater, and on seven farms the actual mean spacing was less than desired.

Regularity of Spacing

The spacing between a very large number of individual plants was measured on each of the seven farms visited in the second year of the study. The result of this work is summarised in Fig. 6. This shows the percentage frequency distribution of the deviations from the actual mean of the spacings between the individual plants set by 19 planters.

[4] WOOD, P. D.; *Broccoli spacing and top dressing*; Rosewarne Experimental Horticulture Station, First Report, 1952-55; page 20; January, 1957.

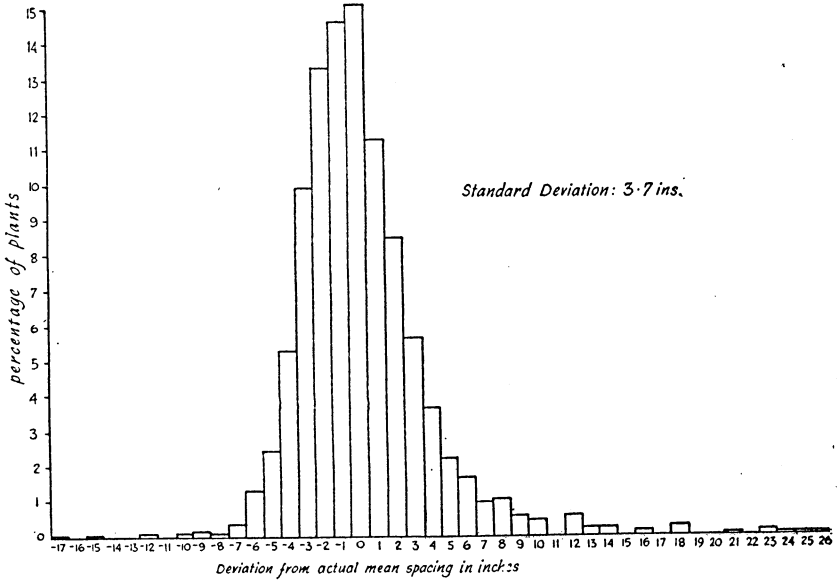
[5] COLE, H. M.; *Broccoli cost investigation in Cornwall*, 1952-53; University of Bristol, Department of Agricultural Economics; May, 1954.

TABLE 38 MECHANICAL TRANSPLANTING—INACCURATE SPACING AND THE EFFECT ON PLANT POPULATIONS

Farm No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Average spacing (ins.)*														
(i) desired	24×18	33×27	25×20	26×18	27×24	28×24	27×24	27×24	26×21	26×20	26×26	26×20	27×24	26×24
(ii) actual	24×20	35×21	25×23	26×20	27×21½	27½×23½	27×23	27×23	26×27	26×25	26×24½	26×24	27×24	25½×21
Plant population (per acre)														
(i) desired	14,520	7,040	12,545	13,403	9,680	9,334	9,680	9.680	11,488	12,063	9,279	12,063	9,680	10,052
(ii) actual	13,068	8,534	10,909	12,063	10,806	9,706	10,100	10,100	8,935	9,650	9,847	10,052	9,680	11,714
Difference	−1,452	+1,494	−1,636	−1,340	+1,126	+372	+420	+420	−2,553	−2,413	+568	−2,011	—	−1,662

* The first figure for each farm refers to the inter-row distance, the second to the spacing between plants in the row.

FIG. 6. DISTRIBUTION OF PLANT SPACING ABOUT THE ACTUAL MEAN
19 Planters



It is apparent that discrepancies between the desired spacing and the mean actual spacing were not primarily due to the exceptionally wide or close spacing of a few plants, but to small errors in the spacing of the great majority of plants.

There were wide differences in the degree of regularity in the spacing of plants, between workers in any one team and between different teams. Table 39 shows the standard deviation from the mean actual spacing of the plants set by each of 19 individual planters, and for the members of each team considered collectively.

MECHANICAL TRANSPLANTING - STANDARD DEVIATIONS OF THE DISTRIBUTION ABOUT INDIVIDUAL PLANTER AND TEAM MEAN SPACINGS

TABLE 39 inches

Farm No.	Planter			Team
	Left	Centre	Right	
2	3.6	—	2.8	3.2
3	3.6	—	3.9	3.9
5	2.8	3.6	2.6	3.7
6	1.8	2.5	2.6	2.3
10	3.0	2.9	2.9	3.0
12	3.6	4.2	2.3	3.8
14	2.9	3.2	5.1	4.0

Figs. 7 and 8 show the distribution patterns for each of six workers in the teams on Farms Nos. 6 and 14[6] and for each team as a whole. The variation in the degree of uniformity of spacing achieved by workers in the same

[6] Both teams were aiming at the same spacing of 24 inches between plants: neither had a feeder nor used a clicker timing device.

FIG. 7. DEVIATIONS FROM THE ACTUAL MEAN SPACING

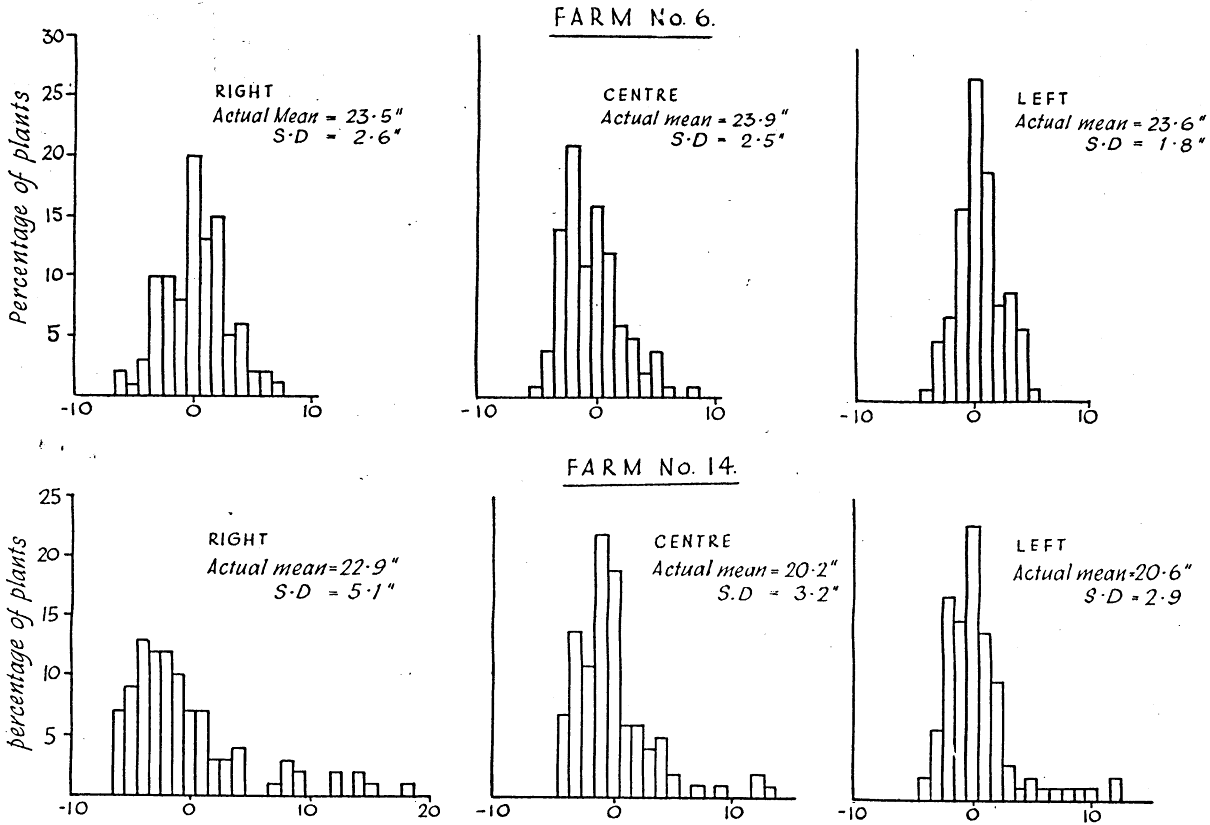
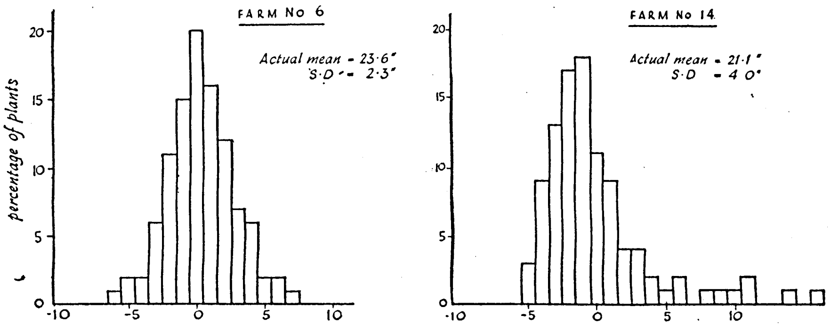


FIG. 8. DEVIATIONS FROM THE ACTUAL MEAN SPACING
(Two teams)



team is evident from a comparison of the distribution diagrams for the right hand planter with those for the centre and left hand planters on Farm No. 14. In contrast, there was a much greater degree of regularity of spacing between the planters on Farm No. 6.

If tractor speed is altered as a means to bringing the mean actual spacing closer to the desired mean, there is unlikely to be any marked change in the shape of the distribution pattern of spacing between plants set by each planter. Nor, as has been pointed out elsewhere, will it result in each member of the team achieving the mean desired spacing and hence the desired population. The result of adjusting tractor speed will be to equate the mean spacing for *the team as a whole* with the desired mean. The more skilful planters will be planting closer than desired, the less skilful wider than desired. A correct plant population will result when the "excesses" of the one just compensate for the "losses" of the other, but the degree of irregularity of spacing between the plants set by each planter will remain substantially the same irrespective of tractor speed.

The effect of irregular spacing on the growth and quality of cauliflowers, is not known. *A priori* reasoning would suggest that regular spacing is advantageous and will result in more uniform growth and maturity of the crop; but what this means in terms of increased value and hence the limits of the extra costs that growers can profitably incur to secure it, must remain a matter for conjecture.

Whether regularity of spacing should be an end in itself or not, is therefore in doubt. But there is no doubt that it is a means to the desirable end of achieving a correct plant population, and from this aspect four ways in which growers tried to minimise discrepancies between desired and actual population by securing a greater degree of regularity of spacing in the row, can be discussed.

Gapping Up

Once transplanting has been completed the only way in which the plant population can be brought up to, or reduced to, the desired level, is by going over the field a second time inserting plants in spaces which are excessively wide, and removing plants where the spacing is too close. In practice a deliberate effort is rarely made to remove plants which are too close, though the occasional "doubles" may be reduced to single plants during hoeing. On the other hand gapping up is commonly performed, partly to make good deficiencies in population by inserting plants in any sufficiently wide space, and partly to replace plants which have died. Examination of Fig. 6 will show that the range of excessively wide spacings was greater than the exceptionally close, indicating that the opportunity for correcting discrepancies in plant population by inserting additional plants is in any case greater than by removing plants which are too close.

The distribution of spacings amongst the 19 planters can be used to give an approximate measure of the number of plants which can on average be inserted during gapping up, without adversely affecting their growth or those of adjacent plants. The overall average actual spacing amongst the planters was 23.0 inches. Taking an arbitrary figure of 18 inches as being the closest spacing permissible between plants in the row, the proportion of spacings sufficiently wide to accommodate an additional plant without leaving two plants at less than 18 inches apart was 1.5 per cent. At the most usual intended population of 10,890 plants this is equivalent to about 160 plants per acre. In relation to the shortfalls in population which this study has shown to occur, this is a small number. This emphasises that the establishment of the correct population depends upon ensuring that the spacing between the majority of plants is closer to the intended mean *during planting*, rather than attempting to equate actual and desired means by eliminating the relatively few very wide spaces by subsequent gapping up.

The "Clicker"

An audible metering device is supplied by the manufacturers of the type of transplanting machine encountered. It is fitted to the press wheels and emits "clicks" at regular intervals to indicate to the planters when to insert a plant. The intervals between clicks can be adjusted to indicate different interplant spacings.

Almost without exception the transplanting machines observed had been purchased equipped with a clicker, but on only one farm was it still in use. In most cases it had been deliberately disengaged, and the reasons most frequently given for this were that the workers found the regular clicking monotonous and irritating, and that they believed they could plant equally accurately without it. No information was obtained from this enquiry which would either support or refute these views. The only farm on which a clicker was used was No. 2 in the tables, and although spacing on this farm was somewhat more regular than most (see Table 39) it was not significantly so. Moreover, the clicker was inaccurately set on this farm, so that the actual average spacing between plants was fully six inches closer than that desired (Table 38).

Even when correctly set the clicker will not automatically ensure accurate or regular spacing, because wheel slip on the press wheel activating the clicker can result in it sounding at intervals longer than desired, and at irregular intervals. For instance, in a controlled test of a machine of this type, the slip on the press wheel operating the clicking gear was such that the distance travelled for one revolution of the press wheel was 53.5 inches, compared with a "no-slip" distance of 44.5 inches, and this caused spacing to average 18 inches when the desired spacing was 15 inches[7].

Further, if the planter is not able to plant in strict tempo with any one click, there is a distinct tendency for him to wait for the next rather than quickly, though belatedly, insert a plant to correspond with the click that was missed.

In addition it must be recognised that if each member of the team is required to plant according to the clicker, then the speed of the tractor will be

7 Report R.T. 15/48038; National Institute Agricultural Engineering; page 3; August, 1948.

limited by the rate at which the slowest planter in the team can just do this. Accuracy of spacing will be obtained at the expense of the inherently faster planters in the team working at a sub-optimum rate.

The use of a clicker is not, therefore, the complete answer to irregular and inaccurate spacing of plants in the row.

"Easy-Feed Attachment"

Little information was obtained from the enquiry about the effect on the accuracy and regularity of spacing of using the "Easy-Feed Attachment", which can be fitted to the transplanting machine most frequently observed. Farm No. 2 was again the only farm where this was in use, and the results from one farm are not conclusive.

In a controlled test[8] with an identical team using the same machine both with and without the attachment, it was found that spacing when it was in use was somewhat less accurate than when it was not used. Two factors may have caused the spacing to be more uneven with the attachment than without it. Firstly, the planter had to wait for the sponge disks to grip the plant, and at the tractor speed in use, a variation of as little as one fifth of one second in this waiting period resulted in the plant being three inches away from its correct position. Secondly, the plants do not always stand out radially from the disks, some point slightly forwards and some slightly backwards, with a corresponding variation in spacing when inserted into the furrow.

However, the use of the attachment does undoubtedly provide greater comfort for the planters, and over long periods this may be reflected in higher working speeds and greater accuracy and uniformity of planting.

"Plant Platforms"

One of the causes of plants being spaced more widely than desired is the interruption of the planting routine which occurs each time the planter reaches for a further handful of plants. Where the feeder is placing plants directly into the hand of the planter, it is necessary for both workers to synchronise their movements. Consequently there is the possibility of both workers making slight misjudgements. The feeder must look for the planter's hand, and the planter for the feeder's. In the short moment of indecision or fumbling which can occur in transferring plants from one to the other, the tractor has moved on, and by the time the planter inserts the first plant from the new handful, the spacing is wider than that desired.

Some growers have tried to minimise this effect by avoiding the need for the planter and the feeder to co-ordinate their actions. This has been effected by the addition to the machines of what may best be described as "plant platforms". One such innovation, is shown in Plate X. In use the feeder places a bundle of plants on each platform instead of into the planter's hands. The planters take plants from the platform with one hand as they insert the last plant from the previous bundle with the other hand. The plants are then always in a fixed position and close by, and the planters are able to maintain the supply of plants without raising their eyes from the planting. The rhythm of plant insertion is not interrupted since they need not search for the feeder's hand, and the risk of fumbling and delay is reduced. The actions of feeder and planters are partially separated and made less interdependent.

A comparison is presented in Table 40 of the mean spacing between plants taken from any one handful and that between the last and first plants from consecutive handfuls. Measurements were made for each planter in each

[8] Ibid.; (Appendix).

TABLE 40

SPACING WITHIN AND BETWEEN HANDFULS OF PLANTS

Method	With feeder—no plant platform						With feeder and plant platform				No feeder or plant platform				
Farm No.	2		12			10		5			14			3	
Planter	Left	Right	Left	Centre	Right	Right	Left*	Left	Centre	Right	Left	Centre	Right	Left	Right
Mean spacing "in handfuls" (ins.)	20.5	20.9	24.1	26.4	21.5	24.6	25.3	22.0	20.5	21.4	20.4	20.3	20.3	22.6	22.9
Mean spacing "between handfuls" (inches)	24.1	23.3	34.7	34.9	34.0	39.8	23.5	29.1	30.5	22.0	30.4	25.5	31.3	28.8	33.5
Difference (inches)	3.6	2.4	10.6	8.5	12.5	15.2	−1.8	7.1	10.0	0.6	10.0	5.2	11.0	6.2	10.6
Average by groups (inches)	8.8						4.0				8.6				
Number of handfuls per acre at actual spacing	533	672	298	298	357	395	517	353	417	417	309	371	371	147	274
Number of plants lost per planter acre †	94	77	131	96	208	244	−37	114	203	12	151	95	201	40	127
Average by methods	142						73				123				

* This planter was spacing plants closer between handfuls, than within handfuls, a fact denoted by the minus sign.
† At mean spacing "within handfuls".

of six teams. Two teams had no feeder and hence no platforms: two had feeders but no platforms: two used platforms[9].

It will be seen that with one exception the mean spacing between consecutive handfuls was greater than that within handfuls. This was the case irrespective of the presence or absence of a feeder or plant platform, but, the average difference in spacing for the teams which had a plant platform was lower than for the teams where these were not used.

The number of records upon which these averages were based was small, and the apparent reduction in the difference between spacing "in handfuls" and "between handfuls" where plant platforms were used, was not statistically significant. Nevertheless, the opinions of workers who had experience of planting with and without platforms, and *a priori* reasoning, would both suggest that the use of plant platforms would facilitate the transfer of plants from the feeder's to the planters' hands, and so enhance the ability of the planters to maintain a uniform spacing when replenishing their supply of plants.

The average number of handfuls of plants was 382 per acre at the actual spacing employed on these six farms; and the overall calculated average loss in plant population solely attributable to the cumulative effect of losing an average of 7.5 inches between each handful was 117 plants per acre. Hence it is apparent that if plant platforms were completely effective, a useful contribution would be made to the aim of avoiding shortfalls in the population, but, in relation to the discrepancies between intended and actual populations which this survey has shown to occur, this contribution is unlikely to be decisive.

It was not possible to make similar observations on Farm No. 6. No feeder was employed and the planters maintained their own supply of plants by the method described on page 78 and illustrated in Plate XI. With this arrangement the planters were able, when they wished, to take plants singly with their left hands from the side-slung canvas and wooden containers, and transfer them to their right hands for insertion. That is single plants were often treated in the same way as were bundles of plants on the other farms. Yet the self feeding arrangement was so satisfactory that the average spacing between plants in the row was 0.4 inches closer than that actually desired, the uniformity of spacing was the best encountered (see Table 39) and the net planting rate per planter was slightly above average (see Table 35). This, together with the results shown in Table 40 for the other two planting teams which did not employ a feeder, would support the view expressed in earlier pages, that the services of a feeder can be dispensed with without adversely affecting either the accuracy or the rate of planting.

9 One of the three planters on Farm No. 10 made no use of his platform and is therefore included in the group where the feeder placed directly into the hands of the planters; a second made only intermittent use of a platform, and has therefore been excluded.

CHAPTER XIII

ALTERNATIVE PRODUCTION PRACTICES AFFECTING LABOUR REQUIREMENTS AND PROFITS

Double Cropping

IT HAS BEEN SHOWN that, on average, autumn cauliflowers grown as a catch crop after early potatoes require 17.6 less worker hours per acre for their cultivation, than do maiden crops.

It would be fallacious to infer from this that by changing from maiden to catch cropping a reduction in the total farm wage bill commensurate with the reduction in the labour requirement of the autumn cauliflower enterprise can be secured, since more intensive use of land may often necessitate additional rather than reduced labour expenditure. Indeed, the reduction in the labour requirement of the autumn cauliflower crop would permit a reduction in total expenditure on labour only if, either the peak labour demands of that crop were transferred to periods when the labour force was relatively under-employed, thereby securing reduced overtime working and expenditure on casual labour, or if the expansion of output from the "extra" land could be managed with the existing labour force.

Transference of the peak labour demand of transplanting from early June to July by the adoption of catch cropping after early potatoes may meet the first of these requirements, but shifting the harvesting peak from September to October would rarely alleviate the pressure of work on a labour force normally busily engaged with root harvesting and autumn cultivations.

The extent to which the output of other crops could be expanded without necessitating additional overtime working or employment of casual workers would depend on the nature of the crops of which the acreage was increased. Thus, by catch-cropping, too little labour is released from cauliflower production, and is freed at the wrong periods, to permit an increase in the area of labour intensive crops such as potatoes and sugar beet without greatly increasing the total farm labour requirement in the spring and autumn months. On the other hand, an expansion of the area of a crop such as vining peas might be facilitated by a change from maiden to catch crop cauliflower growing, since the total labour requirement of that crop is low, and equally important its peak labour demand, for harvesting, occurs mainly at the time when less labour would be required for cleaning cauliflowers.

Hence although the practice of growing autumn cauliflowers as a catch crop will normally result in substantially less labour being required for that crop considered in isolation, the effect on the total farm wage bill of the more intensive systems of land use will depend on the direction in which output is expanded. Moreover, intensification of cropping will normally necessitate an increased outlay on resources other than labour, e.g. seeds, pesticides, fuel and oil, equipment repairs and maintenance, and marketing services; so that total farm expenditure may well be increased even where expenditure on labour is reduced. Nevertheless, so long as the value of the additional output from the intensified cropping system is greater than the additional cost of securing it, i.e. extra expenditure on materials and services plus any increase, or less any decrease, in expenditure on labour, the practice of double cropping will result in increased farm profits.

Buying in Plants

The reduction in labour requirement which can be expected from avoiding the operations involved in raising and pulling plants, is 13.6 worker hours per acre planted. A quarter of this labour (3.4 worker hours) would be released in April and May, and three quarters (10.2 worker hours) in either June or July, depending upon the planting date.

Taking a plant population of 11,000 per acre and a price of only £1 per thousand plants (it will often be higher), the direct cost of purchasing plants is about £11 per acre planted. The cost of raising and pulling plants on the farm would, under average conditions, be less than half this figure, the itemised costs per acre being as follow:

			£	s.
Labour	13.6 hrs.	at 3s. 3d. per hr.	2	4
Tractor running costs	0.6 hr.	at 2s. 9d. per hr.		2
Seed	0.5 lb.	at £6 0s. per lb.	3	0
Seed dressing	0.5 oz.	at £2 5s. per lb.		2
			£5	8

Hence it seems probable that buying in plants will increase costs by more than £5 per acre; it follows that this practice should only be adopted in exceptional circumstances.

The Purchase of Transplanting Machines

Other things being equal, mechanical transplanting requires less labour and proceeds faster than planting by hand; further, the use of the larger machines requires less labour than the use of transplanters with fewer units. The two problems of, firstly, the circumstances under which mechanical transplanting is cheaper than hand planting, and secondly, the most economic size of machine for any given acreage, can be resolved by determining the acreages above which the cumulative savings in variable costs—labour, tractor running costs and repairs—are greater than the annual fixed costs of depreciation and interest incurred by machine purchase.

The magnitude of the annual fixed costs of depreciation and interest charges on transplanters with from two to four units, together with the variable costs of their use, are as shown in Table 41. It is assumed that each unit has a working life of 10 years, and interest on the investment has been

AUTUMN CAULIFLOWER TRANSPLANTING COSTS
TABLE 41

No. of units	Capital costs	Annual fixed costs	Variable costs	
			With feeder	Without feeder
	(£'s)	(£'s per year)	(shillings	per acre)
2	50	6.8	52	41
3	75	10.2	42	35
4	100	13.6	37	31
Hand transplanting			77	

charged at the rate of six per cent. Variable costs are calculated on the basis of the standard performance figures given in an earlier chapter. Labour is charged at 3s. 3d. per hour, tractor work at 2s. 9d. per hour, and a notional charge of 6d. per acre has been allowed for repairs. In the case of hand planting, marking out has been assumed to occupy a man and a tractor for one hour.

From these figures it is calculated that changing from hand transplanting to planting by machine, or from one size of transplanter to the next, would result in lower total costs if the acreage of autumn cauliflowers to be planted annually were greater than those shown in Table 42.

TRANSPLANTING BREAK-EVEN COST ACREAGES

TABLE 42 Acres

	Hand to 2 units	2 to 3 units	3 to 4 units
With feeder	5	7	14
Without feeder	4	10	21

Thus it will be seen that mechanising the transplanting operation will reduce costs even where quite small acreages of cauliflowers are grown. Moreover, at £3.4 per unit, the differences in the annual fixed costs of owning one machine rather than another are not large, and when variable costs are also brought into account the differences between the total costs of owning and using the various machines are even smaller. For instance, as shown in Fig. 9 which depicts the per acre costs of using 2 and 3-unit transplanters on increasing acreages, with only four acres of autumn cauliflowers to plant, the lowest total cost would be incurred if a 2-unit transplanter were used. But the use of a 3-unit machine would increase costs by no more than 7s. 0d. per acre, or 28s. 0d. in all. Furthermore, whereas the job would take a day and a half with a 2-unit machine, a day would suffice if the larger transplanter were used.

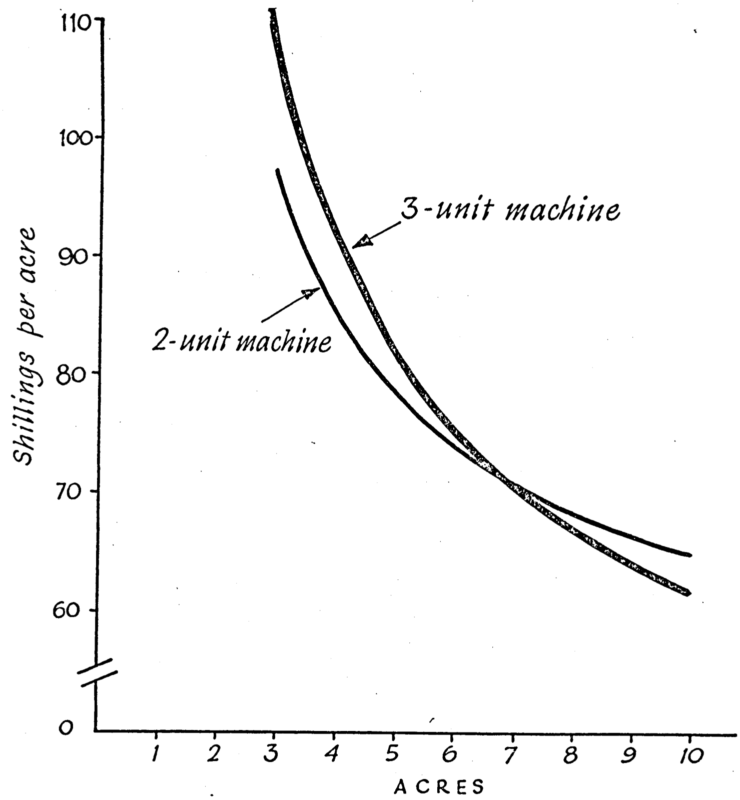
It is apparent therefore, that in choosing one machine rather than another, strict minimisation of the cost of the transplanting operation may play a secondary role. The improved timeliness in the performance of transplanting, and thereby of other labour competitive tasks, might often result in much greater additions to revenue, than the use of a particular sized transplanter on less than the break-even cost acreage would add to transplanting costs.

Selling by the Piece

It has been established that placing the responsibility for cutting and packing the crop on produce merchants will release growers' own labour at an average rate of about five man days per acre. Labour is released mainly in September and October in the case of maiden crops, and October and November for catch crops following early potatoes.

The autumn months, when maincrop potato and sugar beet harvesting and the sowing of winter cereals are undertaken, is a busy, and perhaps the busiest time of the year on a great many farms in the area in which this enquiry was conducted. The harvesting of autumn cauliflowers is an additional and frequently unwelcome burden on an already fully employed labour force. This situation gives the impetus for growers to arrange for produce merchants to undertake this work, since they believe that their own

FIG. 9. PER ACRE COSTS OF MECHANICALLY TRANSPLANTING AUTUMN CAULIFLOWERS



labour can be more profitably employed on crops which are of greater importance in the economy of the farm. The practice would be profitable if the additional revenue obtained from the crops which benefit from the attention of the labour released was greater than any reduction in the value of the cauliflower crop resulting from the adoption of this method of sale, or if its adoption permitted a greater reduction in expenditure on labour than the loss in returns from cauliflowers. Some reduction in returns can normally be expected, since the buyer must meet the costs of harvesting and marketing and will require a reward for assuming marketing risks.

The average gross return from 31 crops sold in the two years of the enquiry by one or other of the alternative methods are compared in Table 43.

The experience of a small number of growers in two years is not an entirely satisfactory basis from which to draw firm conclusions, but accepting the figures at their face value, it would appear that the value of the 43 hours of labour released for each acre of cauliflowers sold by the piece must be almost £20 before the adoption of the practice will result in increased farm profits.

On farms where having cauliflowers cut by a merchant permitted a commensurate reduction in expenditure on casual labour and overtime working, the highest saving likely to be secured would be less than £9 for each acre of cauliflowers sold by this method, i.e. 43 hours at the overtime rate for adult male workers. That is, selling by the piece under these circumstances would seem likely to reduce farm profits by some £11 per acre of cauliflowers sold in this manner.

AVERAGE GROSS RETURN BY METHOD OF SALE

TABLE 43 Per acre

Disposal	1953	1954	Average*
	£ s.	£ s.	£ s.
Grower marketed†	50 4	80 14	62 18
Sold standing	36 4	55 6	43 5
Difference	14 0	25 8	19 13††

* Not weighted by numbers of records in each year.
† After the deduction of the direct costs of marketing, e.g., transport, and market and salesmens' charges.
†† Difference significant at 5 per cent level; standard error, ± £9 2s.

On the other hand, it is probable that on some farms the size of the regular labour force is largely determined by the labour requirement for harvesting arable crops in the autumn months. In these circumstances selling standing autumn cauliflower crops might facilitate a reduction in the number of regular workers employed, particularly if it were associated with other measures which reduce the peak of labour demand, such as the mechanisation of the sugar beet and potato harvests and of root singling in the spring months. In this case the saving on the farm labour bill would far outweigh the probable sacrifice of profit from the autumn cauliflowers, except where very large acreages were grown.

Ways in which the labour released from autumn cauliflower cutting might be used to expand the output from alternative enterprises are numerous. For instance, selling standing cauliflower crops might enable a larger acreage of labour competitive but more profitable crops to be grown, e.g. potatoes and sugar beet; alternatively, growers who restrict the acreage of cauliflowers because of the pressure of work in the autumn months, might increase profits by substituting cauliflowers for some less profitable crop if arrangements were made for harvesting to be done by a merchant; thirdly, the labour released might be used to speed the performance of autumn cultivations and allow the acreage of winter sown cereals to be expanded. However, a reduction of £20 in the returns from cauliflowers to secure the release of five man days of labour represents a cost of some 9s. 0d. per worker hour; so selling by the piece is obviously an expensive form of labour saving. Indeed, whilst the opportunities for employing additional labour in such a way that its value is of this order may present themselves on some farms, and in some years, consideration of general wage rates in agriculture, or of the hourly or piece rates paid to casual workers for operations undertaken at this time, e.g. potato and sugar beet harvesting, would suggest that unexploited opportunities for such profitable use of labour are not generally available on the majority of farms.

Thus it would seem that selling standing crops will usually entail a substantial sacrifice of potential profits, and that growers would generally benefit by placing themselves in a position to undertake their own harvesting, either by taking on additional casual labour, or by securing a reduction in the labour requirement of competing enterprises, for instance by mechanisation of the sugar beet harvest.

However, "nothing is certain but death and taxes" and there is little doubt that the desire to insure against low prices and yields is as compelling an inducement for some growers to sell by the piece, as the desire to concentrate the available farm labour on the more important enterprises, or to reduce their dependence and expenditure on casual labour. Many growers would rather accept a known and secure, though lower, price for their cauliflowers in the summer, than face the vagaries of the market in the autumn months. Whether the sacrifice of profits, which this study has indicated are probable, is a reasonable price to pay for a measure of freedom from income fluctuations and uncertainty, must be left to the individual to decide in the light of his financial position, his family responsibilities, and his ability and willingness to shoulder risks.

CHAPTER XIV

SUMMARY AND CONCLUSIONS

ALTHOUGH AUTUMN cauliflowers occupy the land for little more than five months, during that time they make substantial demands on the farm labour force. Moreover, the labour requirement is unevenly distributed, and the periods of heaviest demand—for plant lifting and transplanting, and for harvesting—occur at the same time as several other crops, of equal or greater importance to the economy of the surveyed farms, require attention. Thus whilst planting can be performed at any time during the months of June and July, the cleaning of row crops, lifting first early potatoes and haymaking, all fall within this period. Similarly, the cutting of autumn cauliflowers competes directly for labour in the September to November period with the harvesting of maincrop potatoes and sugar beet, and the performance of autumn cultivations.

It is probable that the problems presented by this seasonal pattern of autumn cauliflower labour requirements, are less acute at the transplanting stage of the production cycle than at harvesting. This stems firstly from the fact that the transplanting operation has been successfully mechanised whereas cutting and packing are purely hand operations absorbing a major part of the total labour requirement of the crop; and secondly, that whilst both planting and harvesting dates are fairly flexible, it is easier to avoid a clash with other operations at planting than at the harvesting stage. Thus direct competition for labour between planting and the most labour consuming operation performed at that time—the lifting of first early potatoes—can be largely avoided by completing the planting of the earliest established crops before potato harvesting commences, and delaying the planting of later crops until the potatoes are cleared. In contrast, although the date of harvesting is also flexible in so far as it depends upon the variety grown and the planting date, it must inevitably fall in the period when the regular staff and any casual labour available are occupied with securing the root harvest and drilling autumn sown cereals.

Compared with hand methods, the use of mechanical transplanters of the type most frequently encountered on farms in the enquiry has been shown to effect a substantial reduction in the labour requirement of the planting operation. Being low in price, sturdy in construction, and having few moving or wearing parts, transplanters of this type have a long working life, are cheaply maintained, and carry only a low annual charge for depreciation and interest. The purchase of these machines is therefore economic even where relatively small acreages of cauliflowers are grown. Furthermore, the differences in the total costs of owning and using machines of increasing size are small—£3 8s. per unit per annum at most, and less when savings in operating costs are taken into account. Consequently the choice between transplanters may sometimes justifiably be made on the grounds of the relative speeds of planting with the various sized machines, for the need to get transplanting or other labour competitive tasks done quickly may on occasions be of greater economic importance than small savings in the direct costs of plant establishment.

A detailed study of mechanical transplanting on 14 farms provided standards of performance which can be used in management planning, and which it is thought will prove an acceptable basis for the formulation and wider use of output incentives. The study has also focused attention on some of the problems involved in the efficient operation of transplanting machines.

In view of the very great differences in the plant population which growers try to establish, a thorough investigation of the relationship between population and profits would be of considerable and immediate value. In the meantime, it has been shown that some growers are failing to establish the populations at which they are aiming, and which they presumably consider to be the most profitable.

Examination of the work of 19 machine operators has shown that the discrepancies between the populations which were intended and those which were achieved were mainly due to the small errors in the spacing of the majority of plants, rather than to large errors in the spacing of a few. Whether regularity of spacing has a significant effect upon the returns from cauliflower crops, and therefore whether it is worth pursuing for its own sake, is a further problem awaiting the attention of husbandry specialists. But greater regularity of spacing is one way in which discrepancies between the desired and achieved populations can be reduced.

It would seem that a high degree of regularity is virtually impossible with machines of the types observed. The crux of the problem is that at the tractor speeds commonly employed the planters have insufficient time to concentrate on achieving regular spacing ; and secondly, that the judgment of inter-plant distances is subjective. The first of these factors could be overcome by reducing tractor speeds to such low levels that the interval between inserting successive plants was sufficiently long to provide even the least skilful planter with time to ensure that plants were spaced accurately. In theory, audible (or mechanical) metering devices meet the second problem, by taking the subjective element out of the assessment of spacing. But, in practice, the slipping of tractor and press wheels limits the effectiveness of metering devices; and it must further be recognised that any measure which links the rate of forward travel to the speed with which the slowest planter can plant accurately means that accuracy is gained at the expense of a loss in the overall rate of planting.

Thus neither reducing tractor speed nor the objective metering of plant spacing seem to offer a completely satisfactory solution to the task of ensuring that large discrepancies between intended and actual plant population do not occur. Moreover, neither the use of plant platforms during planting, nor the practice of filling gaps after planting is completed, seem likely to be of great value in avoiding or correcting inaccurate populations.

If regularity of spacing is, within wide limits, of no great importance, then the correct plant population may be achieved by allowing each worker to plant at the rate which suits him best, and so adjusting tractor speed that the reduction in plant numbers attributable to the slowest worker is offset by the excess plants planted by faster workers. This is in effect what is happening, but it is evident that many growers need to pay more attention to checking the spacing as planting proceeds, since serious losses in plant population are at present passing unnoticed.

The most obvious and immediately applicable way in which the efficiency of mechanical transplanting may be improved is by dispensing with the services of the "feeder". The experience of a few growers has shown that transplanters of the type observed can be operated without this worker, by means of simple adaptations to the machines made at trifling cost. Neither the rate nor the technical efficacy of transplanting will be adversely affected by so doing.

The purchasing of plants rather than raising them on the farm is a practice adopted regularly by only a minority of growers. This survey has shown that the amount of labour released is small in relation to the additional outlay which buying in entails, and that there is no doubt that growers can raise their own plants much more cheaply than they can buy them.

The intensity of the competing demands made on the farm labour force at the time when autumn cauliflowers require harvesting, is reflected in the frequency with which growers sold standing cauliflower crops to produce merchants. The evidence suggests that the resultant reduction in the gross value of the crop to the grower would generally be substantially greater than the nominal cash value of the farm labour released; but in some circumstances, the adoption of the practice might facilitate a reduction in the size of the regular labour force, and a saving on the total farm expenditure on labour in excess of the loss in revenue from the cauliflower crop.

Although the opportunities for employing the labour released from cauliflower harvesting are no doubt numerous, the amount released —in relation to the loss in revenue and to the price at which additional labour could probably be secured—is not so large as to suggest that selling by the piece would lead to greater profits through the opportunity afforded for expanding the output of labour competitive crops.

It is therefore concluded that selling autumn cauliflower crops by the piece will generally entail a substantial sacrifice in profit; but whether the individual grower will be prepared to follow the course offering the highest profit in the long run, will depend upon the rate at which he discounts future profit at the time a firm bid is made for his standing crop.

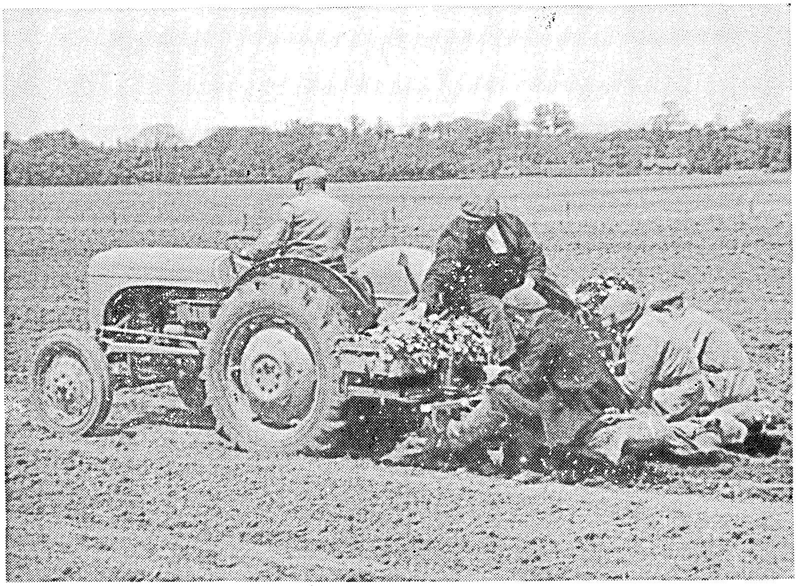


PLATE IX. The usual practice is for a 'feeder' to hand plants to the planters.

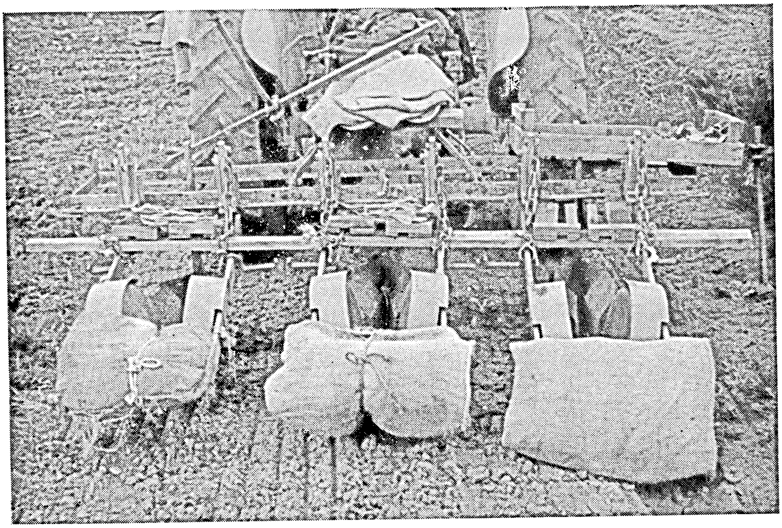


PLATE X. The bundles of plants may be placed directly into the hands of the planters or on to 'plant platforms'.

TRANSPLANTING AUTUMN CAULIFLOWERS

PLATE XI.

PLATE XII.

PLANTING WITHOUT A FEEDER

TRANSPLANTING AUTUMN CAULIFLOWERS

PLATE XIII.

PLATE XIV.

PLANTING WITHOUT A FEEDER

PLATE XV. Even mechanical transplanting can be a fatiguing task, imposing strain on the backs and legs of the planters.

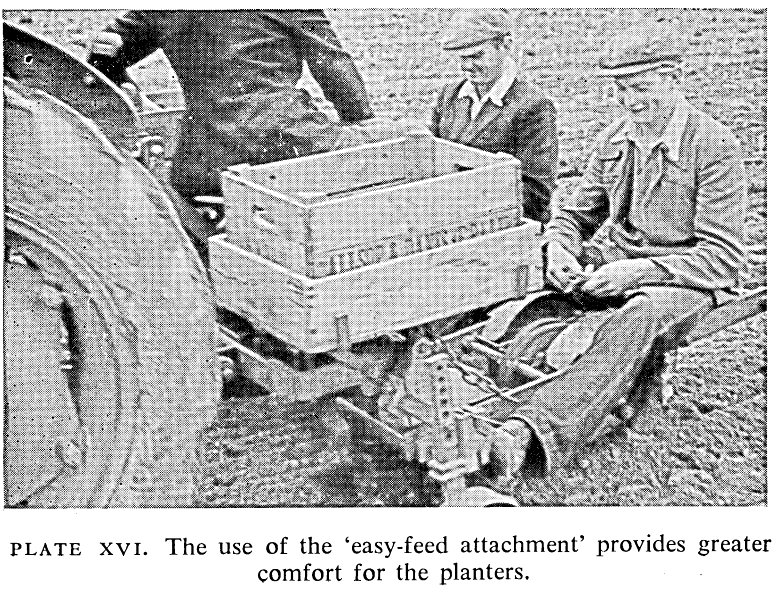


PLATE XVI. The use of the 'easy-feed attachment' provides greater comfort for the planters.

PART E

BRUSSELS SPROUTS

CHAPTER XV

STANDARD LABOUR REQUIREMENTS

THE LABOUR REQUIREMENT standards for brussels sprout production are based mainly on the 43 survey records collected, 20 of these having been obtained from farms and the remaining 23 from market gardens. For groups of operations concerning which the average rates of labour usage were not markedly different in the two classes of holding, all suitable records were used in the derivation of standards irrespective of their source. But for those groups of operations where there was a marked difference in this respect the standards were based exclusively on *farm* records.

One of the most variable aspects in the production of the crop concerned the method of establishment. The standard labour requirements given here presuppose mechanical transplanting with a 3-unit machine, and are based, not on survey records, but on the results of the field study of autumn cauliflower transplanting, since these are thought to provide the best measure of the rate at which the plants of any of the commonly grown brassica crops can be handled under average conditions.

The alternative methods of establishment—by direct drilling, transplanting by hand, and transplanting with the aid of a machine larger or smaller than that assumed for the purposes of the standard—are considered in Chapter XVI.

Operational Labour Requirements

Standard labour requirements by the main groups of operations are shown in Table 44, this being followed by an explanation of their derivation and details of the variations in labour usage recorded for individual crops.

STANDARD LABOUR REQUIREMENTS

TABLE 44 Per acre

Operations	Worker hours	Tractor hours
Preparatory cultivations	9.4	8.8
Plant raising	3.4	0.6
Plant pulling	7.1	—
Transplanting	7.0	1.4
Post-establishment cultivations	21.9	4.4
Total growing labour	48.8	15.2
Harvesting	120.6	—
Total labour	169.4	15.2

Preparatory Cultivations

The operations included in this group were those undertaken in preparing the land for receiving the plants, and comprised ploughing, discing, cultivating, rotovating, harrowing, rolling and the application of fertilisers.

Based on a total of 43 crop records, the average labour requirements for preparatory cultivations were 9.4 worker hours[1] and 8.8 tractor hours[2] per acre. The range was from 3.7 worker hours per acre on a field where sprouts followed oats, and preparatory cultivations were confined to once ploughing, twice discing and fertiliser drilling, to 22.0 worker hours per acre on a field where sprouts followed mixed cropping and all or part of the area was ploughed twice, disced five times, cultivated three times and rolled twice.

Plant Raising

The operations included in this group comprised preparation of the seed bed, sowing and cleaning the plant bed.

The standard labour requirements for this group of operations are not based solely on brussels sprout records, but on a combined total of 64 records of labour used supplied by growers of all the surveyed brassica crops.[3] The standards so obtained were 3.4 worker hours and 0.6 tractor hours per acre of the established crop. Individual brussels sprout records showed labour usage for this purpose ranging from 0.2 to 8.2 worker hours per acre planted.

Plant Pulling

Apart from the actual lifting or pulling, this included sorting, packaging and transporting the plants from the plant bed to the planting site.

Based on a total of 24 crop records[4] the average labour requirement for plant pulling was 7.1 worker hours[5] per acre of the established crop. The range was from 2.0 to 13.7 worker hours per acre.

Transplanting

The results of the study of the mechanical transplanting of autumn cauliflowers (see Chapter XII) were used, after suitable adaptation, for computing standard labour requirements for the mechanical transplanting of brussels sprouts. As a result of that study a standard transplanting rate of 1,680 plants per planter hour was established. Hence, under average conditions, transplanting with a 3-unit machine would proceed at the rate of 5,040 plants per hour. The most usual intended plant population for brussels sprouts encountered during the course of the survey was 6,970 per acre, so that the estimated rate of planting is 1.4 hours per acre with a 3-unit machine. Assuming the machine is operated by a team of five workers, the standard manual labour requirement is 7.0 worker hours per acre. Standard tractor labour requirements are similarly 1.4 tractor hours per acre.

Post-establishment Operations

The operations included in this group comprised gap filling, top dressing, hand and mechanical cultivations for the control of weeds, aphicidal spraying and clearing the stumps after harvesting.

Standard labour requirements were obtained by averaging the rates of labour usage shown in 20 records of crops grown on *farms*. These were

1 Standard deviation, 3.9 worker hours.

2 Standard deviation, 3.5 tractor hours.

3 See Chapter XI.

4 The remaining 19 records were unsuitable for this purpose for one of the following reasons, (i) plant pulling labour requirements could not be separated from transplanting labour requirements, (ii) the plants were purchased already pulled, or (iii) the crop was drilled *in situ*.

5 Standard deviation, 3.5 worker hours.

21.9 workers hours[6] and 4.4 tractors hours[7] per acre. The lowest labour usage recorded for an individual crop was 2.0 worker hours per acre on a field where post-establishment operations were confined to a single tractor hoeing and the application of a nitrogenous top dressing with a drill. At the other extreme, 55.8 worker hours per acre were expended on a field where the post-establishment operations included gap-filling, three tractor hoeings and four hand hoeings, and cutting the stumps down *by hand* prior to ploughing for the next crop.

It is of some significance that, on average, the labour requirements for this group of operations were higher for crops grown on *market gardens* than for those grown on farms. The average labour requirements obtained from the 23 records of market garden crops were 45.4 worker hours[8] and 6.5 tractor hours[9] per acre. Hence, on average, market garden grown crops required an additional 23.5 worker hours[10] per acre.

Several reasons may be suggested for this difference. Firstly, farm crops were generally produced on a larger scale involving larger total acreages, larger fields, more powerful tractors and larger capacity equipment. Thus, whereas on the farms an average of 17 acres of the crop was grown, on the market gardens the average was only 11 acres. Similarly, whereas on the farms the average size of field surveyed was 10 acres, on the market gardens it was only 5½ acres. Secondly, whereas many market gardeners appear to pride themselves on the appearance of their crops, quite apart from the economic advantages likely to be gained from additional cleaning operations, farmers are generally less fastidious.[11] Thirdly, there was a noticeable difference between the two classes of holding in the means adopted for getting rid of the sprout stumps at the end of the picking season. Amongst the farm crops, the field was generally disced or rotovated once or twice to cut up the stumps prior to ploughing for the following crop. Amongst the market garden crops on the other hand, the most usual practice was to collect the stumps and remove them completely from the field. This practice is associated with the high proportion of land devoted to brassica crops on many of the market gardens visited. Under these conditions the incidence of Club Root is high, and growers feel obliged to take all possible precautions against a build up of this disease in the soil; the survey showed this to be an extremely laborious operation.

Harvesting

This group of operations included picking, packaging and weighing. Here again the standard labour requirement is based on *farm* practice. On the majority of the surveyed farms pickers were paid at piece work rates, and the average labour requirement amongst crops picked entirely by pieceworkers was therefore used for this purpose.[12]

Yield differences were allowed for by computing the harvesting labour usage *per ton* for each of these crops. The average labour requirement per ton was 40.2 worker hours.[13] The marketed yield was then

6 Standard deviation, 12.9 worker hours.

7 Standard deviation, 2.3 tractor hours.

8 Standard deviation, 27.7 worker hours.

9 Standard deviation, 3.1 tractor hours.

10 This difference is significant at the 5 per cent level; standard error ± 6.4 worker hours.

11 Nowadays farmers may have some rotational advantages in this respect; since the advent of chemical weed control in cereals, there is less tendency to regard crops in the root-break as cleaning crops.

12 On average, there was a substantial difference in labour requirements between crops picked at piece work rates and those picked at time rates. This is discussed more fully in Chapter XVI.

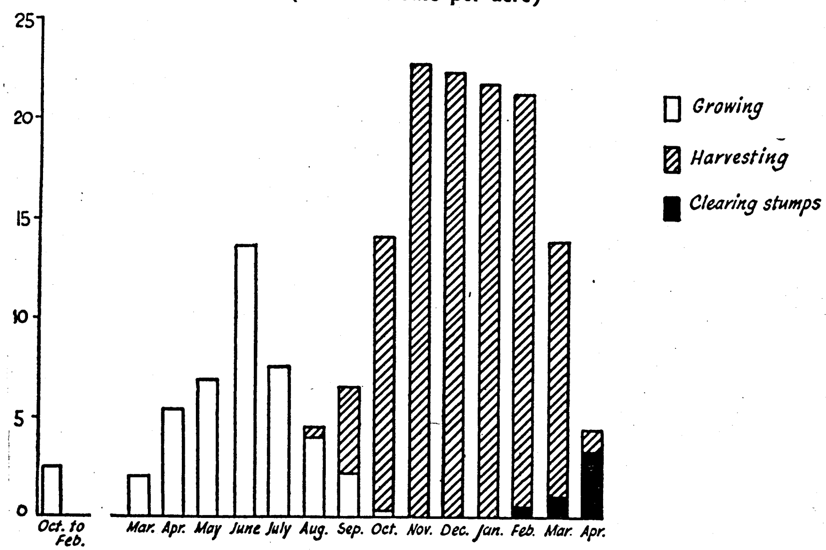
13 Standard deviation, 13.8 workers hours.

standardised at three tons per acre, giving a standard labour requirement of 120.6 worker hours *per acre*.

Seasonal Labour Requirements

The overall picture of seasonal labour requirements for brussels sprout production is shown in Fig. 10. The procedure followed in arriving at the monthly labour requirements was similar to that employed for other crops dealt with in this report.[14]

FIG. 10. BRUSSELS SPROUTS SEASONAL LABOUR REQUIREMENTS
(Worker hours per acre)



Amongst all the crops surveyed preparatory cultivations extended from October to June. The preliminary ploughing for 31 of the 43 crops was completed before March and the remaining preparatory cultivations, i.e. working down the land and applying fertilisers, were mainly carried out during March, April and May.

Plant raising extended over the same period as preparatory cultivations, but since most of the sowing took place in March, a major proportion of the preparatory work on the plant bed was also done in that month; the work of cleaning the plant bed was concentrated in April and May.

Pulling and transplanting were virtually simultaneous operations, and extended from April to June, but the majority of crops were transplanted in early June.

Apart from stump clearing, post-establishment operations extended from May to October. In the matter of labour requirements inter-row cultivations were by far the most important of these operations and were carried out during the months of June, July and August. More hoeing was done in July, however, than in any other single month.

[14] For a general description of the method, see Chapter I.

Amongst the crops as a whole, harvesting operations extended from August to the following April. But over 70 per cent of the harvesting was done from November to February inclusive, and furthermore the harvesting labour requirements in each of these months were approximately equal.

It will be seen that the production cycle for brussels sprouts is relatively long, especially with the later crops where it may extend over as many as nineteen months. Also, owing to the length of the harvesting season, particularly where both early and late varieties are grown, labour requirements are at a relatively high level for a large proportion of this period. Moreover, although the average monthly labour requirement during the establishment and main growing periods—say April to July inclusive—are not so high as they are during the harvesting period, the timing of the operations involved is frequently critical, e.g. transplanting. Furthermore, these operations have to be performed during a period of the year when, on most farms, many other crops such as potatoes, other vegetables, sugar beet and hay are requiring attention. Hence, competitive claims for labour between brussels sprouts and these other crops may cause difficulties during this period. On the other hand, although harvesting labour requirements will generally be much greater in total than growing labour requirements, their impact on other farm enterprises may not be so great, since a large proportion of the harvesting work is done during the dead winter months, and only a small part of the crop requires picking during early autumn when potatoes and other root crops are being harvested, or in the spring when preparations are being made for most of the following season's crops.

CHAPTER XVI

ALTERNATIVE PRODUCTION PRACTICES AFFECTING LABOUR REQUIREMENTS AND PROFITS

Buying in Plants

EIGHT OF THE surveyed crops were grown wholly or in part from purchased plants. This practice may sometimes be resorted to as an emergency measure where a grower has attempted, but failed, to raise sufficient plants for his requirements. On the other hand, it was the deliberate policy of some of the surveyed growers to purchase plants rather than raise them on the farm. It is important that such growers should appreciate the economic implications of such a policy.

Where this policy is adopted, the grower's labour which would otherwise be required for plant raising and pulling may be saved, and it is estimated that the practice of plant purchase reduces the manual labour requirements for brussels sprouts by 10.5 worker hours per acre planted (see Table 44).

The profitability of this practice depends on the difference between the value of this labour plus the cost of seed on the one hand, and the cost of purchased plants, on the other.

The market price of brussels sprout plants at the present time is in the region of £1 per 1,000. Since the most usual plant population encountered during the survey was 6,970 per acre—given by a spacing of 30 inches each way—the cost of purchased plants is about £7 per acre planted.

The cost of seed, including insecticidal treatment, is likely to be about 11s. 0d. per acre planted, i.e. ½ lb. of seed at £1 per lb., plus ½ oz. seed-dressing at £2 5s. per lb. Thus, valuing the labour released by plant purchase at £1 14s. (10½ hours at 3s. 3d.), it is estimated that the total cost *saving* effected by this practice will be approximately £2 5s. per acre.

It is clear, therefore, that since the extra costs incurred are about £7 per acre and the costs saved are unlikely to amount to more than £2 5s. per acre, only under very exceptional circumstances could a sound economic case be made out for a policy of plant purchase.

The Method of Establishment

(a) Transplanting versus Direct Drilling

Some growers of brussels sprouts favour a method of establishment whereby, instead of being transplanted from a plant bed, the crop is drilled *in situ* and subsequently chopped out and singled in the manner of sugar beet. Advantages claimed for this practice are that on some soils it results in a better stand through avoidance of the transplanting check, and since the crop is treated in much the same way as other crops in the root break, no special skills or equipment are required. Disadvantages are that more seed is required and that the land must be ready to receive the crop a full month earlier than where transplanting is practised.

Six of the surveyed crops were drilled and singled. The average labour requirements for drilling were 2.3 worker hours[1] and 1.2 tractor hours[2] per acre, and for chopping out and singling 18.0 worker hours[3] per acre. Thus, on average, the total labour requirements for establishing the crop by this method were 20.3 worker hours and 1.2 tractor hours per acre.

For the transplanting method of establishment, labour requirements vary somewhat according to the choice of transplanting technique. Standard labour requirements have already been given for the use of a 3-unit transplanting machine with a gang of five workers (see Table 44). However, a machine of this size is sometimes used with a gang of only four workers.[4] Moreover, a 2-unit machine may be used and operated by a gang of either four or three workers. There were also a number of growers whose crops were transplanted by hand.

Thus at least five different transplanting techniques were employed by brussels sprout growers in this survey.

Standard labour requirements have been derived for establishing an acre of brussels sprouts by each of these methods, i.e. labour requirements for actual transplanting *plus* the labour requirements for plant raising and pulling. The labour requirements for each of the alternative methods of mechanical transplanting were derived from the standard transplanting rate of 1,680 plants per planter hour, and the labour requirements for transplanting by hand were based on a rate of 500 plants per worker hour.[5] The results are summarised in Table 45 where they may be compared with the average labour requirements for the drilling and singling method.

TABLE 45 — ESTABLISHMENT LABOUR REQUIREMENTS — Per acre

Method	Worker hours		Tractor hours
	With feeder	Without feeder	
Mechanical transplanting			
3 units	17.5	16.1	2.0
2 units	18.9	16.8	2.0
Transplanting by hand	25.4		1.0
Drilling, chopping out and singling	20.3		1.2

The figures in the table support the conclusion that in view of the comparatively small differences between the drilling and singling method and any of the *mechanical* transplanting methods, labour requirements are unlikely to be the primary consideration in determining the more profitable of these two methods of establishment.

However, as already mentioned, the drilling and singling method normally entails a heavier seeding rate. Amongst the six direct drilled crops the most usual seeding rate was 2 lbs. per acre, whereas amongst transplanted crops the most usual rate was ½ lb. in the seed bed per acre planted. Assuming a seed cost of £1 per lb., this implies an advantage of £1 10s. per acre in favour of the transplanting method.

1 Standard deviation, 1.7 worker hours.

2 Standard deviation, 0.8 tractor hours.

3 Standard deviation, 6.9 worker hours.

4 See Chapter XII for a description of methods used for dispensing with the feeder.

5 See footnote 10, Chapter XI.

On the other hand, mechanical transplanting involves the acquisition of a machine, the costs of which must be debited to that method. It has been shown elsewhere in this report that if it is written off over 10 years, and if interest on the investment is charged at a rate of six per cent per annum, the annual fixed costs of a 3-unit transplanting machine are £10 4s. On this basis, the break-even cost acreage on which the costs of the two methods would be the same, is just under 7 acres. Hence, if the acreage to be established exceeded this the mechanical transplanting method would be cheaper. Similarly, if a 2-unit machine were to be employed, the annual fixed costs of the machine would be £6 16s. and the associated break-even cost acreage approximately 4½ acres.

As for the comparative economy of establishment by means of drilling and singling and establishment by *hand* transplanting, it is not considered that the difference between the average labour requirements derived for these methods is sufficiently large or reliable for any definite conclusion to be drawn. Nevertheless, it is clear that if drilling and singling is to be the more profitable of these two methods the extra seed cost of £1 10s. per acre must be offset by labour economies worth more than this. If labour is valued at 3s. 3d. per hour, this means that the labour requirements for drilling and singling must be at least 9½ worker hours per acre less than for hand transplanting, or about 4 hours more than the difference indicated by Table 45.

(*b*) *Choice of Transplanting Method*

So far the discussion has centred round the two main methods of establishment, i.e. transplanting, or drilling and singling. Consideration will now be given to the relative economies of alternative transplanting techniques. The problems involved here are (i) whether to transplant by hand or by machine, and (ii) if planting by machine, how many planting units to employ.

In Table 46 standard transplanting labour requirements per acre are shown for the use of 2, 3 and 4-unit transplanting machines, both with or without a feeder, and for transplanting by hand. A plant population of 6,970 per acre is assumed throughout.

TABLE 46 TRANSPLANTING LABOUR REQUIREMENTS

Per acre

Method	Worker hours		Tractor hours
	With feeder	Without feeder	
Mechanical			
4 units	6.0	5.0	1.6
3 units	7.0	5.6	2.0
2 units	8.4	6.3	2.7
Hand	14.9		1.0

Owing to the method used in their derivation, the differences in labour requirements between machines with differing numbers of planting units are regarded as being reasonably reliable, and they have been used as the basis for calculating the break-even cost acreages between planting by hand and with a 2-unit machine, and between this and larger sized machines. The fixed costs of machine ownership have been calculated on the same basis as in the first part of this chapter, and labour, tractor running costs and machine maintenance have also been charged at the same rates as previously. The results of these calculations are shown in Table 47.

TRANSPLANTING BREAK-EVEN COST ACREAGES

TABLE 47 Acres

Method	Hand to 2-units	2 to 3 units	3 to 4 units
With feeder	8	10	14
Without feeder	6	16	22

As previously noted, the average acreage of brussels sprouts on the surveyed *farms* was 17. The figures in Table 47 indicate that, under the specified conditions, and assuming the employment of a feeder on the machine, this acreage could be transplanted at the lowest cost with a 4-unit transplanting machine. Similarly, with 11 acres of the crop—the average acreage encountered on *market gardens*—the costs of employing a 3-unit machine would be slightly less than those of a 2-unit machine. In circumstances where a feeder was *not* employed, a 3-unit machine would be the most economical on the average farm acreage, and a 2-unit machine on the average market garden acreage. But growers with less than six acres to transplant would not save anything by using a machine, even without a feeder. On this and smaller acreages the value of the labour saved by using a machine would be insufficient to recoup the costs of owning it.

On a holding where a machine was acquired for the transplanting of other crops in addition to brussels sprouts, its use might, of course, be economically justified on brussels sprout acreages considerably smaller than the break-even cost acreages presented above.

Remuneration of Pickers

Where crops were harvested by piece workers harvesting labour requirements were significantly less than where pickers were paid by the hour. For the crops harvested by piece workers, the average harvesting labour requirement was 40.2 worker hours[6] per ton. On the other hand, amongst crops harvested by time workers the average was 63.0 worker hours[7] per ton. Hence, on average, where crops were picked at piece rates the picking labour requirement was about 23 worker hours per ton less than where picking was done at time rates.[8]

A higher *rate* of picking may be advantageous in several ways. In the first place, over the season as a whole, a crop of a given size can be picked with a smaller picking gang, which is advantageous to the grower who has difficulty in recruiting pickers. Conversely, with a picking gang of a given size, a larger volume of crop can be handled over the course of a season, which may enable the acreage of the crop to be increased. Alternatively, with a picking gang of a given size, a greater amount can be picked at any particular time, which may enable the grower to get a larger volume of produce on to the market when prices are most favourable.

There is, however, another aspect of piece rate picking which requires consideration. This is the *cost* of picking at piece work rates compared with the cost at time rates. Given the standard picking labour requirement for time workers and the current hourly wage rate, the break-even cost piece work rate can be calculated, i.e. the piece work rate at which the cost of picking a given quantity of sprouts would be the same whether the pickers were paid by the hour or according to output. With the time work picking

6 Standard deviation, 13.8 worker hours.

7 Standard deviation, 23.0 worker hours.

8 This difference is significant at the one per cent level; standard error, ± 7.3 worker hours.

requirement of 63.0 worker hours per ton and the current minimum weekly wage rate of £7 1s. per week of 47 hours, the break-even cost piece work rate is £9 9s. per ton, or 2s. 4d. per 28 lbs.[9]

A comparison of the piece work rates actually paid to twelve different picking gangs employed for harvesting surveyed crops with the calculated break-even cost rates prevailing at the time, shows that six of these gangs were paid more than the break-even cost rate and six less. The highest actual rate encountered was 3s. 0d. per 28 lbs. bag paid to a gang of male pickers on one farm in both the 1953-54 and 1954-55 seasons, when the break-even cost rates per 28 lbs. bag for that class of labour were 2s. 0d. and 2s. 1d. respectively. The lowest rate was 1s. 5d. per 28 lbs. bag, paid to a gang of female pickers in the 1953-54 season when the break-even cost rate for women was 1s. 7d.

It must not be thought, however, that the practice of paying piece work rates can only be profitable in circumstances where picking costs per ton or per bag are reduced. In circumstances where additional labour cannot readily be obtained, the payment of any rate will be profitable so long as harvesting labour requirements per ton or per bag are reduced, and the time saved can be used to good advantage. For example, with the current break-even cost piece work rate of 2s. 4d. per bag of 28 lbs., paying a piece work rate of 3s. 0d. per bag would increase costs by 8d. per bag. But if the effect of paying the piece work rate rather than the time work rate of 3s. 3d. per hour was to reduce havesting labour requirements per ton by, say, one third, the quantity of sprouts that could be harvested in any given period would be increased by a half. Hence, production could be increased by a half without making any additional demands on the time of the labour force. Such an increase in production would be profitable so long as the realised net profit per bag on the *additional* bags sold averaged *more than* 2 × 8d., i.e. 1s. 4d. Although this example assumes that the time saved is used for the picking of an increased acreage of brussels sprouts, it could be used to increase the production of some entirely different farm product, and certainly should be if this were the more profitable alternative.

In conclusion, it should be remarked that, on average, harvesting labour requirements were 18.7 worker hours[10] per ton greater for crops grown on market gardens than for crops grown on farms. It might have been expected that the market gardeners, who did most of the picking themselves with the aid of family labour, would have achieved an average rate of picking at least as high as the piece workers on farms, since they had the very strong incentive of working entirely for their own profit. But this did not prove to be so. A partial explanation may be that acre for acre the market gardener generally picks more frequently and in smaller quantities than the farmer, since whereas in this area the former generally sells his own produce or supplies local retail buyers, the latter sells mainly on large wholesale markets. However, it may also be suspected that the lack of incentive to speedier picking was due, in some cases, to market gardeners being less than fully occupied during the brussels sprout harvesting season.

9 This is based on the current minimum wage rate for adult *male* workers. In some circumstances it might be more appropriate to use the wage rate for *female* workers, in which case the break-even cost piece work rate would be £7 3s. per ton or 1s. 10d. per 28 lbs.

10 This difference is significant at the five per cent level: standard error ± 6.8 worker hours.

CHAPTER XVII

SUMMARY AND CONCLUSIONS

UP TO THE PRESENT time the opportunities afforded for mechanising the production of brussels sprouts have been limited. Apart from the use of transplanting machines and of tractors instead of horses as the main source of tractive power, production methods remain much the same as they have been for generations. For this reason, and because of the inherent nature of the crop, this is still one of the most labour consuming crops grown by the farmer.

An analysis of labour requirements by the main groups of operations has shown that brussels sprouts make their peak demands upon labour at two stages in the production cycle. These are during the final stage of establishment—i.e. pulling and transplanting, or chopping out and singling—and during the picking season. Moreover, an analysis of seasonal labour requirements has suggested that labour may frequently be in short supply relative to the requirements of other crops particularly during the former period. In the previous chapter, three ways in which labour requirements may be reduced during these peak periods were discussed. These are the purchase of plants, the adoption of mechanical transplanting, and the remuneration of pickers at piece work rates.

It appears most unlikely that the amount of labour saved by buying plants, rather than raising them on the farm, will normally be sufficient to offset the additional costs involved, and the conclusion is that this practice should only be resorted to in an emergency such as might occur when farm raised plants fail altogether, or fall short of full requirements.

It has been shown that with a gang of given size, mechanical transplanting is likely to be quicker than planting by hand and requires less labour, but that due to the additional costs involved, the acquisition and use of a machine is unlikely to be economically justified for *brussels sprout planting alone* on holdings where the total acreage of that crop is less than six. Further savings of time and labour can be made by acquiring and using as many transplanter units as can be conveniently mounted on the tractor tool bar. But since this increases the costs of machine ownership, which remain the same irrespective of the acreage planted, the purchase and use of an additional unit will only pay where the area to be planted is large enough for these costs to be more than offset by savings of labour and tractor costs. The acreages above which the purchase and use of additional transplanting units are likely to be profitable have been calculated up to a total of four units, and these should be of interest to growers of the crop.

The method of establishing the crop by drilling the seed *in situ* and subsequently chopping out and singling to the required plant population, has been compared with the more usual transplanting method. The conclusion reached, within the limits of rather less than fully adequate data, is that with a plant population in the region of 7,000 per acre, the adoption of this practice is unlikely to have any substantial effect upon labour requirements under average conditions. Nevertheless, since mechanical transplanting entails incurring the costs of owning a transplanting machine, direct drilling and chopping out—which requires no specialised equipment—is likely to be cheaper where the total area of the crop does not exceed 4½ acres. This is so in spite of the fact that direct drilling involves a heavier and more costly seeding rate.

One method of reducing labour requirements has been suggested which may, in some circumstances, be adopted without incurring any additional costs. This is the remuneration of pickers at a piece rate which reduces the total cost of picking. Nevertheless, where it is difficult to obtain additional labour, piece work picking can be profitable even where picking costs per ton or per bag are increased, so long as the rate of picking is speeded up sufficiently for the time saved to be used for increasing the production of brussels sprouts, or some other farm product, and the value of the additional output is greater than the additional picking costs.

Although this study has been mainly concerned with the production of brussels sprouts on a farm-scale, it has yielded some interesting comparisons between the practices commonly employed by farmers and market gardeners. It appears that market gardeners use considerably more labour than farmers at two stages in the production of the crop, those of post-establishment cultivations and harvesting. In a number of respects many market gardeners appear to be in a disadvantageous position regarding labour usage. In the first place, since their holdings are smaller, and they are working with smaller acreages of the crop, the scope afforded for the economical employment of larger and more technically efficient machines such as transplanters and steerage hoes is necessarily limited. Secondly, their husbandry problems are frequently complicated by the prevalence of Club Root, which not only reduces yields, but also necessitates very laborious methods of disposing of brassica crop residues. Thirdly, in spite of the fact that market gardeners do a large proportion of the manual work on the holding themselves with the assistance of family labour, on average they expend considerably more labour on the harvesting of brussels sprouts than farmers who employ piece workers for this purpose. This may be partly due to the relatively large number of small pickings which are undertaken in supplying a local market throughout the season, but, in addition, it may be suspected that some market gardeners are less than fully occupied during the winter months, and hence have little incentive to minimise the time spent in harvesting the crop. Finally, market gardeners usually seem to be more fastidious than farmers about the appearance of their crops, and therefore tend to use more labour for weeding and other operations intended to give the crop a tidier appearance than may be economically justified.

All of the foregoing circumstances place small scale market gardeners in a relatively unfavourable position as producers of brussels sprouts, and must tend to depress the rewards they obtain for their management and labour below those obtained by farmer growers. This lends support to the oft expressed view that unless market garden growers are able to modify their methods so as to streamline labour usage, they would be better off if they concentrated less on brussels sprouts (and other coarse vegetables) and more on intensive crops in the production of which they can compete with farm producers on more favourable terms.

PART F

SAVOY CABBAGE

CHAPTER XVIII

STANDARD LABOUR REQUIREMENTS

THE LABOUR REQUIREMENT standards for savoy cabbage production are based on survey records of 37 individual crops. In the presentation of the standards, account has been taken of alternative arrangements for harvesting the crops, since these had a marked effect on growers' labour requirements.

Another variable feature of savoy production is the method of establishment employed. The standard labour requirements given in this chapter relate to crops that are drilled in situ, chopped out and singled. The alternative of establishment by transplanting is dealt with in Chapter XIX.

Operational Labour Requirements

Standard labour requirements by the main groups of operations are shown in Table 48. This is followed by an explanation of the derivation of the standards and details of the variations in labour usage recorded between individual crops.

STANDARD LABOUR REQUIREMENTS

TABLE 48 Per acre

Operations	Worker hours	Tractor hours
Preparatory cultivations	8.7	8.1
Drilling	1.9	1.1
Chopping out and singling	21.4	—
Post-establishment cultivations	20.2	3.8
Total growing	52.2	13.0
Harvesting:		
(i) cut by grower	47.4	3.7
(ii) cut by merchant	10.5	3.7
Total:		
(i) cut by grower	99.6	16.7
(ii) cut by merchant	62.7	16.7

Preparatory Cultivations

The operations included in this group were those undertaken in preparing the land for drilling or transplanting, i.e. ploughing, discing, cultivating, harrowing, rolling, and the application of fertilisers.

Based on a total of 36 crop records,[1] the average labour requirements were 8.7 worker hours[2] and 8.1 tractor hours[3] per acre. The range was from 3.0 worker hours on a field where savoys were grown after barley, and land preparation was confined to once ploughing, a harrowing, and a

1 One crop grown as a catch crop after early potatoes was excluded as being unrepresentative of the group in respect of preparatory cultivations.

2 Standard deviation, 4.1 worker hours.

3 Standard deviation, 3.8 tractor hours.

harrowing and rolling in tandem, to 22.4 worker hours on a crop which also followed barley, but where the land was ploughed four times, disced twice, cultivated and chain harrowed in tandem once, and also received two separate applications of fertiliser.

Drilling

This included both the actual drilling and, in some cases, the associated operation of harrowing behind the drill. Based on records obtained for 27 crops which were drilled *in situ*, the average labour requirements were 1.9 worker hours[4] and 1.1 tractor hours[5] per acre. The range was from 0.9 to 3.6 worker hours per acre. Most frequently, though not invariably, two men were assigned to the operation of drilling.

Chopping out and Singling

This included gapping and singling—frequently done as a combined operation—but *not* the first hand hoeing, though this was frequently included with the former operations in fixing piece work rates. The average labour requirement for chopping out and singling was 21.4 worker hours[6] per acre. The range was extremely wide, from 8.5 to 53.3 worker hours per acre.

It is possible that the level of plant population per acre aimed at had an effect on the labour usuage for chopping out and singling,[7] but no firm relationship in this respect could be established from the survey results. Similarly, although experience shows that labour requirements are reduced by the inducement to work faster provided by the use of the piece work incentive, analysis of the survey records did not yield any reliable quantitative measure of this effect.

Post-establishment Cultivations

This comprised all other operations performed between drilling and harvesting, i.e. rolling after the plants were through, hoeing both by tractor and by hand, the application of insecticides, and fertiliser top-dressing. Cultivations performed to dispose of the stumps after harvesting are also included.

Based on a total of 36 crop records,[8] the average labour requirements were 20.2 worker hours[9] and 3.8 tractor hours[10] per acre. The range was from 1.3 workers hours per acre on a field where savoys followed wheat and where the only cultivations were rolling and a single tractor hoeing, to 49.4 worker hours per acre on a field where the crop was also grown after wheat but where post-establishment cultivations included two tractor hoeings, the use of no less than 34 worker hours per acre for hand hoeing, and discing in the stumps after harvesting.

Harvesting

Harvesting labour requirements are presented on two different bases. With respect to crops cut by growers, the operations included

4 Standard deviation, 0.8 worker hours.

5 Standard deviation, 0.5 tractor hours.

6 Standard deviation, 8.7 worker hours.

7 On average, the growers of these crops aimed at a plant population of approximately 17,000 per acre, though the range covered was from 11,000 to 26,000 per acre.

8 The crop grown after early potatoes was again excluded as being unrepresentative of the group.

9 Standard deviation, 14.1 worker hours.

10 Standard deviation, 1.5 tractor hours.

comprise cutting, packaging, loading and leading off the field. In the case of crops cut by merchants, only those harvesting operations normally performed by the grower are included, i.e. loading and leading off the field.

With crops cut by the *grower* the procedure was complicated by the fact that the marketed yields recorded for individual crops were highly variable. Furthermore, in the 1953-54 season, which was generally one of abundant crops and low prices, a number of the surveyed crops remained unharvested. Fifteen crop records were available giving details both of harvesting labour requirements and the quantity cut. The average manual labour usage *per ton* was computed for each of these crops. The overall average labour requirement was 7.9 worker hours[11] per ton but the manual labour usage for individual grower harvested crops ranged from 3.2 to 16.0 worker hours per ton. The marketed yield was standardised at 6 tons per acre, giving a standard manual labour requirement of 47.4 worker hours *per acre*.

Grower's labour requirements for the loading and leading off of crops cut by the *merchant* were based on 13 records[12] but since yield data for these crops were only available in a few cases, standard manual labour requirements per acre were computed from these records without reference to the quantity handled per acre. The standard thus arrived at was 10.5 worker hours[13] per acre, with a range from 2.4 to 20.0 worker hours per acre.

Since tractor labour is only required for leading the crop off the field, tractor labour requirements were regarded as being common to both groups. Based on a total of 20 crop records,[14] the average tractor labour requirement was 3.7 tractor hours[15] per acre, with a range from 0.5 to 7.0 tractor hours per acre.

Seasonal Labour Requirements

The procedure adopted in the computation of standard seasonal labour requirements was similar to that for other crops dealt with in this report.[16] The overall picture may be seen in Fig. 11 which includes two distributions of labour requirements at the harvesting stage, the one relating to crops cut by the grower and the other to crops cut by a merchant.

Amongst the surveyed crops as a whole preparatory cultivations extended from September to the following August. The preliminary ploughing for 32 of the 37 crops was completed by February, but the peak period for other types of preparatory cultivation was during April and early May.

A few crops were drilled in April, but the majority in May or June, sowings in those two months being almost equally numerous. The period during which chopping out and singling were carried out naturally varied according to the drilling date. With the earliest drilled crops the time elapsing between drilling and chopping out was as much as six weeks, but with later sown crops it was frequently reduced to a month or even less. Hence, although some crops were chopped out and singled in each of the months June, July and August, the month in which these operations were most typically performed was June.

11 Standard deviation, 3.6 worker hours.

12 A further eight crops were harvested entirely by merchants without the assistance of growers for any operation.

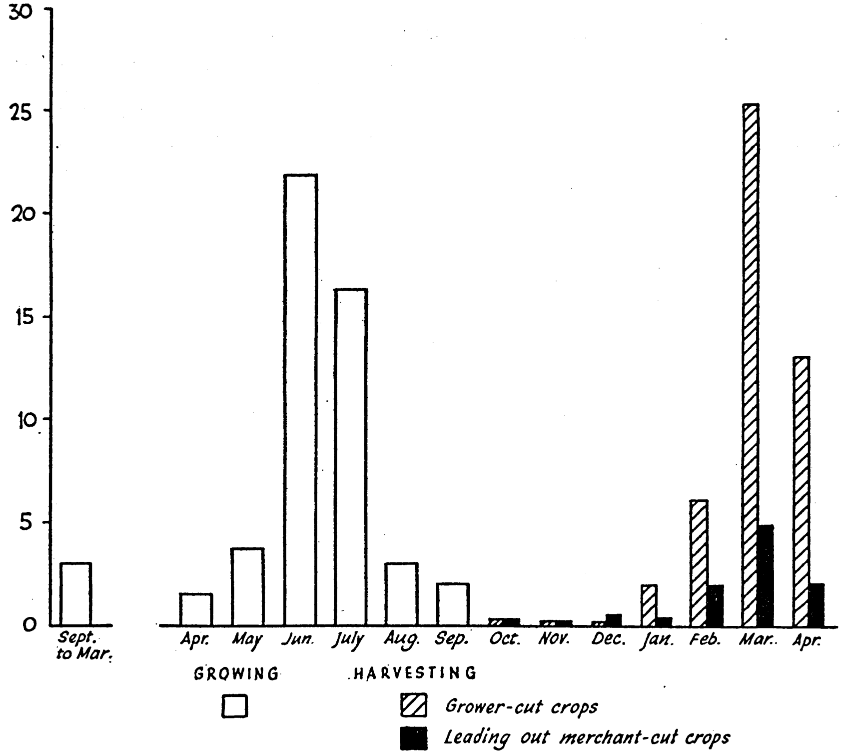
13 Standard deviation, 5.7 worker hours.

14 A further nine grower harvested crops were collected by the buyer direct from the field.

15 Standard deviation, 2.0 tractor hours.

16 See Chapter I.

FIG. 11. SAVOY CABBAGE SEASONAL LABOUR REQUIREMENTS
(Worker hours per acre)



Post-establishment cultivations covered the period from May to October inclusive, though hoeing was completed on the majority of crops by August. Tractor hoeing was frequently started before chopping out and singling, whereas hand hoeing was not started until this operation had been completed. July was the peak month both for tractor and hand hoeing.

Harvesting operations extended from October to April, but a majority of the surveyed crops were cut in March and April, and peak labour requirements occurred very markedly in those two months. This applied equally to crops cut by the grower and to those cut by a merchant, though with the latter the peak labour requirements were naturally much lower.

The main features of the distribution of seasonal labour requirements may be summarised as follows. The production cycle is a long one and may extend over as much as 20 months, but perhaps more typically over a period of 14 or 15 months. Nevertheless, most of the labour demanded by the crop is concentrated into two relatively short periods—June and July for chopping out, singling, and hand-hoeing, and March and April for harvesting. However, the harvesting peak is removed where arrangements are made for a merchant to undertake cutting. On the other hand, with the exception of the earliest harvested crops, savoys demand little or no labour during the late summer and autumn months.

CHAPTER XIX

ALTERNATIVE METHODS OF ESTABLISHMENT

ALTHOUGH AMONGST the crops included in the survey, drilling, chopping out and singling was the most frequent method of establishment, 11 crops were established by transplanting.[1] These alternatives are worth examination from the point of view of labour economy and the likely effects on profits.

The direct drilling and chopping out method of establishment has a number of advantages. Firstly, overall labour requirements are lower. Secondly, the necessity for investing in a transplanting machine is avoided. Thirdly, no special skills are required, and workers skilled in the use of a hoe, in say, sugar-beet, can single savoys with equal facility and without special training. Fourthly, whereas when a transplanting machine is used, the number of workers required to man it can only be varied within very narrow limits, chopping out and singling can be accomplished at different times by varying numbers of workers as is convenient. Fifthly, there is a widely held opinion, probably justified, that on thin soils a better "stand" can be obtained. On the other hand, two advantages may be claimed for the transplanting method. One is that less seed is required, and the second that since the crop is not planted out for at least a month after drilling, additional time is gained for the performance of more numerous preparatory cultivations, or these may be delayed to a later date. Under some conditions, particularly where weeds are a serious problem, this last may be an important advantage.

Information obtained during this enquiry may be used for the critical examination of a number of these points.

In the first place, the average difference in labour requirements between the two methods may be estimated. In estimating the labour requirements for the transplanting method, it has been assumed that the plants are raised on the farm, and 3.4 worker hours and 0.6 tractor hours per acre of the established crop have been allowed for this purpose.[2] For plant pulling, the average labour requirement for the 11 transplanted savoy crops was 11.0 worker hours[3] per acre of the established crop.

The results of the field study of the mechanical transplanting of autumn cauliflowers have been used as the basis for estimating the transplanting labour requirements for savoys, by assuming that they too may be transplanted at an average rate of 1,680 plants per planter hour.[4] So, with a plant population of 17,000 per acre, it is estimated that it would take 3.5 hours to plant an acre of savoys with a 3-unit transplanting

1 On one farm the surveyed field was established partly by direct drilling and partly by transplanting. Since labour was recorded separately for each, for the purposes of this section, this has been regarded as two crops.

2 See Chapter XI.

3 Standard deviation, 6.6 worker hours.

4 See Chapter XII.

machine; furthermore, manual labour requirements would be 17.5 worker hours per acre if a feeder were employed on the machine, and 14.0 worker hours per acre without a feeder.[5] In either case, tractor labour requirements would be 3.5 tractor hours per acre.

By adding together the labour requirements for the three foregoing sets of operations, estimates of *total* labour requirements can be arrived at for the transplanting method of establishment when using a 3-unit machine. These are 31.9 or 28.4 worker hours per acre, depending on whether or not a feeder is employed, and 4.1 tractor hours per acre. These figures can be compared with the 23.3 worker hours and 1.1 tractor hours per acre presented in the previous chapter as the standard labour requirements for the direct drilling and singling method of establishment. It would seem, therefore, that if a 3-unit machine is used the transplanting method requires an additional five to nine worker hours and three tractor hours per acre.

The second matter concerning which factual information is available is the cost of owning and using a transplanting machine. It has been estimated elsewhere in this report that the fixed costs of owning a transplanting machine are £3 8s. per transplanting unit, assuming that it has a working life of 10 years and interest is charged on the investment at the rate of six per cent. It has also been suggested that 6d. per acre is a reasonable estimate of the costs of maintaining the machine.

Finally, the enquiry yielded information about the extra seed required for drilling savoys *in situ*. Amongst the 11 surveyed crops that were transplanted, the average seeding rate was 0.8 lbs. per acre of the established crop. However, since the average plant population of these crops was somewhat lower than the average of 17,000 per acre for crops that were chopped out and singled, for comparative purposes a seeding rate of one pound per acre may be imputed for transplanted crops. Amongst the 27 crops that were chopped out and singled the most usual seeding rate was 3 lbs. per acre. Thus it would seem that the latter method of establishment requires an additional 2 lbs. of seed per acre. With seed costing £1 per lb. this represents an additional expenditure on seed of £2 per acre.

The comparative costs of the two methods can be conveniently considered on a per acre basis, but it will be appreciated that since the annual costs of transplanting machine ownership are fixed irrespective of the acreage on which the machine is used, the per acre costs of the transplanting method of establishment will vary inversely with the number of acres planted each year.

The break-even cost acreages between the direct method of establishment and transplanting with a 3 or a 4-unit machine, either with or without the assistance of a feeder, are shown in Table 49. It has again been assumed that labour costs 3s. 3d. per hour and that tractor running costs are 2s. 9d. per hour.

DIRECT DRILLING AND MECHANICAL TRANSPLANTING
BREAK-EVEN COST ACREAGES

TABLE 49 Acres

	With feeder	Without feeder
Changing from direct drilling to use of transplanter with:		
3 units	60	14
4 units	21	13

5 See Chapter XII for a discussion of methods of dispensing with the feeder.

It will be seen that if strict profit maximisation is the objective, a 3-unit machine should not be purchased for use with savoys unless the total acreage of the crop exceeds 60 if the planters would require the assistance of a feeder, or 14 if the feeder could be dispensed with.[6] On the other hand, the purchase and use of a 4-unit machine would be justified on as little as 22 acres, even though a feeder were to be employed. Of course, it may not always be practicable to use four planter units, due to the limited sizes of tractors or tool-bars available, or irregularities in the topography of the fields being planted. However, where technical considerations allow the choice to be made between the use of 3 or 4-unit machines, the latter will always be the cheaper except on acreages where the direct method of establishment would be cheaper still.

However, too much should not be read into these break-even cost acreages, since the calculated differences in total costs between the various methods of establishment are not very great, particularly on acreages close to the break-even points. For example, on 20 acres the total cost of the direct method would be only about £7 more than that of the cheapest method, i.e. transplanting with a 4-unit machine without a feeder, and some growers may regard the other less tangible advantages of the direct method, mentioned earlier, as being worth at least this amount. Nevertheless, to growers seeking the strict minimisation of ascertainable costs the factual conclusions of this chapter should be of interest.

Finally, it should be emphasised that the break-even cost acreages given only apply to farms where savoys are the only crop for which a transplanting machine is required. Where extensive acreages of crops such as brussels sprouts or cauliflowers are grown, the transplanting of savoys would doubtless pay on acreages smaller than those shown in Table 49.

6 None of the surveyed farms grew as much as 60 acres of savoys; but 13 grew 14 or more acres.

CHAPTER XX

SUMMARY AND CONCLUSIONS

UNDER THE CONDITIONS in which it is grown in the East Midlands the savoy crop competes for labour with other farm crops mainly during the period of singling or transplanting, and again at the time of harvesting. During the former period the clash is with the cleaning operations required by such crops as sugar beet and potatoes, and in the latter period with the spring cultivations of the following season. There are good grounds for thinking, therefore, that savoy growers would generally welcome new production techniques affording scope for profitable production of the crop with less labour, especially during these periods.

At the present time, however, apart from arranging to have the crop cut by a merchant, there seem to be no new techniques offering a really substantial reduction in the grower's labour requirements for savoys. Nevertheless, there is at least one interesting recent technical development which shows some promise for the future. This is the down-the-row thinning machine now being used by a few farmers for the gapping of sugar beet. If this machine could be suitably adapted for use in direct drilled savoy crops, the very considerable amount of labour at present required for chopping out might be substantially reduced. However, no instance of the use of a machine of this type was encountered during the course of this enquiry.

But despite the fact that no spectacular labour saving devices have been brought to light, this enquiry has drawn attention to the average amounts of labour required for growing and harvesting savoys, and how that labour is distributed over the season. This information should be of interest to growers, particularly those with more limited experience of the crop. Moreover, alternative methods of establishment have been examined and discussed from the points of view of labour requirements and profits. The conclusion is that the drilling and chopping out method of establishment is a sound economic practice on farms except where the acreage of the crop is relatively large. Only where there are more than about 14 acres of savoys to be established is mechanical transplanting with a 3-unit or larger sized machine likely to be cheaper, and even then only so long as the planters do not require the assistance of a feeder.

Assuming a harvested yield of six tons per acre, the difference in grower's labour requirements between a crop which the grower cuts himself and one which is cut by a merchant would seem to be a little over four man-days per acre.

This, then, is a way of making a substantial reduction in labour requirements, though almost certainly at the cost of some reduction in the returns realised on the crop. Unfortunately no reliable factual information emerged from this enquiry to indicate how large a reduction may be expected and hence the effect on profits. Analysis of the gross returns from merchant harvested and grower harvested crops failed to show a statistically significant difference between them. This suggests that in this particular sample of growers other, unexplained, factors influence the level of gross returns to an equal or greater extent than the arrangement made for disposing of the crop. However, in a previous section of this report a similar problem is discussed in connection with the merchant harvesting of autumn cauliflowers[1]; this discussion, and some comparative figures showing the average financial results obtained by growers who cut their own crops and those who arranged for cutting to be done by a merchant, may also be of interest to growers of savoys.

[1] See Chapter XIII.

PART G

MAINCROP CARROTS

CHAPTER XXI

STANDARD LABOUR REQUIREMENTS

THE INFORMATION presented in this section was obtained in two ways. The average amount of labour used in bringing the crops to the point of harvest was obtained from records kept by the growers of 58 carrot crops. Averages were taken of the per acre labour usage on all the crops for preparatory cultivations and drilling, and the effect on labour requirements of controlling weeds by means of petroleum oil sprays was determined by averaging separately for sprayed and unsprayed crops the per acre labour usage for all post-drilling operations.

For a variety of reasons a similar procedure would not have proved satisfactory for harvesting operations. Firstly, because of very low prices in the 1953-54 season many crops were either not harvested at all, or were only partly harvested. Secondly, the yields in the second year of the enquiry were generally low in the area of the survey, and harvesting labour requirements were similarly abnormally low on a per acre basis, but possibly unusually high per ton. Thirdly, various harvesting methods were used; while the majority of crops were lifted by hand, some were lifted by fully or semi-mechanical methods. Fourthly, many of the crops were put into pies at lifting, but because of the prevailing low prices in the 1953-54 season not all of those pied were subsequently removed and sold. Hence, the records of harvesting labour usage fell into several groups according to the harvesting method, but in view of the wide variations in marketed yields within each group and the small numbers of records involved, average harvesting labour requirements derived from the survey results would have been unreliable as a basis for standards.

However, an *ad hoc* field study of carrot harvesting methods was made on 10 farms, and the measurements of the performance of workers and machines obtained enabled provisional standard harvesting labour requirements to be derived.

Operational Labour Requirements

The following table presents in summary form the information obtained from the enquiry into the growing labour requirement of the carrot crop.

STANDARD GROWING LABOUR REQUIREMENTS

TABLE 50 Per acre

Operations	Worker hours		Tractor hours
	Sprayed crops	Unsprayed crops	
Preparatory cultivations	8.6		7.9
Drilling	1.7		0.8
Post-drilling cultivations	41.8	57.8	4.9
Total growing	52.1	68.1	13.6

Preparatory Cultivations and Drilling

Included under preparatory cultivations are ploughing, the application of artificial fertilisers, and all spring cultivations performed in bringing the land into a proper condition for drilling, e.g. discing, harrowing and rolling. On average 8.6 worker hours[1] and 7.9 tractor hours[2] were so expended. The range in man labour usage was very wide, from 3.0 worker hours per acre on a farm where it was the practice to hitch implements in tandem, e.g. cultivators and harrows, and harrows and roller, and thereby perform two or more operations each time over the field, to 21.8 worker hours per acre on a farm where emphasis was habitually laid on the thorough performance of cultivations, and where preparation of the land took the form of one deep ploughing and three shallow ploughings, followed by repeated cultivation and harrowing up to the time of drilling.

On the majority of farms drilling the seed was a two man job, one man driving the tractor and a second following the drill. This is reflected in the overall average labour requirement of 1.7 worker hours[3] and 0.8 tractor hours[4] per acre. However, a few growers managed with only one man, and the lowest labour usage was only 0.8 worker hours per acre.

Post-drilling Cultivations

In the main, these comprised all cleaning operations performed on the crop between its drilling and harvesting, including hand weeding and hoeing, tractor hoeing, and spraying with petroleum oils. The application of insecticides for the control of carrot fly was commonly a joint operation with the spraying of weedicides, but where weeds were controlled solely by hand and mechanical cultivations, spraying insecticide was a separate operation.

There was a significant difference in the average amount of man labour used on crops which were sprayed with petroleum oils, compared with those in which weed control was effected entirely by hand weeding and hand and tractor hoeing. On average the sprayed crops required 16.0 worker hours[5] less labour than those which were not sprayed.[6] However, as the following table shows, there was a very wide range in each group, clearly indicating that the use of petroleum oils has not provided a complete solution to the difficulties experienced in cleaning this crop. Thus the highest labour usage in the group which used petroleum oils was 117.6 worker hours per acre for a crop which had to be hand weeded despite the fact that it was twice sprayed. At the other extreme, the lowest labour usage amongst the unsprayed crops was only 6.4 worker hours per acre for a crop which required only two tractors hoeings and the hand hoeing of a few large weeds between drilling and harvesting.

POST-DRILLING LABOUR REQUIREMENTS

TABLE 51 — Worker hours per acre

Treatment	No. of crops	Average	Standard deviation	Range
Sprayed crops	32	41.8	27.3	2.5 to 117.6
Unsprayed crops	26	57.8	32.0	6.4 to 139.0

1 Standard deviation, 3.5 worker hours.
2 Standard deviation, 3.3 tractor hours.
3 Standard deviation, 1.2 worker hours.
4 Standard deviation, 0.4 tractor hours.
5 This difference is significant at the five per cent level; standard error, ± 7.7 worker hours.
6 Tractor labour requirements were not significantly different between the two groups and the figure shown in Table 50, is the average number of tractor hours worked on all the surveyed crops.

Hence it is clear that such factors as the amount, timing and efficacy of cultivations undertaken both before and after drilling, and the state of cleanliness adjudged by individual growers to be desirable, played a larger part in the determination of the labour usage on individual crops than whether they were sprayed or not.

Harvesting

The results of the field study of carrot harvesting are presented in detail in a subsequent section. At this point it is necessary to stress that the figures are derived from observations made on a small number of farms and that the estimates of the amounts of labour required by each method must be treated with reserve.

STANDARD HARVESTING LABOUR REQUIREMENTS

TABLE 52 — Per acre

Method	Worker hours	Tractor hours
Hand topping and lifting (time work)	146	—
Mechanical lifting, topping, and loading into trailers	11	11
Mechanical lifting and topping, and hand picking behind lifter	55	5
Mechanical lifting, topping and heaping, and hand covering of pies	42	6

Where hand work is involved there is likely to be a correlation between yield and labour requirement per acre; consequently the observed results for operations performed entirely by hand have been adjusted to a standard yield of 15 tons of unwashed carrots per acre.

The labour requirement shown in Table 52 for hand lifting is based on the performance of workers paid by the hour. When piece rates are paid, this figure will be reduced to about 104 worker hours per acre under average conditions.

The lifting of carrots by hand for storage in the field in clamps or pies was not observed in the course of the field study. However, the general survey results indicated that the labour requirement for hand lifting, topping, placing the topped carrots in pies, and soiling, requires little or no more labour than when the lifted and topped carrots are bagged for immediate removal from the field. This conclusion is supported by the fact that on many farms an identical piece rate is paid both for pieing and for bagging. On the other hand, taking the carrots from pies is an additional operation, and on 10 farms where this operation was recorded, an average of 4.5 worker hours per ton was required for de-soiling and loading the carrots for transport to the washer. Thus with a 15 ton crop it is estimated that an additional 68 worker hours per acre will be required for pied crops, compared with those lifted for immediate sale. However, this figure can be expected to vary widely with the weather conditions experienced when the pies are opened, being highest when the soil covering is frozen, as was the case with the crops to which the average refers.

The labour requirements shown in Table 52 for the mechanical methods make no allowance for time lost by the operator of the lifting machine, apart from that spent in legitimate rest periods and travelling to and from the field. That is, it is assumed that lifting is a continuous operation, or, where this is not possible, that the lifter operator is employed for other work between bouts of lifting.

The time taken to transport the lifted carrots from the field to the point where they were prepared for market, i.e. washed and, or, graded, was of course peculiar to each farm, and this operation has been omitted from the standards. Further, very little information was obtained about the labour required for washing and grading carrots, mainly because this operation was usually performed by merchants. However, two tons of washed carrots per hour is considered to be an average throughput with the type of carrot-washer most popular in the area of the survey, when operated by a team of five workers. This would give an additional labour requirement of about 40 worker hours per acre for an average sized crop.

Seasonal Labour Requirements

In examining the seasonal pattern of labour usage in carrot production the primary records were first divided into two groups according to whether the crops were sprayed with petroleum oils or not, and the average amount of labour used in each month for all operations up to harvesting was determined separately for each. Similarly, the average amount of labour used in each month for all harvesting operations was determined separately for those crops which were stored in clamps or pies and those which were not. Further, for pied crops a distinction was made between the lifting and storage of the carrots and their subsequent removal from the pies at the time of sale.

Having determined the average amounts of labour used in each month for these groups of operations, the *standard* growing and harvesting labour requirements given in the previous pages were distributed over the same months and in the same proportion as the analysis showed that labour had in fact been used on the surveyed crops.[7] The distributions so obtained are shown in Fig. 12.

For the group as a whole preparatory cultivations were spread over an eight-month period. Most fields were both winter and spring ploughed, but the spring months were mainly occupied with the performance of repeated cultivations designed to secure the germination of weed seeds and the destruction of the seedlings prior to drilling.

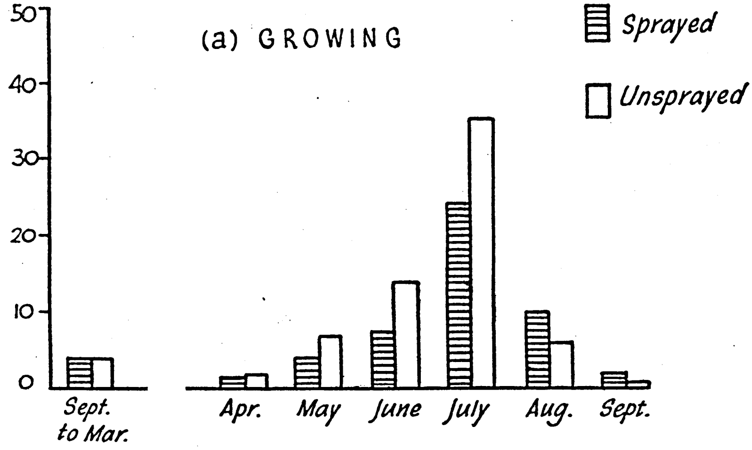
Only one crop was drilled before May; a majority were sown in that month and the remainder in early June. Most growers delayed sowing late enough to miss the first generation of carrot fly.

Cleaning operations started as soon as the carrots were visible in the row, and tractor and hand hoeing continued throughout the summer months. The application of petroleum oils was mainly in June, though some of the late sown crops were not sprayed until July. It will be seen that for crops so treated there was a substantial reduction in labour requirements in those months compared with crops which were not sprayed. This reduction was most marked in July.

Amongst the surveyed crops carrots were sold in every month from late August to May. Those which were marketed before the end of the year were sold concurrently with lifting; sales in the early months of the following year were either from crops lifted in the late autumn and stored in pies, or from crops over-wintered in the ground. There was no common pattern for all farms. Some sold carrots throughout the period and adopted one or both methods of storage; others sold the whole of their crops in a matter of days either early or late in the season.

7 The standard lifting and bagging, and lifting and pieing labour requirements used, were those for crops harvested by hand by hourly paid workers.

Fig. 12. MAINCROP CARROT SEASONAL LABOUR REQUIREMENTS
(Worker hours per acre)



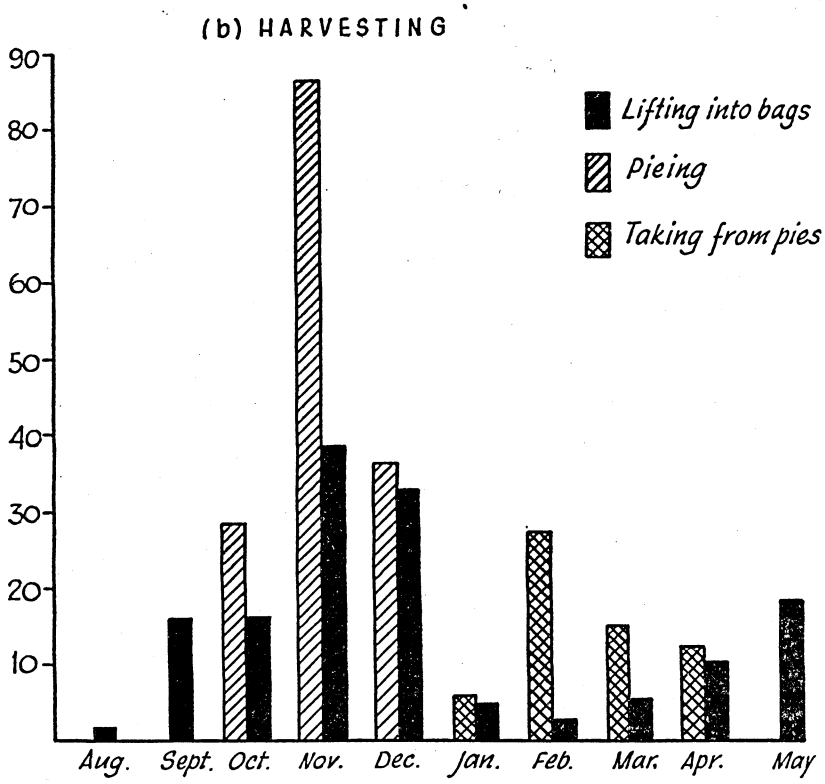


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Fig. 12 (b) shows the seasonal pattern of labour usage on those crops which were sold straight from the ground both early and late. Lifting was first recorded at the end of August, and was continued until May, but most lifting was done in November and December.

Lifting of crops for pieing started somewhat later, in October, but with a marked concentration in November. Taking from pies commenced in January, but since the object of storage in pies was to facilitate the marketing of carrots in the periods when hard frost prevented the lifting of carrots from the ground, the peak month for removal from pies was February. However, the last carrots were not sold from pies until April.

The cycle of carrot production considered as a whole is seen to be exceptionally long. Up to 22 months elapsed between the first preparatory cultivations and clearing the last of the crops, and the carrots commonly occupied the land for as long as a year.

At the growing stage the crop makes its greatest demands for labour in June and July, and though spraying with petroleum oils effects a reduction in the labour requirement of cleaning operations, particularly in the latter month, the requirement is still high at a time when the labour force is extended on the cleaning of other row crops and haymaking. Moreover, the timing of cleaning operations in carrots in relatively inflexible since the weeds must be killed at an early stage in their growth. For these reasons, casual labour is widely employed for hand cleaning operations in the summer months.

From the technical aspect the date of harvesting is highly flexible. But in practice, the desire to take advantage of favourable prices in the early autumn months, and to complete the storage of a proportion of the crop in pies before the advent of severe frosts, frequently results in competition for labour between the requirements of carrot harvesting, the harvesting of other root crops and the performance of autumn cultivations.

The removal of stored crops from pies occurs mainly in the mid-winter months and at this time the competing demands for labour between carrots and other crops are probably at their lowest. However, when pied crops are not sold until the spring, or when crops over-wintered in the ground are lifted for sale, then some competition for labour between carrots and spring cultivations is commonly experienced.

CHAPTER XXII

CHEMICAL WEED CONTROL

THE MOST USUAL RATE at which weed-killing petroleum oils were applied to the crops included in the enquiry, was 60 gallons per acre; this was sometimes put on in two applications. With only one exception ordinary tractor vapourising oil was used. This cost about 1s. 6d. per gallon, giving a direct outlay of £4 10s. per acre for materials alone.

A technique used on a few farms, and worthy of wider adoption, was that of confining the vapourising oil to the rows and a narrow band on either side, weed growth between the rows being controlled by mechanical cultivations. By this means the rate of application was reduced to as low as 15 gallons per acre, and the cost of materials to no more than £1 3s. per acre.

In considering the economy of chemical weed control in carrots, exactly the same problems and principles are involved as those described in the chapter on weed control in vining peas which appears elsewhere in this report (see Chapter III). However, the lack of experimental data is an even more serious handicap to determining when chemical weed control in carrots is likely to be profitable, than was the case for the vining pea crop. Thus, although the average labour requirement of the sprayed carrot crops was 16 worker hours per acre less than for those in which weeds were controlled entirely by hand and mechanical cultivations, the fact that some growers sprayed only because their crops were exceptionally weedy, rather than as a matter of routine, renders this an unreliable guide to the reduction in labour requirements which can be expected under average conditions. Nevertheless, it can be stated that spraying may be expected to reduce labour requirements by *at least* 16 worker hours per acre under average conditions, but that the saving may be much greater in particularly dirty crops.

However, at the high and low rates of application, respectively, a saving of 28 and 7 hours of man labour per acre would be sufficient to recoup the costs of materials.[1] The facts that firstly, the recorded difference between the average labour requirements of sprayed and unsprayed crops (16 worker hours per acre) approached the highest of these figures despite the fact that it is almost certainly an under-estimate of the real saving on the sprayed crops, and secondly, that the average labour requirement for unsprayed crops (58 worker hours per acre) was much higher than either of the above figures, both suggest that a saving of labour sufficient to offset the costs of spraying might frequently be secured.

No experimental or other quantitative data appears to be available about the effect of weed competition on the yield of carrot crops. However, growers well know that excessive weed growth in the critical early seedling

[1] If the spraying equipment was purchased specifically for this purpose its ownership and maintenance costs would be borne solely by the carrot crop, and the per acre reduction in labour costs would need to be greater by an amount sufficient to offset these additional costs, the per acre incidence of which would vary with the total acreage involved.

stage of the carrots can seriously depress the final yield. It is possible that where the saving in labour costs was of itself insufficient to recoup the cost of spraying, then the difference, i.e. the additional cost of spraying, might be recouped by yield increases resulting from the more effective control of weeds in the rows. The additional yield required would depend upon the amount of labour released, the amount of spray material used and the value of the carrots after meeting harvesting and marketing costs, but an additional ton to the acre would be sufficient in most years.

CHAPTER XXIII

A STUDY OF CARROT HARVESTING

IN RECENT YEARS the increasingly widespread use of mechanical sugar beet harvesters has stimulated interest in the possibility of these machines being used for the harvesting of maincrop carrots. A few farmers in this area have been developing this idea, and are now regularly lifting their carrot crops with beet harvesters.

A field study of carrot harvesting was therefore made with the intention of comparing fully and semi-mechanical harvesting methods with the more usual hand method, in respect of their relative labour requirements and technical efficiencies. Hand lifting and topping was observed on six farms, and the use of beet harvesters was observed on four farms.

LABOUR REQUIREMENTS

Hand Lifting

On three of the six farms where hand lifting was observed the workers were paid at piece rates, and on the other three at time rates. The measured performances on each farm are shown in Table 53. Weight determinations were made on the "as lifted" crop, i.e. after field grading, but before washing and further grading at the washer.

HAND HARVESTING LABOUR REQUIREMENTS

TABLE 53 — Worker hours per ton

Method of payment	Piece work			Time work		
Farm No.	1	2	3	4	5	6
Labour requirements	6.4	5.9	6.6	8.2	8.5	9.7

In all cases except that of Farm No. 2 the lifted and topped carrots were placed first into wire baskets; when full these were emptied into sacks. On Farm No. 2, however, unnecessary walking about was obviated by the workers dropping the carrots straight into sacks, the necks of which were periodically unrolled as they were filled. This method is illustrated in Plate XVII.

There were other differences in the lifting techniques, the sizes and compositions of the lifting gangs and in the yields of the various crops, but none of these factors had such a consistent effect on the labour requirement per ton as the method of payment.

The rate of lifting by workers paid by the hour was a little over one third slower than that of workers paid at piece rates.[1] Hourly paid workers lifted, topped and bagged carrots at the average rate of 8.8

[1] This is the usual relationship between time work and piece work rates of output; in industrial work study it is conventional to give a 60 *rating* to a man doing a job at the "normal" rate when he is being paid by the hour, but to expect him to achieve an 80 *rating* if he is doing the same job on piece work.

worker hours per ton, whilst the average labour requirement where piece rates were paid was 6.3 worker hours per ton. These rates of output are based on the measured time spent in the performance of all directly and indirectly productive operations, and the time occupied by short rest periods taken between spells of working. But as a basis for management planning, an allowance should also be made for time spent in getting to and from fields, short breaks for refreshments, and the many other factors which affect overall rates of performance. If it is assumed that 10 per cent of each day is lost in this way, then the above figures would be increased to 9.7 and 6.9 worker hours per ton respectively. On a 15 ton crop, the corresponding average labour requirements *per acre* would be 146 and 104 worker hours, for time workers and piece workers respectively.

Mechanical Harvesting

The organisation of the lifting and topping, the equipment and the way in which it was used, all varied between the four farms on which the mechanical harvesting of carrots was observed. The presentation of the results is, therefore, preceded by a short description of the circumstances on each farm. On all four farms the same basic type of complete sugar beet harvester was used, though the modifications made to the machines varied.[2]

Description of Methods

On Farm No. 7 the harvesting was fully mechanised and no hand work was done. Plate XVIII shows harvesting in progress on this farm. A modified elevator model sugar beet harvester was used to top and lift the carrots and load them into a tractor-drawn trailer running alongside the lifter. Topping was performed by a unit designed and constructed on the farm, consisting of a number of rotovator blades bolted to the revolving member normally carrying the rubber flails (see Plate XXI). The trailers when loaded were hauled to the washer.

An elevator type beet harvester was also used on Farm No. 8, but here the loading elevator had been removed and after passing over the digger-elevator the carrots fell to the ground at the back of the machine (see Plate XIX). Topping was done by the normal side-mounted knife and feeler wheel, with some supplementary topping by the rubber flails. A team of 13 women was employed to gather the carrots from the ground behind the machine. Wire baskets were used as primary containers, and the carrots were tipped from these into sacks. The field was lifted in "lands", and the filled sacks of carrots were loaded on to a lorry and carted from the field at intervals throughout the day for washing.

Dumper type beet harvesters were used on Farms Nos. 9 and 10 to top and lift the carrots and leave them in heaps for pieing; Plate XX illustrates the way in which this was done. By operating the dumper always at the same points along the rows the carrots were left in long, continuous low heaps running at right angles to the rows. These heaps were then shaped and covered by hand. Two men operated the lifter—a tractor driver and a second man working the dumping mechanism and easing the carrots into the "well". Topping on Farm No. 9 was done by the normal side-mounted beet topping unit with supplementary topping by the flails, and on Farm No. 10 by the rubber flails alone.

2 Since the completion of this study the manufacturer of the harvesters observed has introduced a modified version designed specifically for use on carrots, the most important feature being an improved topping unit. It must be stressed that the lifters observed were not of this type, and that the results obtained from the study may not apply *in toto* to the use of this improved machine.

MECHANICAL HARVESTING RATES

TABLE 54

Machine hours per acre

Method	Farm No.	Net topping and lifting	Turning and associated operations	Stoppages and adjustments	Dumping	Sub-total	Waiting	Total
Fully mechanical harvesting, loading into trailers	7	1.4	1.4	1.1	n.a.	3.9	5.3	9.2
Mechanical lifting, hand picking behind machine	8	2.1	1.0	0.1	n.a.	3.2	2.3	5.5
Mechanical lifting and heaping, hand covering of pies	9	2.7	1.3	1.6	0.6	6.2	—	6.2
	10	2.6	0.5	2.9	0.3	6.3	—	6.3
Average		2.2	1.1	1.4	0.5 *	n.a.	n.a.	n.a.

* Average of two farms only
n.a. = not applicable.

In order to place the results on a broadly comparable basis, both with respect to each other, and with the results obtained from the study of hand harvesting, only those harvesting operations which were common to all farms and all methods will be considered. These were lifting the carrots and removing their tops, and their "packaging", either into trailers or sacks prior to removal from the field, or into pies for storage. Operations performed on the carrots beyond this stage, e.g. transporting from the field, washing, grading and packaging for market are so variable between farms that no generally applicable information can be drawn from the experience of the relatively few farms included in this study.

Individual Results

Table 54 gives the average overall time taken to lift an acre of carrots on the four farms and shows the composition of overall time in terms of its elements.

Net topping and lifting comprised the time during which the machines were in forward motion in the row. It was markedly lower on Farms Nos. 7 and 8 than on the two farms where the carrots were being pied. The main reason for this is thought to be the irregularity in tractor speed on the latter farms, associated with the deceleration and acceleration necessitated each time the lifter was halted and the carrots discharged on to the heaps. At the mid-point between halts the tractor speeds were probably no lower than on Farms Nos. 7 and 8, but the overall average speeds were lower as a result of slowing down prior to halting and the delay in reaching the maximum rate of travel when accelerating away from each pie.

Turning and associated operations comprised moving out of one row, travelling along the headlands and turning into the next row. Also included is the time spent running the lifter clear of carrots at the end of each row. On Farm No. 7 these operations took longer than on any other farm, occupying only fractionally less time than that spent actually lifting. This was attributable to the greater complexity of the manoeuvring at the end and beginning of each row as a result of having to synchronise the movements of the lifter and trailer into which the carrots were being delivered. On Farm No. 10 the rows were exceptionally long, and this was the main reason for the small amount of time spent in turning and manoeuvring the lifter on this farm.

The main cause of *stoppages in the row* was the breaking of the digger elevator web by stones lodged between the links. This was a particularly serious problem on Farm No. 10, where a considerable amount of time was lost in this way. In addition, some time was lost in removing accumulations of soil, carrots and weeds from various parts of the machine, particularly from the region of the top web-roller, and to a lesser extent from the space between the lifting shares and the elevator. The users of this machine were agreed that it would be more suitable for carrot lifting if the digger elevator was three to six inches longer, thereby allowing the carrots to fall straight into the well. As at present constructed, it ends short of the edge of the well, and there is a tendency for soil and weeds to accumulate and impede the free flow of carrots. This is illustrated in Plate XXII.

Dumping was of course confined to those farms where the carrots were being pied. Twice as much time was occupied by this operation on Farm No. 9 as on Farm No. 10, the main reason for this being that the crop on the latter farm was very much poorer and the distance between lines of pies was 85 yards as opposed to the 40 yards on Farm No. 9. Consequently the number of times the machine was halted to discharge carrots on to the heaps was about half that on Farm No. 9.

Where the carrots were pied, lifting was continuous with no interruptions apart from those caused by the stoppages described. But on the two farms where the carrots were taken from the fields, lifting was in bouts with *waiting* periods between. On Farm No. 7 this resulted directly from the inability of the farm washing plant to cope with the carrots as fast as they could be lifted, and the lifter was standing idle for a longer period than it was in use. On Farm No. 8 the machine was able to lift the carrots faster than the pickers could pick them up, and there was a long waiting period at the end of each row. This could have been avoided by increasing the number of pickers, but even under the existing arrangements the lifting capacity was in excess of the capacity of the washing plant; to increase the rate of lifting would merely have accentuated the congestion at the washer.

The experience on these four farms shows that where the carrots are being pied the lifter can be kept working continuously provided covering of the pies proceeds apace; but where the carrots are being lifted for immediate sale, it will only be possible to use the lifter to its full capacity if the labour and plant used in preparing the carrots for market are capable of dealing with them as rapidly as they come from the field.

The throughput of carrot washers of the type most frequently found on farms in the survey area is about two tons per hour under good conditions, or say, 15 to 20 tons in a normal working day. This represents the yield from no more than one to one and a half acres—an area which could easily be lifted in half a day by the fully mechanical method in use on Farm No. 7, or by the semi-mechanical method used on Farm No. 8 if the number of pickers was somewhat larger. Thus it would seem that unless the farm's washing and grading plant is on an exceptionally extensive scale it will be unusual for mechanical lifting to be continuous, and waiting periods of the order experienced on Farms Nos. 7 and 8 will be typical.

Average Machine Performance

The best measure of the average rate of working of this type of beet harvester may be obtained by combining the average elemental times shown in Table 54. With only four results there is little to be gained by making fine distinctions between the methods, except that where dumper models are used for leaving the carrots in heaps for pieing the dumping time is clearly peculiar to that method.

Thus, combining the average elemental times shown in Table 54 the operations of topping and lifting may be expected to occupy 4.7 machine hours per acre when the carrots are loaded into trailers or sacks. An additional 0.5 hours may be required for dumping, giving a total of 5.2 machine hours per acre for dumper type machines used for pied crops. These average working rates make no allowance for travelling to and from fields, refreshment breaks and the daily servicing of tractor and lifter. An arbitrary upward adjustment of 10 per cent may be made to allow for these and similar factors affecting overall rates of working. The estimated times for topping and lifting then become 5.2 and 5.7 machine hours per acre, when lifting carrots into trailers or dropping them on to the ground for hand picking, and when lifting for pieing, respectively.

These rates are exclusive of all time lost through waiting for other units of the carrot harvesting organisation; they represent the estimated average performance of the machines when able to work continuously in the field. Where the carrots are being pied, no time need be lost through waiting and the actual performance will approximate to the estimated rate of one acre of carrots topped, lifted and dumped in heaps in 5.7 hours. But where carrots are lifted for immediate sale, and where the performance of the machine is limited by the rate at which other associated operations are carried out, e.g. their washing as on Farms Nos. 7 and 8, then the actual performance may often be lower than the estimated capacity rate of an acre topped and lifted in 5.2 hours.

Packaging and Total Labour Requirements

Following lifting and topping the carrots were bulked or "packaged", either into trailers or sacks prior to removal from the field, or into clamps for field storage. The amount of labour required for this operation varied for each of the three methods.

The packaging labour requirement was lowest on Farm No. 7 where the carrots were *loaded into tractor-drawn trailers*. Where this method is employed, loading time is the same as the working time of the lifter, plus the allowance for rest periods, servicing, etc.. Thus taking the estimated machine time per acre for elevator type lifters (5.2 hours), the total labour requirement for topping, lifting and loading an acre of carrots would be between 10 and 11 worker hours and a similar number of tractor hours.

On Farm No. 8, where the carrots were *picked up behind the lifter* and placed into sacks, 72.3 worker hours per acre were used. The measured yield was 24 tons per acre, giving a labour requirement for packaging of 3.3 worker hours per ton after making the 10 per cent allowance for refreshment breaks, etc.. Thus, at the standard average yield of 15 tons per acre, the labour requirement for hand picking and bagging behind the lifter may be expected to be about 50 hours per acre. The length of time the lifter, and its operator, are in the field will depend on the number of pickers working with it; when working continuously, a little over five hours per acre will be required under average conditions, but this will be increased if the number of pickers is insufficient to keep the machine fully occupied. Thus if the rate at which the pickers on this farm worked is typical, the total labour requirement by this method may be estimated at about 55 worker hours and five tractor hours per acre on an average crop.

The *covering of pies* was observed only on Farm No. 9, and a total of 30.5 worker hours was used for this operation on a crop which was estimated to yield about 15 tons to the acre. The workers were fully occupied, and this figure may be taken as an approximate measure of the labour requirement of this operation. Under average conditions a further 11.4 workers hours and 5.7 tractor hours of labour are required for the operation of the lifter, giving a total of about 42 worker hours and six tractor hours for this method of topping and lifting carrots, and their storage in pies.

It will readily be appreciated that with so small a number of case studies any attempts to suggest standards of performance, whether derived by combining observations on operations common to more than one farm, or by adjusting the observed performance on any one farm to standardised conditions, can only provide the most tentative results. Nevertheless, it is sufficiently clear that mechanical harvesting does show a substantial reduction in labour requirements compared with hand work, and there is little doubt that under comparable conditions, the reductions are of the order indicated in previous pages and summarised in Table 52.

TOPPING EFFICIENCY AND MECHANICAL DAMAGE

Although growers in the enquiry were generally well aware that the use of beet harvesters could lead to a substantial reduction in the labour costs of carrot harvesting, many were deterred from their use by the fear that the removal of the tops would not be so effective as hand screwing, that the amount of mechanical damage would be excessive, and hence that any savings in lifting costs would be more than offset by reductions in the market value of the crop. A comparative study of the efficiency of top removal and the extent of mechanical damage was therefore undertaken on each of the farms included in this study.

On each farm the length of top left on the carrots and the frequency with which four categories of mechanical damage occurred were determined on samples of the "as lifted" carrots[3]. Carrots were taken from each worker in the case of hand lifted crops, from several trailers where the carrots were loaded into trailers, and from each pie for the crops lifted with dumper type machines. In addition, the samples were taken from different parts of the field in order to minimise differences in the state of the crops and working conditions.

Topping Efficiency

It is recommended that no carrot in a market pack should retain more than 0.5 inches of top.[4] Table 55 shows the proportion of carrots meeting this specification after manual removal of the tops on six farms and mechanical topping on four farms, and the proportions falling outside this category.

EFFICIENCY OF CARROT TOP REMOVAL

TABLE 55 — Per cent marketable carrots

Farm No.	Hand topping							Mechanical topping				
	1	2	3	4	5	6	Average	7	8	9	10	Average
Over-topped	1	1	—	—	—	—	..*	5	15	52	1	18
0 in. to ½ in.	48	37	26	51	55	66	47	21	47	42	41	38
More than ½ in. to 1½ in.	31	42	47	38	38	27	37	25	16	3	15	15
More than 1½ in.	20	20	27	11	7	7	16	49	22	3	43	29

* Less than 0.5 per cent.

Mechanical topping was inferior to hand work in so far as a smaller proportion of the carrots met the recommended grade standard with regard to top lengths. Moreover, on average, the proportion of mechanically harvested carrots having more than 1.5 inches of top was higher than amongst hand lifted crops. On the other hand, it will be seen that hand topping was by no means perfect, and more top was commonly left on carrots lifted by this method than might have been expected.

With mechanical topping the length of top left on the carrots is mainly determined by the setting of the topping unit. The danger here is that in the attempt to remove the maximum amount of top, the topping knife or flails may be set so low that the crowns of the carrots are damaged. And in fact, over-topping was a feature of the work where mechanical harvesting was practised. This aspect will be considered in the following

3 Only carrots free from forking, growth cracks and heavy infestations of carrot fly, and not less than 3 inches in length and 1 inch in diameter, i.e., potentially marketable carrots, were examined.

4 *Recommended grades for home grown maincrop carrots*; Marketing Division, Ministry of Agriculture Fisheries and Food; Marketing Guide No. 36, page 26; 1951.

section on mechanical damage, but it will be seen from Table 55 that varying degrees of success were achieved in striking the balance between effective removal of the tops and avoiding damage to the crowns. Thus on Farms Nos. 7 and 10, the topping units were set sufficiently high to give a relatively low incidence of over-topping, but this resulted in between 40 and 50 per cent of the carrots being left with more than 1.5 inches of top. In contrast, on Farm No. 9, although only six per cent of the carrots retained more than 0.5 inch of top, more than half of all the carrots had had their crowns removed.

This study of the effectiveness of hand and mechanical topping was made when the tops were erect and green, and the results would not necessarily apply to topping later in the year when the leaves have fallen and started to rot. The general experience is that mechanical removal at these later stages is somewhat more satisfactory, particularly when the crowns have been slightly ridged over with soil. Further, when mechanically topped crops have been stored in pies for any length of time, the short lengths of tops left on the carrots soften and rot, and a high proportion are automatically rubbed off during removal from the pies and washing.

Mechanical Damage

Four main categories of mechanical damage were classified, and their incidence recorded for both hand and mechanical harvesting methods. As may be seen from Table 56, damage was mainly confined to the mechanically lifted crops.

INCIDENCE OF FOUR TYPES OF MECHANICAL DAMAGE

TABLE 56 — Per cent marketable carrots

Farm No.	Hand lifting							Mechanical lifting				
	1	2	3	4	5	6	Average	7	8	9	10	Average
Over-topped	1	1	—	—	—	—	..*	5	15	52	1	18
Broken tip	1	1	—	—	3	2	1	15	9	23	16	10
Sliced	—	1	—	—	—	—	..*	1	—	—	—	1
Split	—	4	1	6	6	—	3	14	3	9	4	5

* Less than 0.5 per cent.

The most frequent type of damage suffered by mechanically harvested crops was *over-topping*, but the range about the average shows that this was less an inevitable feature of the method than a consequence of attempting to remove a maximum amount of top. However, two further factors were seen to lead to a high incidence of over-topping. Firstly, under damp soil conditions the slight sinking of the machine caused the knife to be too close to the carrot crowns. Secondly, and of fundamental importance, was the fact that carrots did not all project the same height above the soil surface, with the result that those carrots standing highest out of the ground commonly had their crowns cut through by the topping knife or snapped off by the flails.

Breakage of the tips was the second most frequent type of damage amongst the mechanically lifted crops. Damage by the lifting shares was one cause of this, but trapping between the links of the digger elevator web may have been an equally important source of this type of damage.

Slicing of the carrots was confined to Farm No. 7, and even there was of relatively infrequent occurrence. It was caused by a disc-coulter fitted to the machine used on that farm for the purpose of cutting those tops which had fallen into the space between the rows. Under damp soil conditions there was a certain amount of machine side-slipping, and this resulted in about one per cent of the carrots suffering vertical slicing.

Splitting was most severe in machine lifted carrots although it was also the most frequent form of damage amongst the hand lifted crops.[5] It may be significant that splitting was most severe on Farm No. 7 where the carrots were elevated and loaded into trailers in bulk, for there is no doubt that splitting was mainly due to impact between the carrots one with another, and with non-resilient parts of the machine and trailer-bed.

In addition to the four types of damage described, the carrots also showed varying degrees of superficial abrasion and bruising. This type of damage was more evident in mechanically lifted crops and became most noticeable several days after lifting.

In view of the varied and extensive damage suffered by mechanically lifted carrots, it might be expected that the storage life would be seriously impaired. However, this does not seem to be the general experience, and each of the four growers using beet harvesters for topping and lifting stated that they had successfully stored machine lifted carrots for long periods without any serious deterioration in the pies.

Market Reaction

It has been shown that where carrots are lifted with mechanical beet harvesters the quality of the work is lower than where hand lifting is practised. Mechanical lifting seems to entail a higher proportion of carrots retaining an excessive length of top and a greater amount of physical damage. However, the measurements upon which these conclusions are based were made in the field when the carrots were in bags, pies and trailers, but, provided growers are prepared to apply sufficiently stringent grading standards, some of the deficiencies of mechanical harvesting can be rectified during subsequent preparation of the carrots for market.

A questionnaire designed to sound opinion concerning mechanically harvested carrots, was completed by 24 carrot wholesalers in Hull, Leeds, Leicester and Nottingham markets. It was found that there was no prejudice or price discrimination in these markets against mechanically harvested carrots *as such*, nor were quality differences in market packs specifically associated by salesmen and retail buyers with the harvesting method used. On the other hand, quality differences were reflected in price differentials, and mechanically lifted samples might therefore command lower prices than hand harvested carrots if they were not upgraded to about the same standards before leaving the farm.

However, it was of considerable interest to find wide differences of opinion between salesmen in the same market as to the amount of top and physical damage that would be tolerated without detracting from the market value of packs. For instance, some retail buyers associated a modicum of green top with "freshness", whilst others thought the presence of any leaf detrimental. Some salesmen thought that a portion of the leaf base should remain on the crown and that over-topping was a distinct defect, but others in the same market commonly pared the crowns of carrots in the tops of the bags on display to enhance the appearance of the sample. Similarly, some buyers did not object to a proportion of the carrots having broken tips so long as the root was otherwise sound.

5 This category does not, of course, include those carrots showing growth cracks.

It was concluded that depending on the salesman and class of buyer supplied, and the general demand and supply situation for carrots, the additional grading which is necessary on mechanically harvested crops need not invariably be so stringent as to reduce the number of carrots showing mechanical damage and the amount of top retained to the absolute levels of the average hand lifted sample. Nevertheless, some additional farm grading would usually be necessary before mechanically lifted crops commanded the same price as those harvested by hand; if this were not done, then lower prices for mechanically harvested crops could be expected.

CHAPTER XXIV

THE ECONOMY OF MECHANICAL HARVESTING

THE PURPOSE OF THIS chapter is to examine the circumstances under which the employment of sugar beet harvesters of the type used on the four farms in the study would be profitable firstly, if bought specifically for use in carrots, and secondly, if an existing machine already used primarily for lifting sugar beet was modified for this purpose.

Specialised Machines

The capital costs of the machines are shown in Table 57, together with the combined annual depreciation and interest charges attributable to each, and the variable costs of their use. The machine prices shown are those quoted by the manufacturer for harvesters ready adapted for carrot lifting. With the semi-mechanical method where the carrots are picked up by hand after dropping off the back of the machine, it is assumed that the harvester is purchased without the elevator. In calculating annual fixed ownership costs the machines have been written off over six years and interest on the investment has been charged at six per cent. Variable costs have been calculated on the basis of the standard labour and tractor hour requirements given in Table 52, Chapter XXI, man labour being charged at 3s. 3d. per hour and tractor running costs at 2s. 9d. per hour. In addition 10s. 0d. per acre has been allowed for the maintenance and repair of the harvesters, this figure being derived from information supplied by the manufacturer and from growers' records of their expenditure on this item.

COSTS OF CARROT HARVESTING

TABLE 57

Method	Capital costs of equipment	Annual fixed costs	Variable costs
	(£'s)	(£'s per year)	(£'s per acre)
Fully mechanical harvesting, loading into trailers	355	72.2	3.8
Mechanical lifting, hand picking behind machine	305	62.0	10.1
Mechanical lifting and heaping, hand covering of pies	355	72.2	8.2
Hand harvesting	—	—	23.7

It will be immediately apparent that the differences between the variable costs of hand and mechanical methods are so large in relation to the annual fixed costs of machine ownership, that the latter would be recouped even when only quite small acreages of carrots were to be lifted annually. And in fact, the calculated break-even cost acreages above which the purchase and use of this type of sugar beet harvester solely on carrots would result in lower total lifting costs are 3.6 acres for the elevator model used to load the carrots straight into trailers, 4.5 acres when the carrots are dropped over the back of the machine and picked up by hand, and 4.6 acres when a dumper model is used to lift carrots for storing in pies.

The assumptions upon which these figures are based are open to modification. For instance, some growers may be able to get their carrots hand lifted by piece workers for a lower cost than the time work cost shown in Table 57, whilst on some soils expenditure on repairs might amount to more than 10s. 0d. per acre. However, even where the cost of harvesting by hand was only £1 5s. per ton, or £18 15s. per acre on a 15 ton crop, and where repairs to the machines came to £1 per acre, the calculated break-even cost acreages would rise only to 5.0, 7.6 and 7.2 acres for the three methods.

Hence, there is little doubt that the purchase of beet harvesters will reduce total lifting costs even where only small areas of carrots are to be harvested each year.

But this is an over-simplification of the problem in so far as it assumes that mechanical harvesting is technically as efficient as hand lifting, whereas, in practice, there may be additional costs associated with the mechanical methods due to the inferior work done by the machines. These may take several forms, such as increased labour expenditure on grading, a higher proportion of wastage in the pies or during grading, or a lower market price if sufficient additional grading to bring the mechanically lifted sample to a quality standard comparable with that of hand lifted carrots is not undertaken. Had the growers using machines also been selling hand lifted carrots, quantitative measures of these costs might have been possible; since this was not the case, all that can be done here is to indicate the additional expenditure on grading, or reductions in revenue through greater wastage or lower prices, that can be sustained before the savings in lifting costs are completely absorbed.

The following table shows the estimated savings in lifting costs per ton of carrots resulting from lifting mechanically rather than by hand. The fixed and variable costs used are again those shown in Table 57, and it will be recalled that the variable costs relate to crops yielding 15 tons per acre.

ESTIMATED SAVINGS IN LIFTING COSTS BY USE OF A BEET HARVESTER

TABLE 58 — Shillings per ton

Acreage harvested annually	5	10	20	30	40	50
Fully mechanical harvesting, loading into trailers	7.3	17.0	21.8	23.3	24.2	24.5
Mechanical lifting, hand picking behind machine	1.6	9.9	14.0	15.4	16.1	16.5
Mechanical lifting and heaping, hand covering of pies	1.5	11.2	16.0	17.6	18.4	18.8

It will be seen from the table that as the acreage lifted increases, the fixed costs of the machines form a smaller proportion of total costs, and that the savings in lifting costs per ton increase as a result—though at a diminishing rate.

Whether the additional grading costs which would have to be incurred to up-grade mechanically lifted carrots to a quality standard comparable to that of hand lifted crops, or, if additional grading was not undertaken, whether the price differential would be greater than the amounts shown in Table 58, must at present remain a matter for individual managers to decide. However, it is apparent that the saving increases with increasing acreages, so that larger-scale growers need be less cautious in embracing

HARVESTING CARROTS

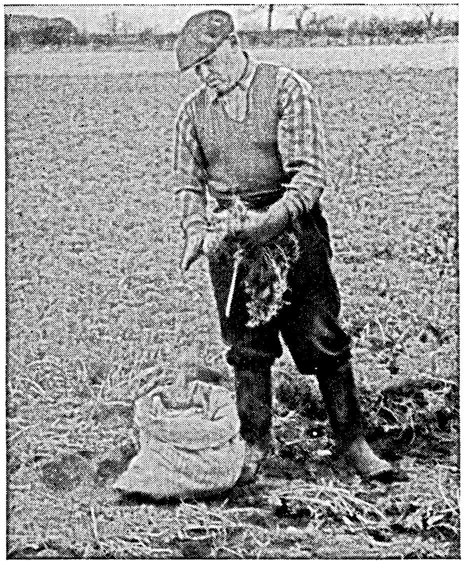

PLATE XVII. Hand lifting is the most costly single operation in carrot production.

PLATE XVIII. A fully mechanised method of carrot harvesting.

PLATE XIX. A semi-mechanical method; the carrots are picked up by hand behind the lifter.

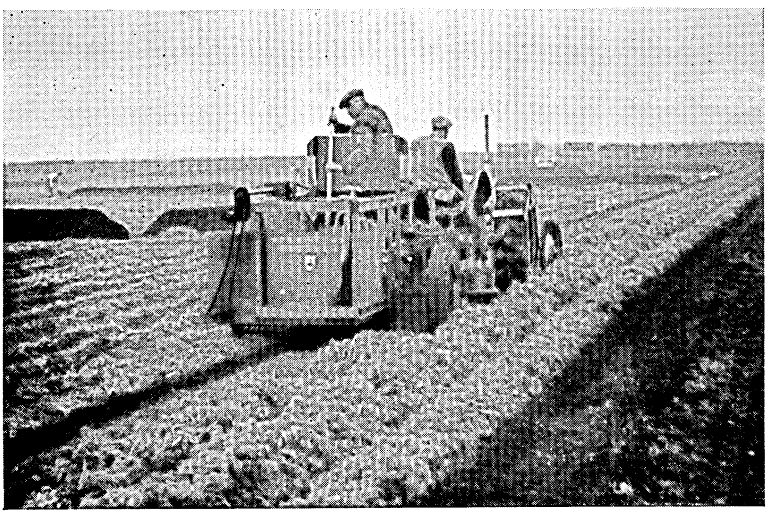

PLATE XX. A dumper type beet harvester lifting carrots for storage in pies.

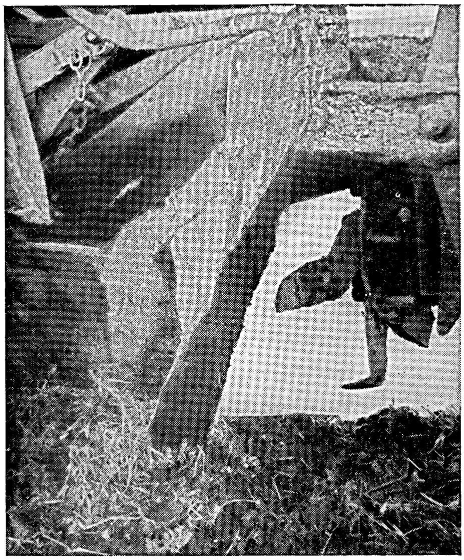

PLATE XXI. A farm designed topping unit made of old rotovator blades.

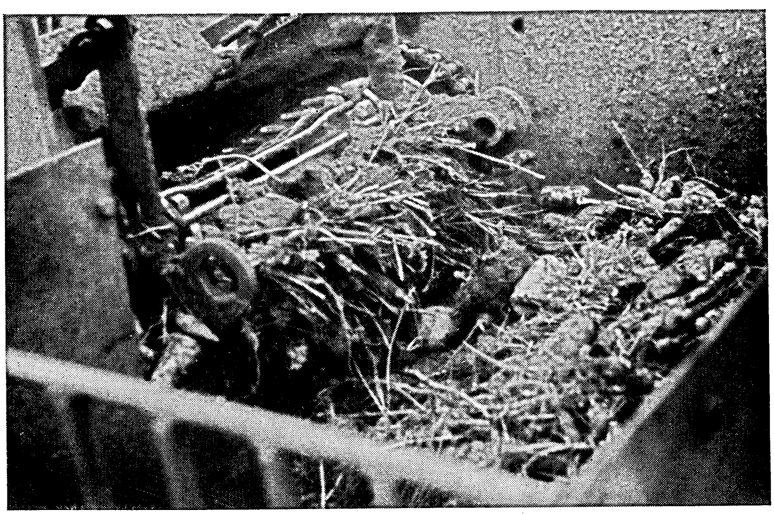

PLATE XXII. There is a tendency for soil and leaves to accumulate at the top of the digger elevator, and impede the free flow of carrots.

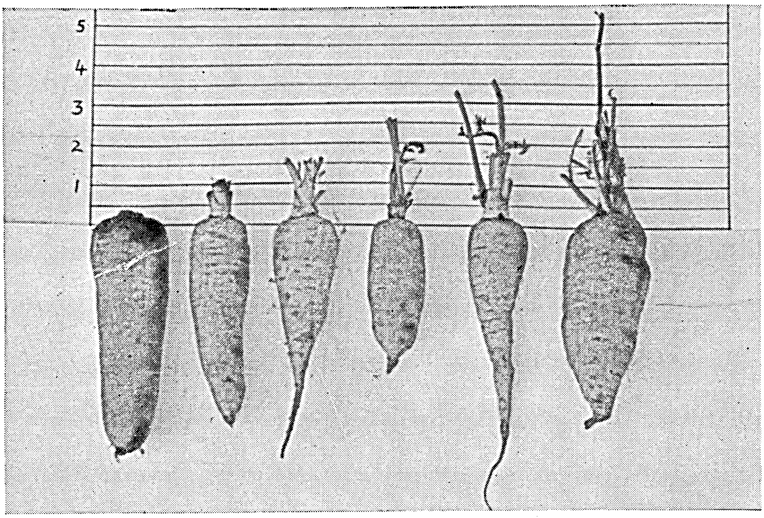

PLATE XXIII. Imperfect topping of mechanically harvested carrots.

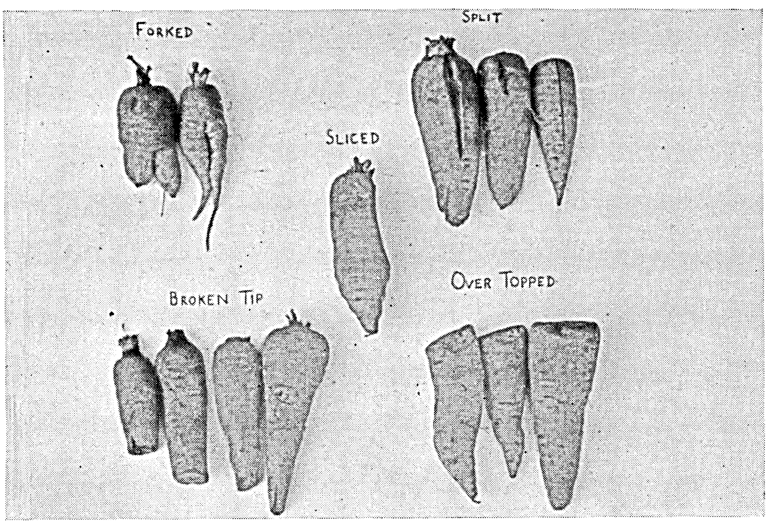

PLATE XXIV. Typical examples of mechanically lifted carrots. Mechanical harvesting entails a higher proportion of damaged carrots and necessitates additional grading.

mechanical harvesting than those with only small acreages of carrots. That is, for a grower with only five acres of carrots who is considering the purchase of an elevator type beet harvester, a probable saving in lifting costs of about 7s. 4d. per ton is a much more slender margin out of which to meet additional grading costs, than the surplus of £1 5s. per ton that the grower of 50 acres would have available for that purpose.

The Use of an Existing Machine

For growers who already possess a mechanical harvester for lifting their sugar beet, but who also wish to adapt it for harvesting carrots, the additional investment required would be approximately £45 for elevator models, and £30 for dumper models or elevator models used to drop the carrots over the back of the machine. Therefore, under these conditions the additional annual fixed charges to be borne by the carrots, and offset against the savings in variable costs secured by lifting with the adapted machine rather than by hand, would be just over £9 and £6 respectively. These figures may be compared with the annual charges of £72 and £62 incurred by the purchase of harvesters of the same type specifically for carrot lifting.

It is estimated that the savings in lifting costs per ton which would be secured by adapting an existing sugar beet harvester would be as shown in Table 59

ESTIMATED SAVINGS IN LIFTING COSTS BY USE OF ADAPTED BEET HARVESTER

TABLE 59 Shillings per ton

Acreage harvested annually	5	10	20	30	40	50
Fully mechanical harvesting, loading into trailers	24.1	25.3	25.9	26.1	26.2	26.3
Mechanical lifting, hand picking behind machine	16.5	17.4	17.8	17.9	18.0	18.1
Mechanical lifting and heaping, hand covering of pies	18.3	19.5	20.2	20.3	20.4	20.5

Because of the lower burden of fixed costs, even greater savings are likely to arise from the use of adapted beet harvesters than from the use of specialised machines, and provided the lower quality work done by mechanical harvesters did not result in revenue per ton being reduced, and, or, grading costs per ton being increased, then the modification of an existing beet harvester for lifting carrots would be a profitable investment for growers with as little as one acre of carrots. But if grading costs were increased, or revenue reduced by amounts as great as, or greater than, those shown in Table 59, the advantages of mechanical harvesting would be lost.

CHAPTER XXV

SUMMARY AND CONCLUSIONS

When grown and harvested by traditional methods—controlling weeds by means of hand and mechanical cultivations, and lifting and topping by hand—the total labour requirement of the carrot crop is high. Moreover the peak labour requirement for cleaning occurs in June and July, and there is competition for labour between this operation, the cleaning of other row crops and haymaking. Similarly, harvesting not infrequently conflicts with the harvesting of sugar beet and potatoes in the autumn months. Consequently, considerable interest attaches to two recent technological advances, selective chemical weed control and the adaptation of mechanical sugar beet harvesters for use in carrots, both of which contain the potential for effecting a radical change in the labour demands of this crop.

Although the control of weeds by spraying petroleum oils reduces the total growing labour requirement by a substantial amount, the costs of spraying as commonly practised are high. This cost may, however, be reduced by spraying only immediately over the rows and relying on the mechanical cultivations, which must be undertaken in any case, to control weed growth between the rows.

Whether the amount of labour released by spraying is sufficient to permit spraying costs to be recouped by reducing the labour costs of cleaning operations, depends upon the amount of spray material used and the degree of weed infestation. The difference between the average amounts of labour used in sprayed and unsprayed crops was substantial, but this difference is almost certainly an under-estimate of the actual reduction in the labour requirement of the sprayed crops. This limitation, together with the absence of quantitative measures of the effect of weed competition on carrot yields, militates against final conclusions about the economy of chemical weed control being drawn. Nevertheless, the conditions under which the practice is likely to be profitable are not exacting, and seem capable of being met in a great many carrot crops.

However, despite the reduction in labour requirements afforded by selective chemical weed control, hand and mechanical cultivations are not entirely obviated, and in common with other root crops, the amount of labour required to bring the carrot crop to the point of harvest remains high.

A method by which the harvesting of carrots could be fully or even semi-mechanised, thereby securing a reduction in the cost of the most expensive single operation in carrot production, would fulfil a long felt need amongst growers. Four case studies of the use of complete sugar beet harvesters for lifting carrots have shown that compared with hand lifting and topping, mechanical harvesting results in a large reduction in labour requirements and in direct lifting costs. When these savings in lifting costs are equated with the additional costs of depreciation and interest on the investment, it would seem that the modification and use of an existing sugar beet harvester, or even the purchase of a beet harvester specifically for use in carrots, would be a profitable investment even for growers with quite a small acreage of the crop.

But this takes no account of differences between the quality of the work when lifting is done by hand and when it is done by machines, differences which a comparative study of the efficiency of hand and mechanical topping, and of the incidence of four types of mechanical damage has shown to occur in practice. In fact, it would seem that the relative qualities of hand and mechanical lifting may be of critical importance, particularly when machines are used on the smaller acreages and where, as a result, the overall savings in lifting costs are not very large. The extent of the additional costs attributable to the lower quality work of mechanical harvesters is an aspect which might well be pursued further; at present all that can be done is to indicate the magnitude of the savings in lifting costs which can be secured by harvesting mechanically, and leave it to the individual to decide in the light of the acreage grown whether these savings are greater or less than the additional grading costs and, or, price reductions which are likely to be sustained.

Many of the technical problems of mechanical carrot harvesting are essentially the same as those experienced in the development of machines for the harvesting of potatoes, and to a lesser extent sugar beet, namely, how to secure the separation of soil and roots with a minimum of damage to the latter, and how to overcome the difficulties presented by stony soils. But with carrots the removal of the tops seems to present an additional and especially intractable obstacle to completely successful mechanisation.

The main difficulty is that carrots protrude at irregular heights above the surface of the soil; consequently some over-topping or under-topping is bound to occur with existing topping devices. Furthermore, the fact that with present methods and rates of seeding carrots tend to grow in narrow bands rather than singly in a row, would militate against the complete success of any topping device activated on the feeler wheel principle, even if a mechanism sufficiently sensitive to adjust the height of the knife in relation to the height of individual carrots could be designed. Finally, any topping device cutting only in the horizontal plane is further handicapped by the fact that the outer leaves of carrots commonly fall over into the space between the rows.

It may be, therefore, that the solution of the problems of mechanical carrot harvesting lies partly in the improvement of the design of the topping unit, and partly in modifying husbandry techniques to suit the practice. "Tailoring" of the crop to facilitate mechanical harvesting might take several forms; for instance, in the deliberate selection of strains and varieties having a propensity for uniform growth, the practising of deep cultivation and irrigation to facilitate root penetration, the use of precision seed drills to ensure that the carrots grow in a single line and not so thickly as to push each other apart into bands, and perhaps by ridging the rows from an early stage so as to keep the outer leaves erect.

It is to be hoped that these, or alternative approaches, will be the subject of research by husbandry specialists and engineers, for there can be little doubt that a completely successful method of mechanical harvesting offers the greatest possibilities for reducing the costs of carrot production.

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