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Some Orchard Costs 1950–59

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REPORT No. 8

Some Orchard Costs 1950–59

A progress report on some field-gate costs of growing apples and pears on a small group of mixed farms in south-east England.

Copies of this report may be obtained, price 4s. post free, from: The Secretary, Wye College, Ashford, Kent.

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FOREWORD

Until this report was published, the most recent data available on apple production costs in south-east England was 10 years old. Since 1951 so much has happened, both on and off the farms, that many growers are wondering how other growers have fared in the meantime, and whether they have all had similar experiences. The fortunes of eight fruit growers in the last decade are reported herein in as much detail as remote control of recording operations and financial transactions on the farm, and the desire for anonymity, will allow.

These cost-of-production figures were not the chosen end-product of this investigation into orchard economics. Divorced as they are from the associated returns and profits, the costs of production have a much restricted meaning in an activity like fruit growing which allows of great latitude in expenditure (and returns) an acre according to whether the trees are "done well" or not. The real object of study was the relationship between size of tree and the associated labour requirement, yield and total cost, in order to see whether they would give any guidance to where, among the many combinations possible, lay the one giving a maximum output/input ratio for the labour employed per acre or for the total variable cost per acre.

The evidence that can be offered on this topic is circumstantial and not conclusive: to some extent the number of variables involved in any assessment of comparative efficiency has been reduced (i.e. by costing separately trees of different size but operated by the same staff and manager) but there is no way round, for example, the unwelcome fact that when bush trees' performance is compared to standards', most standard trees are of culinary varieties and most bush trees are of dessert varieties: so comparable yields per tree cannot be directly measured, but only imputed.

The attempted input/output relationships for trees of different size thus form only part of a report which necessarily has a strong historical flavour. In case apple-growing costs should be a matter of public interest when this report is published, it is necessary to say now that nothing in this report can be construed to represent costs of production since 1959 on the leading larger, specialized and highly capitalised fruit farms. It is realised, also, that retrospective figures are of more value at a time of stable prices than during a period of inflation.

As an additional insurance against misinterpretation, let it be said again that the fruit growers have to meet marketing costs, possibly of an equivalent magnitude to those now shown for growing the fruit, of which no account is taken in this report. Production costs have been one of the growers' lesser worries in the last ten years.

SUMMARY

On eight mixed but predominantly apple and pear growing farms in Kent and Sussex during the period 1950-59, growing and picking the crop cost an average £84 an acre each year for a crop of 270 bushels an acre. During the ten years, expenditure in the orchards was being reduced relatively to the increase in costs of essential materials and labour, by about 1½ per cent a year. Taking culinary and dessert fruit together, cultural costs had increased proportionately less than picking costs or overhead charges, as a result of more mechanization and reduced expenditure on chemicals.

Various combinations of men and machines were used on the several operations in the orchards. Farms with 21-35 acres of orchard operated at less cost per acre than smaller or larger farms. An economic exchange of machine labour for man labour has been made in manuring, spraying and mowing, and the time is ripe for increasing mechanization of pruning and picking. Mechanization of fruit-growing operations has made very uneven progress.

Costs per acre and costs per bushel for pruning rose by 53 per cent for dessert orchards and eight per cent for culinary orchards: "other operations" cost more, but there were no other significant changes. The labour released by mechanization was not entirely saved, but used elsewhere on the farm. Picking cost, for crops of equivalent size, increased by 27 per cent. Physical efficiency of production in these orchards was on the wane: 100 hours' work on cultural tasks produced fewer bushels of apples in 1958-1959 than in 1950-51. Culinary apples gave 50 per cent more bushels per worker-hour than dessert apples. In terms of *value* of production, however, a 15 per cent improvement in net returns per acre from dessert apples raised the adverse movement of costs to returns on dessert apples to 21 per cent, compared with a 24 per cent adverse movement on culinary fruit.

Pruning and picking are the two improvable operations. There is some evidence of diminishing returns to time spent on pruning; and in picking, heavy crops on each farm cost more per bushel to pick than the heaviest or the lightest crops. Taking mature trees of sizes ranging from 12ft. to 17ft. span, the larger trees required a greater number of hours' work per acre, but in relation to a conjectural average yield, trees of many sizes should perform at equal rates and return about 150 bushels of apples for each 100 hours' manual work on cultural tasks.

DESCRIPTION OF THE FARMS AND THE COSTING METHOD

The Farms

The eight farms concerned were originally selected because they were in many respects typical of fruit-growing practice in south-east England. This fact alone should make it clear to readers that they cannot be a sample of the "best" growers. Nevertheless, the farms are all fully commercial, privately-financed undertakings.

Apples and pears in Kent are more frequently grown on mixed farms than on specialised holdings: consequently, a majority of the costed farms grow other crops as well as top fruit. In all cases, however, apples and pears constituted at least 75 per cent of the farm business: on the smaller farms, other crops were ancillary, and on the larger farms the top fruit enterprise was a well-defined department of the farm, having its own staff and specialised equipment. Each year, some 280 acres of apples and pears have been costed, dessert-apple orchard units being in number and acreage twice that of culinary-apple orchard units. Four farms had separate culinary and dessert orchards, four had only dessert orchards. The acreage in bearing on each farm was distributed among arbitrary size-groups as follows:

10-20 acres, 2 farms; 20-50 acres, 4 farms; 50-100 acres, 2 farms.

Geographically, the farms are situated along a shallow arc from East Kent to West Sussex, with a local concentration of three farms in the West Kent area. The average age of dessert apple and pear trees costed was 25 years, and of culinary apple trees, 55 years; all were well-grown and at normal spacings. In 1950 five of the growers were grading and packing on the farm; by 1959 the number was reduced to three. All the remaining growers were marketing co-operatively. Only one farm had its own gas stores.

Costing Method

Information from the farms was collected in the same way as for *The Cost of Growing Apples*,* but used in a different way. The accent in this report is more on the overall *change* in costs, rather than the actual costs, so the results on individual farms are not as appropriate as in the previous report, and are not published on this occasion.

By means of daily records of manual work, and of the use of machines and materials—quantitatively checked with purchases and changes in stocks—accounts are prepared which break down annual expenditure into its constituent parts and at a later stage re-assemble the constituents to make complete costs for the several operations indispensable to fruit growing.

*Published by Wye College in 1954; now out of print.

Only in a few cases is all the bearing apple or pear acreage on one farm costed in a block ; this happens only where the orchards are uniform in age and type. More usually, the farms have different blocks of trees which it is more instructive to cost separately. In this way the eight farms give rise to 13 consecutively-costed orchard units, distributed by size as under :

below 10 acres, 3 ; 10-20 acres, 5 ; 20-50 acres 3 ; over 50 acres, 2.

All the blocks of trees costed were at least 10 years old in 1950. As on most fruit farms in Kent, all the costed farms had a proportion (between 5 and 30 per cent.) of young trees which were growing into bearing during the decade under review. These young orchards, like the ancillary crops, helped to give better utilization of the labour and equipment on the farm and also reduced some elements of both direct and overhead cost per acre on the mature orchards. Overhead costs have been spread among enterprises in proportion to the enterprises' use of labour.

For the sake of efficiency with simplicity, all comparisons of costs, whether between one year and another or one farm and another, are made on the basis of what is spent in or on the orchards. This study does not, for example, indicate whether a grower's annual costs of fruit farming are increasing because his overdraft is increasing. If he is borrowing so that he can spend more on the trees, the recorded expenditure will increase ; if he is borrowing in order to maintain liquidity of his capital, he may be reducing his production expenditure, and this change, too, will duly be picked up in the accounts. The level of spending, of course cannot be dissociated from contemporaneous changes in a grower's net worth, but the effect is indirect—and the growers concerned are not likely to be cutting-back expenditure unless many other growers are doing likewise, in which case a trend towards reduced expenditures on certain types of farm would be correctly reported in the study.

In the early sections of this report the focus of attention is the level of expenditure on the bearing trees. In the last section the focus is on derivations from the observed results which might have a much longer period of usefulness than the observed results themselves.

At the time of writing it is not known whether there is, for example, a highly-significant tree diameter—say, at 18 feet span (meaning that a tree of this size is considerably more productive in relation to the work put into it than a tree of 16 feet span or one of 20 feet span). The research method employed is unlikely, however, to reveal any optimum tree size unless it is measurably superior to any other. A more likely result is a general indication of the relative economy of small, medium and large trees.

CHANGE IN COST, 1950-59

Average cost per acre

An average cost per acre, itemized into operations, covering the orchards for the ten-year period, is given in Appendix A (page 33). This includes all *production expenses* (i.e. money spent, but not value lost), and shows :

(*a*) cultural operations in the orchard cost £51 16s. an acre,
(*b*) the share of farm overheads and business expenses cost £15 0s. an acre,
(*c*) picking of the average crop cost £17 10s. an acre,

making a total of £84 6s. an acre for a 270-bushel an acre crop of both culinary and dessert varieties.

Assuming interest at 6 per cent. on both the original fixed capital and the working capital, and after making an allowance for orchard replacement, £34 an acre is added, making a total of £118 an acre, or 8s. 9d. a bushel, excluding any marketing expenses. This general statement is progressively refined as the report proceeds.

At £69 an acre, cultural and picking expenses combined were *lower* than the £75 an acre previously quoted for the period 1948-51. Direct comparison of these two figures is inadvisable because different farms are concerned. At the same time, while it is true that some high-cost farms relinquished orchard costing after 1951 and were replaced by (more) farms having younger trees and consequently lower costs, it is also true that yields are not as high as they were—which would deflate picking costs—and that actual orchard expenses on some farms were lower after 1951 than before, labour costs having been kept down, and purchases of chemicals reduced.

This result, it should be stressed, is a *general* picture, and does not reflect the course of expenditure on many progressive and specialized dessert apple farms.

Annual cost per acre

The trend in cost per acre is made known because it is less liable to fluctuations and gives a better idea than cost per bushel—which is probably more important for the grower to know—of the changes in cost affecting top fruit growing.

Average costs per acre have not shown the steadily and irrevocably climbing trend that most growers surmise. The mixed farms—those having culinary varieties as well as dessert varieties —have had a sobering influence on the group results. On the whole, the figures lend support to the belief that cost control is not only possible but is practised in fruit growing.

Table I. Cost per acre on mature apple and pear orchards, 1950-59

	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959
	Part A. Cultural, picking and overhead costs									
Actual (£) ...	79.5	80.8	84.7	74.7	81.8	75.0	76.1	83.0	88.9	97.8
Index (1950-51=100)	99.1	100.8	105.6	93.2	102.0	93.5	94.9	103.5	110.9	122.0
	Part B. Cultural costs only									
Actual (£) ...	49.5	51.3	56.7	48.0	49.5	46.9	49.9	51.3	49.0	60.4
Index (1950-51=100)	98.2	101.7	112.5	95.2	98.2	93.0	99.0	101.5	97.2	119.8
	Part C. Overhead costs only									
Actual (£) ...	14.8	12.5	11.7	13.2	14.3	13.9	13.1	15.0	19.6	16.6
Index (1950-51=100)	108.4	91.6	85.7	96.5	104.8	101.8	96.0	109.9	143.6	121.6

NOTES. *Cultural costs* include pruning, manuring, spraying, cultivations (or mowing), thinning, anti-canker, and any operation having the *tree* as a basis (i.e. grafting) rather than the orchard (i.e. brushing boundary fences).

Overheads does not include orchard depreciation or interest on investment in fixed assets (which is more appropriate than a rent, seeing that the full cost of maintaining buildings, etc., is included in operational overheads): not less than £12 an acre could be allowed for depreciation and interest.

Costs of *picking* the crop have not been included up to this stage in order to see more clearly the change in production expenses which took place irrespective of any changes in size of crop. If yields were increasing each year, total expenses per acre would increase and this might give the idea that *all* expenses had risen. The causes of the movement in cultural cost per acre are fully dealt with at a later stage of the report

In Table I it is shown that the actual expenditure made on, or on behalf of, the mature orchards—by growers who know their costs—was some 16½ per cent. higher in 1958-59 than in 1950-51 (part A). There was a noticeably faster rate of increase in cost per acre after 1957 than during the previous period 1950-57. Cultural costs increased by the relatively small margin of 8½ per cent. during the ten years (part B). Picking costs and overhead costs both increased relatively more than cultural cost—picking costs by some 28 per cent. Overhead costs increased by almost 33 per cent. (part C) ; the big movement in this type of expense is symptomatic

of, among other things, the increasing importance and complexity of management. To keep up to date in orchard practice necessitates time and travel, and to chart and execute the plan for progress for the farm requires wide acquaintance with science in its many applications and contact with various authorities. All this takes time and money.

The post-1950 history of costs is different on culinary-apple orchards and dessert-apple orchards. There has not been the same reason for retrenchment in dessert-apple growing as in culinary-apple growing, and it would appear that the march of efficiency is faster in dessert-apple growing. Thus, for two different reasons, average cultural costs per acre in 1959 were not so high as the unthinking application of the increase in agricultural wage rates in the last ten years to the production situation would suggest. If the cultural costs per acre at the start and finish of the period be compared, the results are :

Change in cultural costs per acre, 1950-51 and 1958-59

	1950-51	1958-59	% change
on dessert apple orchards	£54.5	£59.4	+10
on culinary apple orchards	£40.2	£38.8	- 4

These are not freak results, and correctly report the trend on the farms concerned. The growers were at pains to prevent undue rises in costs, because profit margins were being eroded after 1951 on dessert fruit as well as on culinary ; caught between the two blades of reduced yields and increased marketing deductions from a relatively static market price, the growers resorted to cost control. Trends in the costs of single operations, together with estimates of the savings made in use of labour and materials, are explained in a later section of the report.

The rate of progress

If the growers concerned had not been interested in more efficient production, it is likely that they would have been spending something like an average of £84 an acre, excluding picking, in 1958-59, instead of the average £73 recorded, because by 1958-59 the computed cost of the 1950-51 programme of work in the orchards had risen 32 per cent.* The visible rate of cost-saving, then, was £11 an acre in 10 years, or about 1.5 per cent. of the total expenses excluding picking each year. This rate of saving would not by itself be sufficient to maintain growers' net incomes on a par with those of other business men, but it is evident that cost-saving can make a contribution towards that end.

*see note on page 11.

Average cost per bushel

Growers could have expected some respite from the pressure on profits if they had been experiencing rising yields of fruit per acre over the ten years. Each would then have been producing more fruit at his ruling cost per acre. There is no indication that this was happening on the farms in question, and there seems to be little doubt that this was fairly general experience with mature trees.**

Within the sample costed are some continuously profitable orchards, some occasionally unprofitable and some predominantly unprofitable ones. Heavier alternate-year bearing is not characteristic of the group of farms as a whole. The average yields per acre bear out the contention that the growers are getting average performance from their dessert apple and pear trees, less-than-average performance from their culinary apple trees. Average yields per acre for the ten-year period were :

Dessert apples	251 bushels of 40 lbs.
Culinary apples	316 bushels of 40 lbs.
Pears	262 bushels of 48 lbs.

When a crop failed, fruit of inferior quality cost between £6 and £7 a bushel to grow. It is obviously unrealistic to include such high figures in a general average for a small number of farms—it would grossly inflate the average cost per bushel, and it would also be alien to the purpose of this study. Costs per bushel, therefore, have been averaged over the " normal " crops—meaning those which could be called either " light ", " full " or " moderate " according to the season, but were not failures.† On this basis the average cost per bushel (as defined below) produced was 6s. 7½d.

Annual cost per bushel

A repetition of the cost per acre analysis in Table 1 gives the following composition of, and trend in cost per bushel (Table 2).

** See *Ten Years' Yields of Apples and Pears,* R. R. W. Folley, Wye College, February, 1961.

† Yields of less than 90 bushels an acre were considered crop failures.

* the computation for page 10 is as follows :

Item	1950-51 *value* (£)	*% of total cost*	*% increase since* 1950-51	1958-59 *equiv.* (£)
Labour	24	31.5	57	37.7
Chemicals	30	39.5	10	33.0
Fuel and power	14	18.5	33	18.6
Overheads	8	10.5	36	10.9
	76			100.2

$$\% \text{ increase: } \frac{24.2 \times 100}{76} = 32$$

Table 2. Cost per bushel on mature apple and pear orchards, 1950-59

	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959
No. of bushels per acre	314	281	265	238	260	149	204	274	285	295
				Part A. Cultural, picking and overhead costs						
	s. d.	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s. d.*
Actual (£) ...	5 1	5 9	6 4½	6 3	6 3½	10 0½	7 6	6 0	6 3	6 7½
Index (1950-51=100)	93.8	106.1	117.7	115.4	116.2	185.2	138.5	111.1	115.4	122.3
				Part B. Cultural costs only						
	s. d.	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s. d.*
Actual (£) ...	3 1½	3 7½	4 3½	4 0½	3 9½	6 3½	4 10½	3 8½	3 5	4 1
Index (1950-51=100)	92.6	107.4	127.1	119.7	112.3	186.4	144.4	109.9	101.2	121.0
				Part C. Overhead costs only						
	s. d.	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s. d.*
Actual (£) ...	- 10½	- 10½	- 10½	1 1	1 1	1 10	1 3½	1 1	1 4½	1 1½
Index (1950-51=100)	100	100	100	123.8	123.8	210.5	147.6	123.8	157.1	128.6

NOTE. *Picking cost* includes putting-out and collecting orchard containers, pickers' earnings, transport out of the orchard, and wear and tear on containers and bags, but not ladders. No part of the cost of marketing is included.

By coincidence, bi-annual yields per acre at the beginning and end of the period were similar, and between 290 and 300 bushels an acre. The increase in cost per bushel over the period is again some 18 per cent.—from 5s. 5d. in 1950-51 to 6s. 5½d. in 1958-59, and it can be repeated that apparent efficiency of production in the orchard was advancing at a rate of almost 1½ per cent. a year. Some growers have had the experience of producing fruit at the same cost per bushel between 1957 and 1959 as in 1950 to 1952, when yields per acre were somewhat lower. The cheapest fruit was produced in 1957, and the dearest in 1955.

The last decade has seen the abandonment of pressure mains spraying, the advent of the artificial manure spinner, the low-loading trailer or trolley and the fore-loading lifter for boxes or trays in the orchards. While there were changes in *technique* on the farms, there were no changes in policy to account for the trends in cost, i.e. no grower suddenly took to fruit thinning half way through the period, or gave winter pruning a miss. The same job was done throughout—modified, of course, by seasonal influences.

The means of economic progress are examined more closely in the next section.

COSTS OF ROUTINE OPERATIONS

The structure of costs

The year's work on a fruit farm consists of a succession of operations, each having distinct requirements of men, machines and materials. In no two operations is the admixture the same. Whilst this makes for interest in organizing work, it means that a fruit grower is constantly faced with adjusting his work-resources to suit the job in hand. Contrast, for example, the work output of a man with a knife or pair of secateurs with that of a man with a tractor and a triple set of gangmowers.

The recording of what takes place on the fruit farms concerned, and its subsequent analysis, is so arranged that the cost of each major routine operation is obtained in three parts—one cost for the labour used, one for the materials and one for the services of machines, implements and other semi-pemanent things like orchard boxes and bomb trolleys.

At the present stage of technique, mechanization has made very uneven progress in fruit-growing operations. Basically, the spring and summer operations are carried out at a high level of labour productivity ; those in autumn and winter at a low level of labour productivity. Since fruit-picking is an unskilled and manual operation, casual workers supply the need for additional labour in autumn. Pruning, on the other hand, is a skilled operation and is best done by workers who know the farm and the trees ; on a specialized fruit farm therefore, the size of the regular staff tends to be determined by the requirement for winter pruning.

The structure of the cost of the routine operations for the farms in question is as follows (Table 3).

Table 3. Factor costs of routine operations, 1950-59

	Pruning	*Spraying*	*Culti-vations*	*Manuring*	*Other Op'ns*	*Picking*
			£ an acre			
Labour	11.4	2.1	2.4	1.1	4.1	15.7
Materials	—	12.0	—	9.2	0.5	—
Services	0.5	4.0	3.1	1.0	0.5	1.8
Total	11.9	18.1	5.5	11.3	5.1	17.5

The evidence of progress in carrying out each operation is discussed in the following section on " efficiency in operations ". For the moment, attention is given to minimum costs and minimum-cost combinations of labour, materials and mechanical aid. Each operation is taken in turn.

Pruning (£11 18s. an acre)

Pruning is not widely considered an operation lending itself to careful organization ; a " team " or " process " basis is rarely,

if ever, adopted, and the cost is the measure of the speed and skill of individual workers and the precise job they are given to do (which varies from orchard to orchard). Incentive schemes have generally proved worthwhile ; these may take the form of a piece rate per tree (graduated according to size of tree) or of a small bonus per tree once a certain rate of work accomplishment (trees per day or per week) is realised. Such bonuses have to be set orchard by orchard, too. The method of working must include dealing with the prunings, but mechanical handling seems not to be associated with a low cost for the whole operation of pruning ; perhaps the cost on the farms concerned is lower than it would be without machine raking, but it is still relatively high.

Average costs per acre for dessert apples ranged from a minimum of £7 to a maximum of £20, the former for widely-spaced, lightly-pruned bush trees, about 18 years old, the latter for half-standards about 40 years old. The range in costs for culinary apple orchards was somewhat less, and lay between £5 and £16 an acre—the former for mainly "saw" work, the latter (in the early 1950's) for a spur-pruning specification. As is subsequently reported, there was less difference between costs per bushel than between costs per acre for this operation, i.e. trees that were yielding well were carefully pruned, while if careful pruning did not result in high yields, less time was given to it. Each farm has its own *level* of costs of pruning, and the actual figure in any year seems to have been determined more by the job that was done than by the scale on which machine work was substituted for hand work. Machine costs and labour costs were high and low in the same years.

What does emerge, taking all the farms together, is that the machine-cost tends to be the same whatever the level of the manual labour-cost fraction. Thus, where the average labour cost was £7 an acre, machine cost was 9s. an acre ; where labour cost was £17 an acre, machine cost was 9s. 6d. an acre. Machine work has not yet replaced hand work in pruning to a significant degree, so it is appropriate to calculate the apparent rate of substitution of machine-work for man-work. About one-eighth of the time on actual pruning (say, 9 hours an acre) has been required for dealing with the prunings. When the job is mechanized, about 2 tractor-hours and 4 man-hours an acre have been required so the savings have been useful rather than sensational. Two hours of tractor labour have been substituted for five hours' manual labour.

Power-associated pruning can be expected to come into general use, at least on the larger and more specialized fruit farms. Pneumatic equipment helps to bring down the number of men required for pruning to nearer the number required for the summer operations. In one case, assuming that the savings obtained by a one-third adoption of power-pruning on dessert bush trees would

have been tripled by complete adoption of the process, pruning costing £10 an acre in 1950-51, and which would have cost £17 10s. an acre in 1958-59 without power pruning, can be estimated to cost no more than £12 10s. an acre, as shown below.

Hand pruning	£ s.		*Power pruning*	£ s.	
Labour ...	16 15	an acre	Labour ...	10 5	an acre
Machinery ...	— 15	an acre	Machinery ...	2 5	an acre
TOTAL	17 10	an acre	TOTAL	12 10	an acre

On this basis £1 of machine cost substitutes for almost £5 of labour cost.

There is considerable scope for cost-reduction here, which is probably best implemented on relatively mature trees.

Spraying (£18 2s. an acre)

Spraying, in contrast to pruning, is an operation which repays careful attention to good organization. All the farms are not equally well laid out, and for this reason the economic effects of, say, low-volume spraying as against high-volume may not be made apparent—good organization and an economical layout may minimize a technically big labour requirement, while poor organization may enhance a technically low labour requirement. Technical advance has been faster in spraying than in any other operation, but yearly costs of spraying do not show the real savings resulting from progress in technique because at the same time more expensive materials have been used, and the number of washes given each year has tended to increase, even where the grower aims at a commercial rather than a complete, control of pests and diseases.

Considering the farms singly, costs for labour varied between £1 and £8 an acre, for materials between £9 and £26, and for machinery (tractors and sprayer) between £2 10s. and £8 ; total costs varied between £12 and £32 an acre. The present study is concerned with the organizational aspects of fruit growing, and not with obtaining protection against fungus and insect attacks at minimum cost in materials. What is of present interest is the cost of getting the wash on to the trees—particularly the cost of labour and machinery and the relationship between the two. Arguing from first principles, it would appear that the ratio of man : machine cost for automatic spraying should be 1 : 2, because a tractor and a spraying machine each cost about as much per hour as a man ; this premise is fully substantiated by the average figures, £2.1 for the manual labour and £4.0 for the machine work (which, incidentally, includes the cost of the upkeep of water-supplying facilities).

What is perhaps more pertinent is that, on a group of dessert-apple farms, labour costs were £1.82 an acre in 1950 and only

£1.88 an acre in 1959, machine costs being likewise steady at £3.8 an acre.

Orchard acreage is another factor affecting the cost of applying wash, and affects labour cost as well as machine cost. For instance, when roughly grouped by size, the 30-40 acre group operated at less cost, for an equivalent amount of wash, than the group of farms having either smaller or larger acreages.

Spraying cost in relation to orchard area

	Farms with less than 20 acres of orchard £ per acre	*Farms with 21-35 acres of orchard* £ per acre	*Farms with more than 70 acres of orchard* £ per acre
Labour	4.98	1.41	2.15
Machinery	6.09	3.88	3.32
Total	11.07	5.29	5.47
Materials	14.00	17.05	14.19

Apparently, the medium-sized farm, which can get full utilization of one automatic machine, gains up to £5 an acre in cost of spraying over the smaller farm, and is at no disadvantage to the larger farm.

The area of orchard is therefore a factor to be reckoned with when assessing the marginal costs of spraying or the rate of substitution of machines for men. Taking as example one large block of trees on one farm which has had the minimum of changes in composition of wash and type of application (automatic) each year, the marginal cost of applying an additional £1 of wash per acre, was about 4s. 9d.; that is, if an additional £5 were spent on materials *for more spraying* (not for the same volume of wash) there would be 23s. 9d. to add for the cost of the extra "rounds", making the total cost £6 3s. 9d. more.

On another farm, the change from hand-lance spraying with pressure mains to automatic low-volume work has been made in the last decade. Where labour formerly cost between £4 and £6 an acre for spraying, the cost, at the former rates of pay, is now less than £1 15s. Machine cost per acre, however, has risen, and the years' costings look like this :

	Pressure mains (av. 3 years)	*Automatic mobile* (av. 3 years)
Labour	£4.57 an acre	£1.91 an acre
Machinery	£4.07 an acre	£6.07 an acre
Total	£8.64 an acre	£7.98 an acre

The present actual gain, therefore, is about 13s. an acre over the season—or about £1 10s. an acre less than the labour-intensive method would have cost in the same circumstances; this 30s. represents a saving of about 1½d. a bushel and would not be worthwhile on its own unless equally satisfactory, in pest control as hand-lance spraying. The savings in this type of progress are indirect rather than direct, and do not absolve the grower from mechanizing elsewhere so as to use to the full the partial opportunities for releasing labour created by automatic mobile spraying.

In this case an average of £3.56 an acre of extra labour cost was circumvented by installing an economically superior machine costing an extra £2.00 an acre; thus £1 of machine cost substituted for £1.78 of labour cost.

Cultivations (£5 10s. an acre)

Most growers have the same idea about a grass sward—to keep it short. Taken over a period of twelve months, to carry out this idea means roughly the same number of hours' work for one man, one tractor and one mowing machine, with the man possibly doing a little extra hand-work. Costs per acre for cultivations varied between a low figure of £3.99 an acre and a high figure £10.4 an acre. As with spraying, the area treated was influential in determining cost per acre. Using the same groups of farms as were constituted for the analysis of spraying cost, results were:

	Farms with less than 20 acres of orchards	*Farms with 21-35 acres of orchards*	*Farms with more than 70 acres of orchards*
	£ per acre	£ per acre	£ per acre
Labour	3.4	2.1	2.6
Machinery	3.8	3.6	2.9
Total	7.2	5.7	5.5

These results repeat those for spraying. The small farm operated under a handicap of more than £7 an acre (12 bushels of apples?) on these two operations alone.

Manuring (£11 6s. an acre)

Manuring, which consists largely of mechanically spreading artificial manures, is another straightforward and standard job like mowing. As this operation is less repetitive than either spraying or mowing, size of orchard area is a less important factor. Determinants of cost in this case were the weight of fertilizer applied and the number of applications. The lowest average yearly cost recorded was £0.57 for applying £4.26's worth of artificials per acre, and the highest £6.4 for applying £21.28's worth, which includes some organics. As regards the conventional procedure of one dressing of compound in the early spring and one dressing of nitrogen in the autumn, the marginal cost of applying an extra £'s worth (in volume, not value) appears to be 2s. 6d. That is,

if, say, 2 cwt. Muriate of Potash were added to 3 cwt. nitrogenous manure, the cost of manuring would be increased by £2 5s. an acre—£2 for the material and 5s. for putting it on. The trend in progress in applying manure is to increase the output of labour while keeping the machine cost relatively constant.

Other cultural operations (£5 0s. an acre)

These do not lend themselves to systematic analysis ; the jobs differ, and the time given to each differs from farm to farm : consisting mainly of grafting, thinning and anti-canker measures, labour is the most important factor here. In view of the stress laid on fruit thinning in a previous fruit report, costs of this operation deserve separate mention, although it is almost impossible to specify the job that was done in every circumstance—the number of fruitlets retained being just as important as the number removed, although it is the latter that cost the money. Expressed as a cost per acre of orchard, growers spent between £5 an acre and £1 an acre. In the first case thinning would be a general occupation for the staff, with the labour available being the limiting factor to what would be achieved ; in the second case perhaps only one variety would have been thought to require thinning.

Picking (£17 10s. an acre)

Picking fruit is more of a process than one operation ; it begins when the containers are carted out to the orchard, and ends when all is cleaned up again. There is also a much-augmented labour force to be reckoned with, a variable crop, and different sizes of tree. It is not surprising, then, to find that costs per acre for the process of picking varied from £33.4 down to £3.5. The latter figure is a reminder that not all plantations succeed : the respective yields per acre were 370 and 80 bushels. Piece-rates of earning being the rule for the casual pickers (at least), the costs per bushel for picking show less difference between any two farms than for any other operation.

Looking at all the farms' results together, three conclusions emerge. First, that picking into trays instead of boxes adds up to 30s. an acre to costs. Secondly, that disproportionately high machinery costs on some farms are most reasonably explained by the fact that the farms concerned are larger, and transport from the orchard to the farm buildings takes longer. For the same weight of crop, costs on the 100-acre farm may well be 30s. an acre higher (over the whole season) than on the 25-acre farm. Thirdly, that at higher yields to the acre, better utilization of machinery is obtained than at low yields per acre (when there is possibly more picking-over). For a five-fold change in crop-size, the machinery-cost change was less than three-fold.

Although the machinery-cost element in costs is not important it appears that the marginal cost of this element is about 3s. 6d. per 100 bushels an acre, i.e. other things being equal, and

the pickers' wages constant, Farm A, having an average yield of 200 bushels an acre more than Farm B, will tend to experience machinery costs in picking of 7s. an acre more than Farm A. *Costs per bushel picked,* of course will be lower on Farm A by about 5s. per 100 bushels (0.6d. a bushel) an acre.

Looking at particular farms, it also becomes apparent that (effects of the season apart), above-average crops are handled slightly more cheaply than below-average crops, and that a big crop is, in practice, picked *relatively* more cheaply from standard trees than from bush trees. Typical marginal costs for picking (labour and machinery) were: on culinary-apple orchards, 6d. a bushel; on dessert-apple orchards, 10½d. a bushel.

No case of bulk harvesting was included in these cost data. The *trend* in cost of picking is dealt with in the section on efficiency of production.

PROGRESS IN EFFICIENCY OF PRODUCTION

Tests of efficiency

The fruit grower cannot expect his mature trees to bear increasing crops of marketable quality of fruit for the same expenditure as they did when younger. In other words, unchanged cultural attention may give rise to diminishing net returns per acre, and additional cultural attention may be necessary to maintain net returns. Improved production methods, then, have a definite bearing upon continued financial success; the profits resulting therefrom may not be as spectacular as, say, those arising from a new *Cox* orchard coming into bearing, or a season of high prices, but their effect can be considerable if continued over a ten-year period.

It is impossible to say, of course, how much of the recorded work on the farm in any year, was maintenance of the *status quo* and how much was the increment designed to improve results. Suffice it to say that many physical factors in the orchard—the growth of the trees, the restriction upon movement between the trees, and so on—tend to constitute a sort of handicap, making more difficult the grower's task of actually achieving increased efficiency in and from his consumption of resources.

The measurement of efficiency itself is no easy task ; there is no single comprehensive measure free from undesirable side effects. For the present purpose, two measures have been chosen : (*a*) the man-hours applied on cultural tasks per acre of trees (which is not affected by the falling value of money), and (*b*) the bushels of fruit produced per man-hour of labour. If apples decline in value and workers draw higher wages, it is a pre-requisite of progress that the number of bushels produced per man-hour should advance at a more than compensating rate. At a later stage the analysis of efficiency is re-converted to money terms by referring to (*c*) the bushels produced per £100 spent on cultural labour, and (*d*) the value of fruit produced per £100 spent on wages. It is realised that items (*c*) and (*d*) are very severe tests to apply over the period 1950-59.

First, however, the trends in expenditure on the farms on labour, materials and services are examined.

Trends in factor costs

At this stage, cultural costs in dessert-apple orchards must be separated from those in culinary-apple orchards. Whereas the growers of dessert fruit retained reasonable optimism and were prepared to spend wisely in anticipation of higher revenues, growers of culinary fruit have been concerned to "cut their losses" and not spend more than the low prices (and low yields) merited. Table 4 shows the separate costs per acre for 1950-51, for the middle year 1954-55, and for 1958-59.

Table 4. Factor costs in operations in dessert apple orchards, 1950-51 to 1958-59

		£ an acre			index, '58-'59
		1950-51	1954-55	1958-59	('50-'51=100)
Pruning:	labour	8.6	9.1	13.3	155
	services	0.4	0.5	0.5	125
	total	9.0	9.6	13.8	153
Spraying:	labour	2.1	2.2	1.6	76
	materials	12.3	11.6	13.0	106
	services	4.0	4.0	3.5	87
	total	18.4	17.8	18.1	98
Cultivations:	labour	2.2	2.5	2.8	127
	services	3.3	3.3	3.1	94
	total	5.5	5.8	5.9	107
Manuring:	labour	1.0	1.0	1.3	130
	materials	12.0	7.6	9.5	79
	services	1.2	0.9	1.6	133
	total	14.2	9.5	12.4	87
Other operations:	labour	3.1	4.0	6.4	206
	materials	—	1.2	0.2	—
	services	—	0.4	1.1	—
	total	3.1	5.6	7.7	248

A whole philosophy of production economics is borne out by the above figures. Where labour works alone, as in pruning, costs inevitably rise as wages rise. Where a repetitive or mechanical process is involved, as in spraying, technical improvements enable costs to be held down. If technique is stationary, as in mowing, costs increase from year to year. Given a standard practice and standardized materials, as in artificial manuring, costs can be regulated by varying the amount of materials used.

As was mentioned earlier, the culinary orchards costed have not yielded well whilst under scrutiny, and the story here is one of definite cost-cutting. It has been done, for only in pruning is the cost in 1958-59 higher than in 1950-51—and then by only 18s. an acre (see Table 5).

Table 5. Factor costs in operations in culinary apple orchards, 1950-51 to 1958-59

		£ an acre			index, '58-'59
		1950-51	1954-55	1958-59	('50-'51 100)
Pruning:	labour	10.1	10.0	10.8	107
	services	0.5	0.3	0.7	140
	total	10.6	10.3	11.5	108
Spraying:	labour	1.7	2.0	1.7	100
	materials	12.0	7.3	8.3	69
	services	3.5	2.8	4.0	114
	total	17.2	12.1	14.0	81

		£ an acre			index, '58-'59
		1950-51	1954-55	1958-59	('50-'51=100)
Cultivations:	labour	3.0	2.3	1.9	63
	services	3.1	2.5	2.1	68
	total	6.1	4.8	4.0	65
Manuring:	labour	0.3	0.8	0.8	267
	materials	7.1	5.4	6.1	86
	services	0.3	0.5	0.6	200
	total	7.7	6.7	7.5	97
Other operations:	labour	1.3	3.0	2.4	185
	materials	—	0.6	0.5	—
	services	—	1.0	0.8	—
	total	1.3	4.6	3.7	284

It is possible to trace also a change in policy after the middle of the decade. Within the first five years costs were definitely deflated ; since 1954-55 some recovery can be traced.

Fruit Picking

No definite efficiency trends can be seen in the data on picking the crops. This is the least standardized and the most variable job on the farm—it is for this reason that its strong influence on the total costs for any year has been separated from other costs and given separate treatment. There is some encouragement, however, in the fact that picking costs *per acre* were not visibly rising in constant-money terms (for the same size of crop), because this implies that the organization of picking has improved—or do pickers work faster now than they did ten years ago?

The "picking" situation is outlined in Table 6, below, and the comment following.

Table 6. Costs of apple picking, per acre, per bushel, and in constant-money terms, 1950-59

	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959
Cost per acre (£)	15.2	17.0	16.3	13.5	18.0	14.2	13.1	16.7	20.3	20.8
Index (1950-51=100)	94.4	105.6	101.2	83.8	111.8	88.2	81.4	103.7	126.0	129.2
Av. yield per acre (bu.)	314	281	265	238	160	149	204	274	285	295
	s. d.	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s. d.*
Cost per bushel	1 1	1 2½	1 0½	1 1½	1 5	2 0	1 11	1 2½	1 7	1 6½
Cost per bushel at constant-money	1 1	1 1½	-11¼	-11¼	1 1½	1 6	1 4	1 0	1 0	-11¼

Expenditure per acre is seen to have risen by 26-29 per cent. during the ten years—by more than cultural costs as a whole, but by less than in another labour-intensive operation, pruning (30-35 per cent.). The low yields of the middle period help to account for the time-lag in the rise of cultural costs per acre, but they inflated costs per bushel.

The labour-cost component in picking was less important in 1958-59 than in 1950-51. The increased services-cost shown below is due to the introduction of picking trays on to some of the farms, and to the use of specialized trolleys and mechanical box-lifting devices. If the 1959 crops had been picked in 1950-51 fashion, it is likely that the cost would have been £25.6 an acre instead of £20.5. An increase in efficiency in this process on the farm of 2 per cent. a year coincides with a substitution of non-labour cost for labour cost and the saving of perhaps £8 an acre in manual labour for an additional service cost of £1 an acre. This is a more favourable ratio than was calculated for any other operation.

Factor Costs in the Process of Fruit Picking

	£ *an acre*			*Index*, 1959
	1950-51	1954-55	1959	('50-'51=100)
Labour	14.6	13.7	17.4	119
Services	1.5	2.4	3.1	207
Total	16.1	16.1	20.5	127

Confirmation of the reduced labour cost in picking is given by the constant-money cost per bushel For comparable crops, less was paid in 1958 and 1959 than might have been paid if the 1950-51 situation had remained unaltered. Possibly, more women than formerly are now employed as pickers.

As in previously described circumstances, picking of dessert-apple crops has possibly become relatively more costly than pick-ing culinary-apple crops. Comparative indices (at 1958-59 prices) are :

	1950-51	1959
Dessert apples	1s. 8½d. a bushel	1s. 7d. a bushel
Culinary apples	1s. 8d. a bushel	1s. 6d. a bushel

A further test of *worker-hours per acre* spent on picking shows that in 1950-51 on farms averaging 324 bushels an acre the inclusive process of fruit picking, i.e. putting out boxes, picking and hauling fruit out of orchards, the work-input per acre was lower than in 1958-59 when the average crop was 273 bushels an acre. Nothing decisive can be derived from these figures because, presumably, the trees were wider and taller at the end of the period than at the beginning, and there is no telling whether the pickers' *task* was not therefore greater in 1958-59, than in 1950-51. Picking time in relation to size of tree is referred to in the next section of this report. Details of worker-hours per acre are :

1950-51	324 bushels an acre	53½ hours an acre
1958-59	273 bushels an acre	57½ hours an acre

The productivity of manual labour

Machines having made only piecemeal penetration into orchard operations, success still largely depends upon the human factor. With the present level of adoption of mechanical aids to labour productivity, the workers are no more than keeping pace with either, or both, (*a*) the increasing task per tree or (*b*) the failing capacity for sustained work, because the worker-hours expended per acre in cultural tasks in 1958 and 1959 were, in the aggregate, closely similar to those of 1950 and 1951, as follows :

Worker-hours expended on cultural tasks in orchards

	dessert and culinary	*dessert*	*culinary*
1950-51	121½	124	114
1958-59	124	135	106

This result shows how hard it is for a grower to profit to the full from the potential cost-saving inherent in mechanization. On the whole, hours were being reduced on culinary-apple orchards, but were edging upwards on dessert-apple orchards. There are dessert-apple orchards on the same farms as the culinary-apple orchards, and it cannot be gainsaid that labour is probably being transferred to the dessert trees. It does not follow then, that labour has been likewise cut on specialized culinary-apple orchards outside the purview of this report. The increase in work on the dessert trees would appear to be more representative of general experience.

Upon closer examination it is revealed that the change in hours has been largely confined to the operations of pruning and "other operations"—the latter being partly the desire to change the orchards (e.g. by grafting, thinning-out or partial grubbing) and partly the use of labour freed from the time saved on routine operations.

Table 7, below, shows very clearly how progress in efficiency of production in the orchard is being fostered—and hampered. More efficient ways of doing the same job—or, alternatively, a modest scaling-down of the effort—have reduced the operations involving movement past the trees by perhaps six hours an acre over the period of ten years. Meanwhile, the trees have been expanding, and the operations *actually involving the tree,* pruning and picking, have required additional work to accomplish the same job, while the time saved in the spring and summer has been increasingly re-employed in non-routine operations, and in 1958-59 averaged 29 hours an acre on these farms.

Table 7. Worker-hours per acre on routine orchard operations, dessert and culinary apple orchards, 1950-51 and 1958-59

	dessert orchards		*culinary orchards*	
	1950-51	1958-59	1950-51	1958-59
Pruning	66	73	75	67
Spraying	13	9	8	6½
Cultivations	17	16	12	10
Manuring	9	8	5	4
Other operations	19	29	14	18½
Total	124	135	114	106

Bushels per 100 worker-hours

In terms of the second measure of efficiency—bushels of apples produced per 100 worker-hours on cultural tasks—the results are similar in portent to those above ; on the farms in question, yields per acre as a whole have not risen sufficiently to compensate for the increased use and cost of labour. In 1950-51 one hundred hours' labour in the orchard (prior to picking) produced 242 bushels of apples, in 1958-59 only 210 bushels.*

Culinary apples, by virtue of their higher yields gave 50 per cent. more bushels per worker-hour than dessert apples, although the fall in output over the last decade has been greater than with dessert varieties, thus :

Bushels of apples produced per 100 *worker-hours on cultural tasks*

	1950-51	1958-59
Dessert apples	209	184
Culinary apples	307	257

Very large differences exist among the farms in this respect. Absolute maximum and minimum results for any orchard for any year were respectively 449 bushels (culinary) and 319 bushels (dessert) per 100 hours, and 74 (culinary) and 80 (dessert). The highest averages for any orchard were 359 bushels (culinary) and 270 bushels (dessert) ; the lowest were 156 (culinary) and 113 (dessert).

If the same amount of labour in the orchard produces either 197 bushels of dessert apples or 282 bushels of culinary apples, the net price home of dessert apples can fall to 50 per cent. above that of culinary apples before the dessert-apple grower need contemplate planting culinary varieties to help to maintain the profitability of his farming.

Economic efficiency

Instructive as the above account of the exchange of worker-hours for bushels of apples is, it leaves out of account the changing

* It has already been pointed out that the costed group of farms did not share in the heavy crops common in 1958 ; this makes the figure quoted lower, but fairer in comparison, than for an augmented yield figure.

relationship of the cost of labour and the price of apples ; this omission is made good in the two remaining tests of efficiency.

Many factors have a bearing upon the price obtained for apples. If, for example, a grower is improving the quality of his fruit by using the new chemicals, the price/cost relationship will tend to move in his favour ; if, on the other hand, markets are at the same time becoming more selective, a grower may have an increasing amount of the smaller sizes of fruit which he cannot sell in the fresh market, in which case the price/cost relationship will tend to move against him.

In the next paragraph the cost of labour (on cultural tasks) has been related, first to the number of bushels of apples produced, and, secondly, to the value of apples produced, at the beginning and end of the ten-year period. The value-estimate used is the *net returns per acre* on the orchards concerned. This figure automatically makes allowance for occurrences like an increasing proportion of *Cox* in the output, a decline in yield, or more small apples. Prices of the single varieties which have been merged into the one figure are available and are listed in Appendix D (page 38).

Bushels of apples produced per £100 labour cost on cultural tasks

	1950-51	1958-59	*change from* 1950-51 *to* 1958-59
Dessert apples	1650	1134	—30 per cent
Culinary apples	2210	2125	— 4 per cent

Value of apples produced per £100 labour cost on cultural tasks

	1951	1959	*change from* 1950-51 *to* 1958-59
Dessert apples	£914	£737	—21 per cent
Culinary apples	£733	£557	—24 per cent

The gist of the above figures is, that whereas the work on culinary trees was reduced, approximately, to accord with the yield, there was no corresponding yield increase in the dessert-apple orchards to compensate for the increased labour cost per acre. Nevertheless, the price of dessert varieties was much better maintained than that of culinary varieties, so the culinary orchards made a slightly less favourable showing over the ten years than the dessert orchards.

Productivity of all expenditure

Were labour the only productive resources, the story would be grim indeed. In practice however, growers are continually substituting cheaper alternatives for labour, either in the form of machines, or superior sprays. The effect of mechanization has been

previously referred to when dealing with operational costs ; over the whole range of cultural tasks its effect has been to reduce labour costs to some 12 per cent. below what they otherwise might have been, as is shown below.

Overall relationship of labour and machine cost per acre, 1950-51 *and* 1958-59

	1950-51		1958-59 (*actual*)		1958-59 (*raised* 1950-51)	
	Labour £	*Machines* £	*Labour* £	*Machines* £	*Labour* £	*Machines* £
Dessert apples	17.95	8.30	25.45	9.90	28.90	11.20
Culinary apples	14.95	6.45	17.65	9.10	24.20	8.20

Assuming that manual work was accomplished at the same rate throughout, cultural costs per acre (excluding materials) are between £4 15s. (dessert) and £5 13s. (culinary) an acre less than if 1950-51 practices had been maintained throughout. The effect of non-mechanical improvements is impossible to assess, but when tested against all expenditure on cultural tasks, the recent performance of the orchards is much more encouraging than are the labour-productivity figures alone (see Table 8).

Table 8. Value-productivity of all expenditure in cultural tasks in apple orchards

	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959
Bushels of apples per £100 expenditure										
All apples	634	548	467	496	525	323	409	535	582	488
Dessert apples	500	567	347	443	438	361	338	550	510	441
Culinary apples	922	610	695	710	793	314	462	298	786	641
Net returns from fruit per £100 expenditure										
All apples (£)	*	258	314	281	315	245	224	422	175	235
Dessert apples (£)	*	298	350	295	340	282	244	463	188	294
Culinary apples (£)	*	200	238	259	274	161	171	236	163	171
Index of net returns per acre (1951=100)										
Dessert apples	*	100	128	101	108	84	82	161	57	115
Culinary apples	*	100	136	86	124	69	79	112	74	79

* insufficient data in 1950

Although the *physical* output of apples per £100 spent has declined (1950-51, 591 bushels ; 1958-59, 535 bushels), and for both the dessert and culinary varieties, the fact that dessert apples have risen in price in years of a sub-normal crop enabled these growers to show almost the same *value* of output per £100 expenditure in 1959 as in 1951 (£294 as against £298). The dessert apple index had risen by 15 per cent., while the culinary apple price index had fallen 23 per cent. and in such circumstances it was impossible to show as good results in 1959 as in 1951.

Seen as a whole, this study of progress in efficiency shows very well how growers of dessert apples have been able to offset rising costs with improved methods of production and a higher average price for fruit sold. Improvements in the past decade, however, have been in the operations *on the ground*. The actual work *on the tree* has been left as yet unimproved. A more difficult decade, therefore, lies ahead of growers. Dessert apple prices will continue to decline in relation to labour costs, and growers are at present committed to heavy expenditure for labour on pruning and picking. Ultimately, these labour-intensive operations will only be done at minimum cost when the optimum size of tree is more closely standardized than at present, or when each tree ceases to be so much of an individual. Perhaps, in the future, efficiency in production will start in the tree nursery, with budding, and be continued through the early years of formative pruning.

THE WORK REQUIREMENT OF DIFFERENT SIZES OF TREE

As was implied in earlier sections of the report, further economic progress in orchard practice is bound up with the two operations of pruning and picking ; further comment follows.

Pruning

Taking pruning first, no connection could be established between the time spent on pruning and the following crop, or (because pruning anticipates the harvest and is affected considerably by whether the previous crop was large or small) between pruning time and the preceding crop, although on dessert apple orchards there was a tendency for pruning costs to be relatively high after a good preceding crop.

There was a connection—which can hardly be fortuitous—between average time spent on pruning and the associated average yield per acre of dessert apples. It would be rash to read too much of an " efficiency " content into these figures, which may only reflect, firstly, the fact that on some farms where the orchards are close together, or the trees are tall, the pruning task is greater. Also, the farms may not have similar proportions of high-yielding varieties, and the response in yield to a standard amount of pruning will be different for each variety.

The diagram on page 39 shows a curvilinear relationship intimating that there can be diminishing returns to pruning effort—the time spent per acre above the normal 70 hours appears to be less productive than that within the limits of 50 to 70 hours.

Picking

Picking is a more measurable task than pruning, although far from a standard process. " Picking-over " an orchard is more frequent where the varieties are mixed than where large blocks of separate varieties have to be cleared in turn, but the latter practice outweighs the former in frequency. On the other hand, the whole process of picking has been so little altered that it would not be wrong to infer that picking took a minimum of hours per acre in, say, 1957, *because* average yields were light, and that picking hours per acre were high in, say, 1950 *because* there was a heavy crop in that year.

The effort put into picking fruit was measured in two ways : first, by the estimated number of hours of work ; secondly, by the money cost. The number of hours worked, however, was calculated from the pickers' earnings and is likely to prove unreliable as between a situation in which regular farm workers pick a light crop and one in which predominantly casual workers pick a heavy crop, so this measure must be used with caution. The remaining variable is size of apple—a factor which may well account for some of the anomalies in the data.

Taking average annual work requirement first, it would seem that, with bush trees and crops of between 150 bushels and 375 bushels an acre, the average increment of time required for picking an additional 50 bushels an acre was some 6 hours an acre.

But looking at results for individual farms, a surprising outcome occurs in most cases. The most expensive crop to pick was the above-average crop—not the best crop experienced in the ten years (and not, of course, the worst). In the diagram on p. 39 the index of cost per bushel (at constant-labour cost) is shown in relation to the index of crop size ; in this way all the farms' results can be equated, and the difference in cost and yield levels between farms can be negated.

There is no evidence that the easy and regular transition from a high cost per bushel for picking a light crop to a low cost per bushel for picking a heavy crop, which was expected, actually occurred in practice. In three-quarters of the orchards—whether of dessert or culinary apples or pears—the good crop was the most expensive to pick, and costs per bushel were lower for both the light crop and the heaviest crop in each case. It seemed to be general experience that light crops were picked relatively cheaply ; then, with crops normal to the farm, costs per bushel increased, to increase for one above-average crop in the decade and decline for the heaviest crop of the decade, thus tending to give a U-shaped cost curve instead of the expected straight or curved line of single attitude. The shape and disposition of the cost curves obtained indicates that fruit picking would be a most deserving object for further economic study.

All cultural tasks

Whether there are few or many trees on an acre, and whether those trees are high or low (excluding the intensive systems) will not greatly affect the time on spraying, manuring or mowing, and these operations are, in any case, not big users of labour. Where large trees may be economically vulnerable is in the cost or labour of pruning and picking them—and in the added difficulty of ensuring a uniformly clean crop.

From the management point of view, the question at issue is whether a grower should expect to have to recruit more staff at any given period in the trees' life—or at least invest in aids which will enable the existing staff to accomplish more. On the farms concerned there is no evidence that the work-requirement on bush trees between the age of 20 years and 30 years (or on standard trees in later life) does increase significantly if yields per acre are stationary. What may be of greater importance is the work-requirement of trees of different size.

Any of the present conclusions on this score must be considered tentative. There can be no assurance that the staff on all the farms worked at the same speed, and no check that the same kind of work (e.g. in pruning) or work of the same quality, was carried out on all farms. Only very obvious differences in work-requirement can be considered significant, and in two particular fields: (*a*) as between standard trees and medium-sized bush trees; and (*b*) as between larger and smaller bush trees.

The recorded data on the performance of standard trees has been considered uncharacteristic and inadequate to this exercise, but there are differences in size among the bush trees which are significant—significant of different degrees of development (growth), not of different degrees of vigour in a rootstock, nor of different ages of tree.

Given further information, it would presumably be possible to harness the labour-requirement figures in three ways, amending the yield figures as appropriate: (*a*) to absolute size of tree (as has been done); (*b*) to the rootstock normally producing a mature tree of the same size as those specified; and (*c*) to a rootstock producing trees of the size specified at a given age.

A ranking of the bush trees by size leads to precisely the same disposition of orchard units as a ranking by work-requirement, i.e. the larger the tree, the greater the work-requirement per acre. Trees in all the orchards were measured in 1954 or 1955, midway through the study. As recorded, the results were:

Orchard unit no.	*Mean size of tree, 1954-55 (span and height in feet)**	*Mean hours per acre on cultural tasks, 1950-59*
3 (dessert)	17 x 17 x 14	196
8	14 x 14 x 11½	165
11	14 x 14 x 10½	131
1	12½ x 12 x 9½	123
4	10½ x 10½ x 9	100
10	11 x 10½ x 9½ (wide plant)	84
12 (culinary)	34½ x 34½ x 22½	156
7	32 x 32 x 25	88
6	27 x 27 x 20	78

*As in previous reports "span" is the lateral distance for which the tree impedes passage: it is not the actual limits of growth.

Yield in relation to work requirement

At this point in the analysis the records have exhausted their usefulness and further progress must depend upon speculation—not so much "blind" as "calculated" speculation. The author is in a position to judge the farms' performance and results by a common, but intuitive standard. For instance, the work-requirement of some recorded trees is higher than it might otherwise be because

the farm is small, and the orchard acreage small in relation to the available labour ; similarly, some orchards have not yielded well —certainly not as well as they should have done considering the work put into them. Also, crop failures have reduced a grower's average yield through no fault of his own ; one orchard is much more widely planted than the others, and so on. All these particular circumstances interfere with the "normal" relationship between input of work and output of fruit.

In preparing the next table, work-requirements on cultural tasks have been "normalised", actual average yields "corrected", spraying and manuring programmes equated and fruit-picking costs for the corrected crop added to the cultural-task requirement. Finally, *the bushels produced per* 100 *hours' manual labour* have been calculated, as a surmise to the most productive size of tree.

Table 9. Conjectural relationship between size of tree, work-requirement and yield per acre

Orchard unit no.	Hours of labour on: *Pruning*	*Cultivations*	*Manuring*	*Spraying*	*Other op'ns*	*Total*	*Assumed yield per acre (bu.)*
3	90	13	5	20	15	143	320
8	76	13	5	17	15	126	283
11	70	16	5	15	15	121	265
4	60	16	5	15	15	111	250
1	55	16	5	15	15	106	240
10	49	18	5	15	15	102	230

Net effect of size of tree

Orchard unit no.	*Hours on picking*	*Total hours per acre*	*Bushels per 100 hours manual work*
3	65	208	154
8	58	184	154
11	55	176	150
4	54	165	151
1	52	158	152
10	48	150	160

The most proper conclusion to be drawn from these results is that equivalent results are possible from any size of tree under review. Unfortunately, there is a relatively small range in size.

By comparison, standard trees would give the same performance as these bush trees if yields of 400 bushels an acre could be obtained from 260 hours' work a year. As a form of tree, therefore, the vigorous standard or half-standard is not ruled out on the score of productivity alone. It is the practical difficulties of working the tree and maintaining size and quality and adequate bearing wood in later life which have led to the standard tree's decline.

APPENDIX A

Apple production: average cost per acre (trees over 17 years), 1950-59

	£ *an acre* (*for* 42 *acres*)	
Pruning	11.9	
Spraying	18.1	
Cultivations	5.5	
Manuring	11.3	
Other operations	5.0	
		51.8
Picking	17.5*	
Farming overheads and business expenses (shares)	15.0	
		32.5
TOTAL		£84.3

Additional items

Interest on investment: 6% on £350 an acre	21.0	
Interest on working capital: 6% on £84 an acre	5.0	
Provision for orchard replacement	8.0	
		34.0
TOTAL		£118.3

NOTES.

1. Non-recurrent costs not included.
2. Actual values; mean is appropriate to 1954-5.

* Picking, of course, is a variable cost per acre. The figure shown applies to a 270 bushel an acre crop.

APPENDIX B

Apples or pears for profit ?

With a few exceptions, growers have pinned their faith to apples, with pears as a second string. This may be partly because there is not the same range of good varieties of pear as of apple, and consequently not the same extended picking season, or the same known marketability. Largely, of course, the growers' reliance on apples is due to the size of the market for dessert apples being larger than for pears—the consumption ratio being about five to one. Post-war plantings of *Conference* and *Cox's,* however, have been proportionally similar: but this does not seem to have been a conscious effort on the growers' part to popularize the pear relatively to the apple. Subconsciously, consumers feel that pears are more expensive to buy than apples and must, therefore, be more costly to grow than apples.

From the consumers' point of view the large size and high value of single pears is a handicap, because weight for weight, pears can be produced at least as cheaply as apples, and would bear an advertising campaign if the net result thereof were not to switch consumption away from apples!

This small continuing study of fruit production costs is not sufficient authority for a pronouncement on the average costs on existing apple and pear orchards. In all likelihood, in the pear-growing parishes (e.g. Ditton) pears are to be preferred to apples, and in the apple-growing parishes, apples to pears ; these results may not be the best guide to results on fruit farms in general. Only by means of a comprehensive survey could the relative merits of apples and pears be properly tested.

One test—though not a conclusive one—is the comparative performance of apples and pears *on the same farms,* under the same management ; three of the costed farms have pear orchards of the same age as the dessert apple orchards, on one-quarter of the scale of the apples. The comparison on these farms is in favour of pears —as a subsidiary enterprise and assuming equal accidental damage to both apple and pear crops. In well-wooded districts the hazards in pear-growing are distinctly higher than with apples. Where there was no abnormal damage, the pears have required less expenditure per acre than dessert apples, have cost less per pound to produce, have given higher net returns and higher profit per acre over the last ten years. Taking *all* costed crops into account, pears cost more per bushel than apples because there were more crop failures ; but in the years when both apples and pears succeeded, comparative costs were as shown in Table 10.

Table 10. Average costs per acre of normal apple and pear crops, 1951-59, on the same farms

	Apples £	*Pears* £
Pruning	13.26	11.12
Spraying	18.45	14.74
Cultivations	5.65	6.82
Manuring	10.81	13.68
Other operations ...	5.92	4.22
Total cultural costs	54.09	50.58
Picking	15.97	16.65
Overheads	15.51	15.00
	31.48	31.65
TOTAL	£85.57	£82.23
Average yield per acre ...	265 bu.	314 bu.

NOTE. The pears' yield was high relatively to that of the apples'; whether cause or effect, they were, therefore, more liberally treated; *for equivalent yields,* pears would cost some £10 an acre less than apples.

In Table 10 the main differences between cultural practices in apple orchards and in pear orchards are financially evaluated. Spraying cost about £3 15s. an acre less, and pruning about £2 3s. an acre less than on apples; because the pears were not grassed down, cultivations (including cleaning round the boles) cost some 25s. an acre more, but, more important, a supplementation of organic manures increased the cost of manures to almost £3 an acre above that of apples. Anti-canker measures, grafting, removing water shoots, and other ancillary operations cost more for apples than for pears. To pick pears was rather more costly because there was a larger average crop—314 bushels an acre compared with 265 bushels an acre of apples.

Net returns home on these few farms averaged, in round figures, 17s. 6d. a bushel for dessert apples (about 60 per cent *Cox's Orange*) and 21s. 0d. for pears (about 70 per cent *Conference*). Taking these prices and using the average yields per acre previously given, returns per acre would be £220 (apples) and £275 (pears). Looked at another way, there was a 50-50 chance that the average net price home of pear crops would be higher than of apples, and any such price advantage was likely to exceed 2s. 6d. a bushel. This is perhaps as fair a test as any, and it gives the following advantage to pears:

Margin in price of pears over price of dessert apples, 1950-59

Margin per bushel	*Percentage of crop-years concerned*
plus 2s. 7d. or more	52
plus 2s. 6d. to minus 2s. 6d.	38
minus 2s. 7d. or more	10

APPENDIX C

A comparison of costs of production—U.S.A. (Oregon) and Great Britain (Kent).

By coincidence, the Agricultural Experiment Station of Oregon State College published in May, 1961, an economic report covering apple and pear production in the Hood River area for the period 1947-56. This area was the source of most of the pre-war imported Newtown Pippin apples, but for the last 30 years has been turning more and more to the production of Bartlett (Williams') pears for canning, and D'Anjou pears for fresh consumption in winter.

The comparative total costs and costs of operations are shown in the tables below. Dollar costs have been converted to sterling at the rate of $2.8 to the £ ; and cost items for which no equivalent British figure is available have been omitted.

Cost of production of dessert apples, Great Britain (av. 1950-59) and United States (av. 1949-56)

Operation	*Great Britain (Kent)*	*U.S.A. (Oregon)*
Labour and materials only	*£ per acre*	
Pruning	12.9	13.7
Spraying	13.1	18.5
Cultivations	2.5	2.2
Manuring*	9.3	13.1
Other cultural costs	4.2	14.4 (incl. fruit thinning)
Cultural costs ...	42.0	61.9
Picking and hauling	14.0	33.4
Machine and implement costs	17.0	18.2
Farming and business overheads	12.0	13.2
Interest on capital (5%) ...	18.0	17.1
Total	103.0	143.8

* includes irrigation in Oregon.

Notes.

(i) Kentish orchards were 100% mature and in bearing and averaged 40 acres in size ; Oregon orchards were 67% mature and averaged 15 acres in size.

(ii) Kentish orchards grew 60% Cox's ; Oregon orchards 60% Delicious.

(iii) No. of farms reporting: Kent, 8 ; Oregon, 22.

(iv) Yields per bearing acre: Kent, 251 bushels ; Oregon, 435 bushels.

Cost of production of dessert pears, Great Britain (av. 1950-59) and United States (av. 1949-56).

Operation	*Great Britain (Kent)*	*U.S.A. (Oregon)*
Labour and materials only	*£ per acre*	
Pruning	10.1	16.3
Spraying	11.7	17.7
Cultivations	2.8	1.9
Manuring*	10.7	8.4
Other cultural costs	3.2	2.1
Cultural costs	38.5	46.4
Picking and hauling	14.6	32.2
Machine and implement costs	16.0	20.0
Farming and business overheads	12.0	17.9
Interest on capital (5%) ...	18.0	19.5
TOTAL	99.1	136.0

* includes irrigation in Oregon

NOTES.

(i) Kentish orchards were 100% in bearing and 75% mature and averaged 8½ acres ; Oregon orchards were 73% in bearing.

(ii) Kentish orchards grew 66% *Conference ;* Oregon 87% *D'Anjou.*

(iii) No. of farms reporting: Kent, 3 ; Oregon, 20.

(iv) Yields per bearing acre: Kent, 265 bushels ; Oregon, 530 bushels.

Harking back to the same area in 1915 affords pointed comment upon the nature of economic progress ; it can be looked upon either as more pay for less work, or the march of mechanization, according to choice. From the figures, however, it becomes obvious that the jobs on which a man works unaided took considerably longer in 1952 than in 1915, although, to grow and harvest a bigger crop took 14 per cent less manual labour (see below), and, because recent yields are higher, the output per man-hour has exactly doubled (in 40 years!).

Man-hours per acre on apple production, Hood River, Oregon. Change in time on operations: 1952 *as percentage of* 1915.

Pruning	+38%	Thinning fruit ...	+72%
Picking-up prunings ...	—60%	Orchard maintenance	—12%
Spraying	—77%	Irrigating	—25%
Cultivations	—85%	Picking	+52%
Manuring	—67%	Other harvesting operations	—45%

Total labour applied per acre: —14%.

Loose bushels produced per man-hour: + 100% (1.1 to 2.2).

APPENDIX D

Net Home Prices of Dessert and Culinary Apples, 1951—59.

ASSOCIATED WITH QUOTED RATES OF NET RETURNS PER ACRE

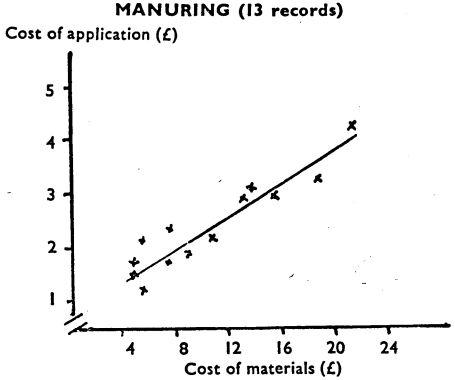
	1951	1952	1953	1954	1955	1956	1957	1958	1959	Average
DESSERT APPLES	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s. d.*
Miller's Seedling	15.3	7.10	—	8.6	19.11	26.0	26.0	18.0	6.8	14.3
Worcester Pearmain	13.6	12.8	10.5	10.7	12.6	17.2	15.5	6.8	7.9	11.10
Laxton's Superb	16.1	19.6	9.2	9.10	12.6	11.7	20.5	6.6	13.9	13.4
Cox's Orange Pippin	24.7	25.8	21.8	19.2	25.11	24.11	26.9	14.8	26.4	23.4
CULINARY APPLES	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s. d.*
Grenadier	11.1	6.6	12.9	4.7	10.4	8.1	8.9	5.1	5.10	8.1
Lord Derby	—	6.4	5.7	6.0	9.3	7.0	8.8	3.7	4.2	6.4
Bramley's Seedling	—	6.7	5.2	6.5	9.6	6.10	13.6	5.8	5.3	7.5

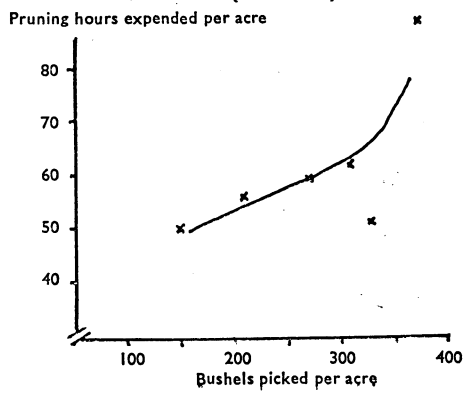
Average Net Returns per Acre, 1951—59.

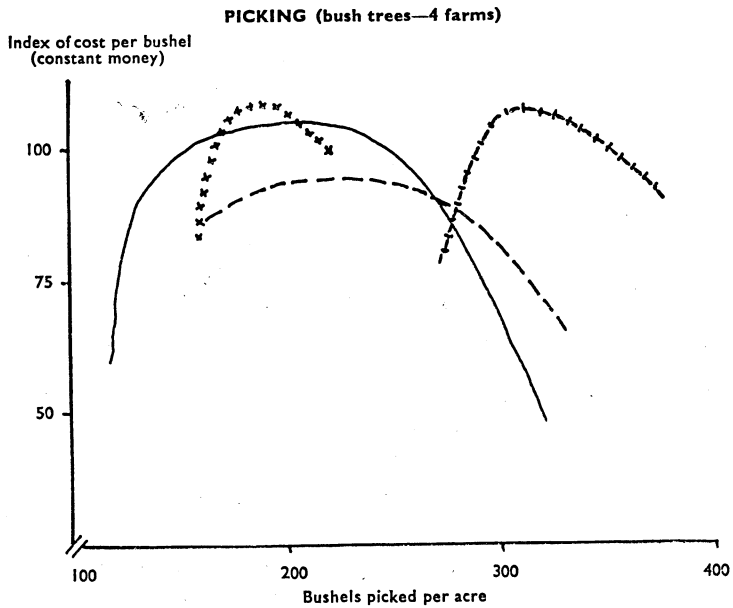
	£	s.	d.
Dessert Apples	173	10	0
Culinary Apples	97	2	0
Pears	257	16	0

APPENDIX E.

Some input/output relationships in orchard operations.







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