Apples - Cost of production

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Investment in Orchards

by

R. R. W. FOLLEY and K. C. YATES

DEPARTMENT OF AGRICULTURAL ECONOMICS
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ECONOMICS OF FRUIT FARMING

Report No. 5

Investment in Orchards

A study of the cost of establishing post-war commercial orchards of apples and pears, with a discussion of some economic principles involved.

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ACKNOWLEDGEMENT

THIS report draws heavily upon experiences on one fruit farm: the Department would like to acknowledge its indebtedness to Mr. Thomas Neame, V.M.H., for his readiness to make known to a wider audience the interim results of his planting-up experiment.

The economic principles of fruit tree spacing are the outcome of an extended study, and the conclusions proffered are the authors' own.

SUMMARY

IN one notable and well-documented case, it cost £326 an acre excluding interest, or £381 an acre if interest were charged on half the capital required, to create a new fruit farm and bring the trees up to the point at which their crops should normally be large enough to keep the farm running without additional calls for capital to maintain the trees.

The time taken to reach this condition was nine years, and year-by-year summaries of expenditure and revenue, and of operational costs and yields are given (Chapter I).

Economic establishment comes when the revenue from a crop in any year suffices to pay the production costs of two crops—the current one and the following one. The peak of investment (expenditure minus revenue) in the orchard proper will often occur just before economic establishment; but this is only the beginning in capitalizing a fruit farm.

A seven- or eight-year period prior to economic establishment of a new fruit farm will be more normal: in such cases a prudent intending fruit grower would allow for an investment (to establishment) of £375 an acre (Chapter II).

Measures available to reduce overall cost of establishment are: (a) to extend the orchard area on existing fruit farms; (b) to intercrop the young trees; (c) to plant widely. The apparent saving in extending an orchard rather than planting a new one on a new site can amount to £219 an acre (Chapter III).

Experimental results have been augmented and adapted to serve as the basis of formulation of some principles of orchard establishment. These are:—

1. For outright economy in capital, plant only permanent trees.
2. For a quicker build-up of business and return of capital per acre, plant filler trees.
3. For quickest economic establishment and maximum annual profits in the first nine years, plant early-maturing filler trees.

As the number of trees planted to the acre is increased, the capital required increases, but the time for which the excess will be required is reduced. At the same time, revenue per acre will increase in relation to costs. So the intending fruitgrower has a number of choices between a slow development of his business over ten years at a capitalization of £100 an acre, or of a more

rapid development over five years at a capitalization of £300 an acre, excluding land and buildings.

Although net returns per tree were below average, filler trees on M.IX rootstock in one trial earned a profit of not less than 8s. 5d. a tree nine years after planting. This margin, which was more than enough to pay for subsequent grubbing, was increased to an equivalent 17s. 0d. a filler tree by a heavier yield on the permanent trees resulting from the protection from wind afforded by closer planting. The performance of M.VII in the same trial was disappointing: trees on this rootstock showed a profit of not less than 1s. 8d. a tree in the same period, increased to an equivalent 18s. 6d. a tree in the same way as for M.IX—but there was only one third the number of trees to the acre.

Specifications are given for procedures to (a) minimize investment per acre; (b) produce quickest establishment; (c) produce maximum profit in the first 10-12 years. Size of business will be determined by the number of permanent trees planted; but an initial "plant" of about 450 trees an acre is likely to give the highest return on capital in the first eight to ten years (Chapter IV).

INTRODUCTION

In the winter of 1946/47 an unique horticultural experiment was begun upon the exposed North Downs, between Ashford and Faversham. This experiment was to test on the full scale the economic effects of planting fruit trees at different distances apart. Each of four major treatments covered 10 acres of land, thus leaving no doubt about the applicability of the experimental results to commercial practice.

This is the second report upon the experiment in question. Report No. 1* of this series covered the experiment up to the end of September 1949. This publication is now out of print, so for the benefit of new readers the outline of the experiment is summarized in the next paragraph.

To prepare for the trees, 157 acres of land, all of it above the 400 ft. contour, was cleared of hedges and ring-fenced, and new farm buildings were put up in a central position. Within the boundaries four adjacent experimental plots, each of 10 acres, were set out, as follows:—

(*a*) a widely-planted plot; trees on M.II at 25½ ft. square; making a total of 676 trees.

(*b*) a plot carrying, in addition to 676 permanent trees, 625 filler trees on M.VII—one in the middle of each square; total, 1,301 trees.

(*c*) a plot carrying, in addition to 676 permanent trees, 1,900 filler trees on M.IX—three to each permanent tree; total, 2,576 trees.

(*d*) plot (*a*) repeated, but underplanted with soft fruit—5 acres blackcurrants and 5 acres gooseberries.

Plot (*d*) was withdrawn after three years; the soft fruit did not succeed and was prematurely grubbed.

All apple trees were maidens. The permanent plant on each plot was distributed between: Cox's Orange Pippin (17 rows); Worcester Pearmain (5 rows); Fortune (2 rows); and Sunset (2 rows).

The remainder of the fruit farm was planted up with dessert apples, pears and cherries.

With the help of the grower and his farm manager the Department of Agricultural Economics has been keeping records of expenditure

* *Costs of Orchard Establishment*, **1946-49.** J. B. Butler.

and revenue on each experimental plot in the form of analytical cost accounts, which have also covered the whole farm.

The first report was necessarily concerned most of all with costs —costs of planting and costs of maintenance in the early years— for sales of fruit were negligible during that period. Now, more than ten years after the trees were first put in, the sales of fruit are beginning to match in value the yearly cost of producing the crop. The trees have been slow coming into bearing, as the site is exposed and the soil was in need of improvement; and the grower has had his full share of misfortune, but at the end of the 1955 season the orchards as a whole had reached a condition of potential continuing profitability, and the experiment was considered ripe for a second economic examination.

Upon closer examination it will be seen that the first profitable year of an orchard's life does not necessarily mean that the fruit enterprise has become established commercially, and will not need further capitalization. In this respect it should be noted that the cost of providing organized marketing facilities has not been considered in this report. Comment is made only upon the outlays found to be necessary to bring a newly-planted orchard up to the point at which the demand for further capital investment on the trees themselves ceases. The fact that in addition to the houses for the farm staff, marketing facilities and working amenities have to be provided too before a new farm can be considered properly equipped, only tends to heighten the effect of the conclusions that the establishment of new fruit farms requires a very great deal of money.

The conclusions about the economics of establishing orchards to be found in this report are not derived solely from the one experiment mentioned above. For this purpose the results from the experimental plots have been combined with others derived from the cost accounts of fruit farms which the Department of Agricultural Economics keeps as a routine piece of work. Many growers with whom the Department is in touch have had considerable acreages of new planting on their farm and these non-bearing plantations have always been costed separately from the bearing trees. And secondly, in an attempt to amplify the Department's meagre data on yields of apple trees in the first ten years of life, records of initial yields of fruit were requested from thirty growers in several south-eastern counties, and the results incorporated in Chapter II.

From the information obtained in these three ways it is possible to measure with greater certainty and precision than before the actual

cost of bringing various kinds of apple and pear orchards into bearing, and also—and what is perhaps more important—to begin to develop the economic principles relating to planting-out fruit trees. These conflict at some points with what the husbandry adviser might recommend. But by taking note of these principles growers will have a reasonable guide as to how best to meet any cultural advice given, supposing they wished either:—

(*a*) To have a profitable crop as soon as possible, or

(*b*) to make a limited amount of capital finance as big a business as possible, or

(*c*) to make the best return on capital possible during the early years of cropping.

It is clear from the results that the aims of an early return on capital, a good return on capital, and minimum use of capital are to some extent mutually exclusive. Capital in new orchards can be made to fructify in four or five years if the rate of investment per acre is high enough. By waiting for seven or eight years to get a return upon the investment, some saving of capital can be made: and by prolonging the waiting period still further it is possible to economize rather more on the investment if suitable measures are taken. Within limits, a new grower can choose to buy either less land and more trees or *vice versa;* and the amount of capital and the length of time for which he will want it are in part governed by his initial decisions regarding acreage and density of planting.

The next question raised is how, in the national interest, an expanded area of new orchards can be brought into bearing with least cost in terms of new capital expenditure. The most economical way of providing new orchards is, clearly, to replace blocks of uneconomic trees on economic sites. Considerable saving can be realized, too, by extending the orchard areas on farms already growing fruit, instead of starting out to establish new orchards upon entirely new sites. There is a considerable difference between the cost of developing a new fruit farm and that of extending the area of orchards on an established farm by the same amount. These two alternative ways of extending the fruit acreage have always been kept apart in this report.

This second report on the large-scale experiment previously referred to is not the final one. Final results will not be available until the filler trees on both plots have been taken out, leaving the three plots carrying the same number of permanent trees. When this condition has been reached the time will be ripe for a third report reviewing the position up to this stage.

If the trees' subsequent behaviour can be shown to have been influenced by the events in the first ten or fifteen years, a final report will be called for to explain which planting system is likely to provide maximum profit over the whole life of the orchard. It is more likely, however, that the later years of the experimental plots will be more usefully used in comparative studies of different grubbing policies. Replacement, and the most economical and effective method thereof, will come increasingly to exercise fruit-growers' minds in the future years and any data bearing upon the stage at which the additional costs in producing high-quality fruit from old trees become greater than those incurred in replacing them will be welcome.

CHAPTER I

THE COST OF ESTABLISHING A FRUIT FARM—A CASE STUDY

THIS chapter consists of an examination of the costs of starting fruit growing after World War II—including the provision of farm cottages as well as of orchards—on an entirely new site. In fact, in this case, a new fruit farm was created in what was by tradition a relatively poor area of small arable farms. The soil was of less than average fertility, but the land was cheap; and it was available, whereas it was hard to come by elsewhere. Most of the planting was completed during the winter of 1946/47.

Not all the land was put into fruit, but, even so, planting was on a scale which few growers would feel inclined to undertake, and then only over a period of years. For this reason, the costs have been presented as costs per acre, so that they might be held relevant to farms having between, say, 80 and 120 acres of top fruit. Some of the costs so recorded are low because the farm is relatively large: land, for example, and mechanical equipment, will both be provided at lower cost, acre for acre, on a fruit farm of 150 acres than on a fruit farm of 25 acres. On the other hand, yields of fruit may be expected to be relatively low on the larger farm. With these considerations in mind, the analysis has been extended, and a cost of establishment for the typical smaller fruit farm has been computed in Chapter II.

In the first example, dessert apples and pears were both planted, in the ratio of three acres of apples to one of pears. One orchard of cherries was also set out. Apple varieties and rootstocks were in accordance with the best current tradition—two-thirds Cox's Orange, with three dessert pollinators, predominantly on M.II rootstocks. A somewhat more experimental plant—including Williams', Fertility and Laxton's Superb in addition to Conference —characterized the "plant" of pears.

To give a guide to the general level of management on the farm. and to account for the use of labour and materials as shown in the costs, there now follows a brief technical description of the annual cultural operations on the farm.

Management of the young trees

Pruning.—The general policy has been to prune lightly.* The two aims have been to form the tree correctly and to induce fruiting at an early age. To this end, little or no tipping of leaders was done

* This would not be true of the period *after* 1955.

either on permanent or filler trees. The pruning system is perhaps best described as "modified regulated".

Soil management.—Most of the farm was laid down to grass with a seeds mixture of 17 lbs. Kent perennial ryegrass and 3 lb. wild white clover per acre while the trees were still quite young —four years old. The clover has not been persistent, owing to a naturally acid soil and a low phosphate condition. The grassing-down was followed by a year of drought that gave the trees a severe check: for three years they made very little growth. Since the sward was established it has been kept short by frequent mowings, with both gang mowers and Hayter machines, until the downward spread of the branches prevented easy passage of the tractor. After the fruit was taken off, two or three further mowings were necessary to remove the late summer growth of grass. It has been found advisable to bury the stones by using a heavy plain roll prior to the first mowing each year. Growth around the trees was kept down in the early years by brushing with a scythe, and later by a motor scythe and winter mowing.

Mulching was tried experimentally shortly after grassing-down to see whether it would help the trees to overcome the effect of competition from the grass in a drought year. The first plots were mulched in 1949; and in 1952 and 1953 the practice was extended to all the apples and pears. Several materials were tried, and with each one there were no half measures. The mulch as applied was two feet deep in some cases. Each tree's ration was an area seven feet square, which left just enough room for the passage of the gang mower. Straw was the first mulching material tried. Spent hops and sawdust were also used. A green mulch was found to be best of all, and in the middle years leys to provide the mulch were put down on the farm and cut and carried to the trees. Sawdust was found to be less satisfactory than the other mulching materials. In the opinion of fruit advisers the trees benefited from the mulching; certainly it promoted vegetative growth.

Manuring.—A preliminary soil analysis had shown an acid reaction, and deficiencies of phosphate and potash in certain areas. Therefore the first job of manuring was to correct these conditions. Superphosphate was applied at the rate of 3 cwt. an acre every other year, alternating with basic slag. It had been the custom to apply 2 cwt. of muriate of potash every year, but a magnesium deficiency became apparent in 1953. This was corrected by spraying with Epsom salts in that season, and was followed by an application to the soil of magnesium sulphate at 3 cwt. an acre in 1954 and a further 2½ cwt. an acre in 1955. Thereafter the rate of potash application was reduced to 1 cwt. an acre every year. To re-stimulate

the trees in 1953 after the check, applications of nitrogen were stepped up to 10 cwt. an acre in the form of Nitro-chalk—5 cwt. an acre was given in February and a further 5 cwt. in May. By 1956, the nitrogenous manuring had been reduced to 8 cwt. an acre a year.

The initial acidity was countered in the early years by dressings of chalk applied at rates of up to 3 tons an acre according to need: the maximum dose on any plantation was 7 tons an acre.

Spraying.—In the first eight years the trees were never given a tar oil spray. For the first five years, early spring applications of DNC were given, but this formulation was abandoned in 1952 in favour of BHC or DDT. Damage from insect pests has been, on the whole, light. Red spider has become the main trouble, a build-up becoming apparent in 1955/6. The incidence of fungoid diseases, particularly scab, has been more serious—which was perhaps only to be expected in this environment. Colloidal sulphur was the chief agent in scab prevention until 1954 when the attack was severe. Sulphur and mercury formulations were tried but caused considerable damage to the fruit. In 1954, Captan (then a new material) was tried and found successful and has been the mainstay in scab control since then. Prior to 1955 spraying was done with two P.20 machines, each feeding three men with a lance. Low-volume spraying was introduced in 1955. In an attempt to save time, one-way washing was tried out. Successive applications were made at right-angular lines of travel. This experiment was not repeated.

No windbreaks were in existence (one was planted to the south-west) and the whole site, measuring approximately 1,000 yds. by 650 yds. was uniformly open. Nevertheless, at eight years old the M.II and M.VIIs were standing without stakes, but the M.IXs continued to be staked. It was expected that, in view of the elevation and exposure of the site, the trees would be liable to gale damage. The exposure has proved a great hazard. Bruising of leaves and tearing of leaf margins has been experienced, but the trees have grown well considering the conditions and they stood the summer gale of 1956 with fewer losses than on many more sheltered sites. There has not been any excessive tendency for the long, slender fruiting branches to be broken in the wind. The plantation of cherries too has made far better growth than have similar trees planted at the same time in a supposedly less exposed site in the nearby Stour valley.

Following this brief technical description of the establishment process, more attention is paid to financial events. Each year is taken in turn, expenditure and operations costs summarized, and developments noted*. For the sake of brevity, the extended four-year period of planting has been telescoped into two years.

* Movements in costs of annual operations are also shown in Fig. 5 (page 58).

FIRST TWO EFFECTIVE YEARS—OCTOBER 1946 TO SEPTEMBER 1948

Comment

By Sept. 30th, 1948—almost four years after the first plantings—the investment in the farm had reached £189 (£207 expenditure minus £18 revenue) an acre: £75 of this was the cost of trees and work put in on the new plantations.

Taking land at £70 an acre, the total cost of land, buildings and equipment at this stage was £132 an acre, 64 per cent. of the total investment.

93 acres had been planted up with 10,714 dessert apple trees: varieties, Cox, Worcester, Sunset and Fortune, mainly on M.II.

Average density of planting: 115 trees an acre. Five acres were interplanted with blackcurrants, and 5 acres with gooseberries.

28 acres had been planted up with 3,810 pear trees: varieties, Laxton's Superb, Conference, Williams' and Fertility, on Quince stock.

Average density of planting: 136 trees an acre.

10 acres of cherries had been planted also.

Arable cropping was continued on a 10 acre field and under 19 acres of trees, the main products being potatoes and wheat.

In the second year, the pears (the first to be planted) brought in £18 an acre—more than in any of the next three years.

Strawberry runners were the only other fruit crop to provide any income this year. Two-thirds of the revenue came from wheat and potatoes.

Financial Summary

	up to 1948 £
Expenditure per acre of land	
Land	70
Buildings	51
Machinery	11
Trees	30
Total, fixed assets	162
Manual labour	16
Materials: manures, mulches	6
spray materials and water	1
packing and other materials	3
fruit bushes, arable crop seeds	7
Services: fuel, machinery upkeep, contract work	6
Overheads: business expenses	6
Total, current expenditure	45
Total expenditure	207
Revenue per acre	
Arable crops	11
Top fruit	3
Other items	4
Total revenue	18
Investment per acre (expenditure minus revenue)	189

Operational Costs per Acre of Fruit*

	up to 1948 £
Operation	
Planting (including trees)	55
Gapping, re-tying	—
Pruning	1
Manuring	8
Spraying	1
Cultivations (or mowing)	8
Other work	—
Harvesting	—
Total operations	73
Overheads (share of)	6
Total	79
Yield (marketed bushels/acre)	—

* On 30 acres of apples and pears. Average 152 trees an acre.

Comment

Planting was an expensive process, because on part of the farm an explosion charge had to be used to break up a layer of flint, and also because more than 10 per cent. of the trees had to be replaced following the damage directly and indirectly caused by the very severe winter of 1946/7. The weather also interfered with the original planting: at one stage the planting gang left the farm, and could not be reconstituted afterwards.

Planting rate: 284 trees per 100 man-hours.
Cost of planting (overall): 1s. 7½d. a tree.
Total costs, other than planting, for the first two years averaged £12 an acre a year, one quarter being overheads.

Share of investment in form of:

Land and buildings	59 per cent.
Machinery	5 per cent.
Trees, cultivations and residue	36 per cent.

THIRD YEAR—OCTOBER 1948 TO SEPTEMBER 1949

Comment

In the third year, 1948/49, arable crops were restricted to 10 acres of open land. No more planting was done, but an expenditure of £2 an acre on replacement fruit bushes was necessary.

Total expenditure amounted to £36 an acre, half of it on labour. A further £4 an acre was spent on mechanical equipment and on providing the minimum covered space for machinery and stores.

Total revenue amounted to £19 an acre, still predominantly from arable crops. Some sales of the 1948 potato crop are included in this year's figures. The 121 acres of apples and pears produced £71. Fourteen acres of blackcurrants and gooseberries yielded a first crop valued at £642. The 2·5 acres of strawberries produced £241, mainly from sales of runners. Sales of top fruit were negligible.

The feature of this year was the amount of manual labour required. In no subsequent year in the establishment period was it higher. The high requirement was due to the work on the strawberry beds, the soft fruit plantation and the potato crop being superimposed upon additional work on the trees (largely mulching). Not till the arable and soft fruit crops had been taken out could the farm staff be stabilized.

Financial Summary

	for year £	up to 1949 £
Expenditure per acre of land		
Land	—	70
Buildings	1	52
Machinery	3	14
Trees	—	30
Total, fixed assets	4	166
Manual labour	18	34
Materials: manures, mulches	2	8
spray materials and water	1	2
packing and other materials	1	4
fruit bushes, arable crop seeds	2	9
Services: fuel, machinery upkeep, contract work	4	10
Overheads: business expenses	4	10
Total, current expenditure	32	77
Total expenditure	36	243
Revenue per acre		
Arable crops	9	20
Top fruit	1	4
Other items	9	13
Total revenue	19	37
Investment per acre (expenditure minus revenue)	17	206

Operational Costs per Acre of Fruit*

Operation	for year 1948-49 £	up to 1949 £
Planting (including trees)	—	55
Gapping, re-tying	1	1
Pruning	1	2
Manuring (including mulching)	4	12
Spraying	2	3
Cultivations (or mowing)	8	16
Other work	2	2
Harvesting	—	—
Total operations	18	91
Overheads (share of)	4	10
Total	22	101
Yield (marketed bushels/acre)	0·5	0·5

* On 102½ acres of apples and pears. Average 120 trees an acre.

Comment

Cost of operations this year at £18 an acre, or 3s. a tree was twice that for 1947/8. Cultivations were the biggest expense. Accumulated cost exceeded £100 an acre.

Share of investment in form of:

Land and buildings	50 per cent.
Machinery	6 per cent.
Trees, cultivations and residue	44 per cent.

FOURTH YEAR—OCTOBER 1949 TO SEPTEMBER 1950

Comment

The fourth year, 1949/50, followed closely the pattern of the third. Both expenditure and revenue were near their previous level. There was more planting-up, however. Two acres of apples (Bramley's and Sunset on M.II) replaced the fruiting strawberries, and 9½ acres of pears (Conference, Laxton's Superb, Beurré Hardy and Comice, all on Quince A) replaced the arable crops. (All 1,425 trees had been raised on the farm nursery, so there is no record of any purchase of trees.)

The rise in expenditure to £38 an acre was due to purchases of larger quantities of fertilizers and sprays on top of an undiminished labour requirement. Increasing use of these materials was due partly to the increasing size of the trees, partly to get more complete control of pests and diseases, and partly to offset the effect of grassing-down some of the orchards. Heavier fertilizing was backed up by mulching the recently grassed-down trees. Mechanical reliability was safeguarded by exchanging an old tractor for a newer one.

Revenue increased rather more than expenditure. Receipts from arable crops were much reduced but were offset by higher sales of apples, soft fruit and strawberry runners.

Sales of top fruit averaged £7 an acre, total revenue was £22 an acre.

Financial Summary

	for year £	up to 1950 £
Expenditure per acre		
Land	—	70
Buildings	3	55
Machinery	—	14
Trees	—	30
Total, fixed assets	3	169
Manual labour	18	52
Materials: manures, mulches	5	13
spray materials and water	1	3
packing and other materials	1	5
fruit bushes, seeds	2	11
Services: fuel, machinery upkeep, contract work	4	14
Overheads: business expenses	4	14
Total, current expenditure	35	112
Total expenditure	38	281
Revenue per acre		
Arable crops	1	21
Top fruit	7	11
Other items	15	28
Total revenue	23	60
Investment per acre (expenditure minus revenue)	15	221

Operational Costs per Acre of Fruit*

Operation	for year £	up to 1950 £
Planting (including trees)	—	55
Gapping, re-tying	—	1
Pruning	1	3
Manuring (including mulching)	6	18
Spraying	4	7
Cultivations (or mowing)	8	24
Other work	2	4
Harvesting	—	—
Total operations	21	112
Overheads (share of)	4	14
Total	25	126
Yield (marketed bushels/acre)	6·0	6·5

* On 102½ acres of apples and pears. Average 120 trees an acre.

Comment

Manuring and spraying costs were beginning to increase. Cultivation costs were maintained: cost of grass seed is included with cultivations.

Share of investment in form of:

Land and buildings	44 per cent.
Machinery	5 per cent.
Trees, cultivations and residue	51 per cent.

FIFTH YEAR—OCTOBER 1950 TO SEPTEMBER 1951

Comment

In 1950/51, the fifth year, the gap between expenditure and income opened up considerably: it was never so large again. All black-currants were grubbed this year. They had not developed well and the work on them conflicted with the work on the trees. There was no prospect that they were going to be profitable.

Expenditure per acre increased noticeably and also changed in character. Purchases of new machinery, including a higher-capacity spraying machine, cost £7 an acre. Cost of fertilizers and sprays increased to £9 an acre. On the other hand, labour cost fell by £6 an acre.

Revenue was light in the absence of sales of black currants, potatoes or wheat. Total revenue an acre was £14. Sales of top fruit averaged £9 an acre.

Financial Summary

	for year £	up to 1951 £
Expenditure per acre of land		
Land	—	70
Buildings	2	57
Machinery	7	21
Trees	—	30
Total, fixed assets	9	178
Manual labour	12	64
Materials: manures, mulches	7	20
spray materials and water	2	5
packing and other materials	2	7
fruit bushes, seeds	2	13
Services: fuel, machinery upkeep, contract work	16	30
Overheads: business expenses	4	18
Total, current expenditure	45	157
Total expenditure	54	335
Revenue per acre		
Arable crops	—	21
Top fruit	9	20
Other items	5	33
Total revenue	14	74
Investment per acre (expenditure minus revenue)	40	261

Operational Costs per Acre of Fruit*

Operation	for year £	up to 1951 £
Planting (including trees)	—	55
Gapping, re-tying	—	1
Pruning	1	4
Manuring (including mulching)	8	26
Spraying	6	13
Cultivations (or mowing)	7	31
Other work	2	6
Harvesting	1	1
Total operations	25	137
Overheads (share of)	4	18
Total	29	155
Yield (marketed bushels/acre)	8	14·5

* On 102½ acres of apples and pears. Average 120 trees an acre.

Comment

Aggregate costs exceeded £150 an acre. Annual costs £4 an acre higher: first significant harvesting cost; manuring and spraying costs 40 per cent. higher.

Share of investment in form of:

Land and buildings	38 per cent.
Machinery	6 per cent.
Trees, cultivations and residue	56 per cent.

SIXTH YEAR—OCTOBER 1951 TO SEPTEMBER 1952

Comment

In the following year, 1951/2—six years after planting—the farm came near to making a profit. Revenue and expenditure were equal. A further 1½ acres of Cox and Worcester were planted. A start was made with grubbing the gooseberries, the one-acre plantation in open ground being taken out.

Expenditure was reduced to £36 an acre. Less fertilizer was bought, but more was spent on all other materials. The big saving was in machinery purchases, there being no need to repeat the heavy investment of the previous year. Mowing equipment was provided at a cost of less than £1 10s. an acre.

For the first time there was considerable revenue from top fruit, averaging £29 an acre. Total revenue was £36 an acre.

Per acre of apples and pears, fruit revenue was £38 for the year.

Financial Summary

	for year £	up to 1952 £
Expenditure per acre of land		
Land	—	70
Buildings	—	57
Machinery	2	23
Trees	—	30
Total, fixed assets	2	180
Manual labour	14	78
Materials: manures, mulches	5	25
spray materials and water	3	8
packing and other materials	3	10
fruit bushes, seeds	—	13
Services: fuel, machinery upkeep, contract work	5	35
Overheads: business expenses	4	22
Total, current expenditure	34	191
Total expenditure	36	371
Revenue per acre		
Arable crops	1	22
Top fruit	29	49
Other items	6	39
Total revenue	36	110
Investment per acre (expenditure minus revenue)	—	261

Operational Costs Per Acre of Fruit*

Operation	for year £	up to 1952 £
Planting (including trees)	—	55
Gapping, re-tying	—	1
Pruning	2	6
Manuring (including mulching)	10	36
Spraying	6	19
Cultivations (or mowing)	6	37
Other work	2	8
Harvesting	2	3
Total operations	28	165
Overheads (share of)	4	22
Total	32	187
Yield (marketed bushels/acre)	28	42·5

* On 120 acres of apples and pears. Average 120 trees an acre.

Comment

Pruning and harvesting costs were doubled. Annual operations still cost less than £30 an acre—equivalent to 4s. 8d. a tree—but an increase of 50 per cent. in the last three years. A crop of 28 marketed bushels an acre more than paid for all operations and overheads on the orchards.

Share of investment in form of:

Land and buildings	34 per cent.
Machinery	6 per cent.
Trees, cultivations and residue	60 per cent.

SEVENTH YEAR—OCTOBER 1952 TO SEPTEMBER 1953

Comment

There was little change in the seventh year, 1952/3. Revenue and expenditure were again equal, on the same level as in 1951/2. The 3·8 acres taken out of soft fruit was planted up with dessert apples. (Cox and Worcester on M.II, M.XVI and Crab C.) Gooseberry bushes interplanted on 5 acres were grubbed up.

Chief item in a somewhat greater investment programme was a new medium-powered tractor. The cost of manual labour was reduced as a result. More phosphate and potash were applied than in previous years.

Fruit sales averaged £35 an acre.
Total revenue was £37 an acre.

Financial Summary

	for year £	up to 1953 £
Expenditure per acre of land		
Land	—	70
Buildings	—	57
Machinery	3	26
Trees	1	31
Total, fixed assets	4	184
Manual labour	12	90
Materials: manures, mulches	7	32
spray materials and water	2	10
packing and other materials	4	14
fruit bushes, seeds	—	13
Services: fuel, machinery upkeep, contract work	4	39
Overheads: business expenses	4	26
Total, current expenditure	33	224
Total expenditure	37	408
Revenue per acre		
Arable crops	1	23
Top fruit	35	84
Other items	1	40
Total revenue	37	147
Investment per acre (expenditure minus revenue)	—	261

Operational Costs Per Acre of Fruit*

Operation	for year £	up to 1953 £
Planting (including trees)	—	55
Gapping, re-tying	—	1
Pruning	1	7
Manuring (including mulching)	11	47
Spraying	6	25
Cultivations (or mowing)	5	42
Other work	1	9
Harvesting	2	5
Total operations	26	191
Overheads (share of)	4	26
Total	30	217
Yield (marketed bushels/acre)	34	76·5

* On 123½ acres of apples and pears. Average 120 trees an acre.

Comment

Total costs were kept down below those of the previous year: there being less ancillary work. Accumulated costs exceeded £200 an acre.

This year the sales of fruit exceeded *costs*, but not all expenditure. The crop of 34 marketed bushels an acre, selling at an average of 24s. 9d. a bushel net home, left a surplus of £5 an acre.

Share of investment in form of:

Land and buildings	31 per cent.
Machinery	7 per cent.
Trees, cultivations and residue	62 per cent.

EIGHTH YEAR—OCTOBER 1953 TO SEPTEMBER 1954

Comment

In the eighth year, 1953/4, the farm moved away from, and not nearer to its first profit. The fruit crop was disappointing, due to a wet harvest, and the equipment of the farm had to be substantially reinforced and improved in order to cope with the increased amount of work on the trees. The orchards were now in their finished state—98 acres of apples, 37 acres of pears and 10 acres of cherries.

Expenditure was at the rate of £53 an acre. £12 of this went in re-equipment: two old tractors were exchanged for two new diesel models; the two tank sprayers were replaced by one low-volume machine, and a pallet loader and a tipper trailer were bought to help handle the crop in the orchard, The previous rate of expenditure on fertilizers was maintained and the introduction of Captan in place of colloidal sulphur noticeably added to the cost of spray materials. Scab had built up during the 1953 season; colloidal sulphur did not control it, and mercury eradicants which had been tried late in the season had seriously affected fruit quality.

Revenue this year was not up to expectation. There was a good set of fruit but the crop did not grow out well and was of poor quality. Fruit sales fell back to £33 an acre, making £117 to date. Revenue from all sources averaged £38 an acre.

Financial Summary

	for year £	up to 1954 £
Expenditure per acre of land		
Land	—	70
Buildings	3	60
Machinery	12	38
Trees	—	31
Total, fixed assets	15	199
Manual labour	14	104
Materials: manures, mulches	6	38
spray materials and water	4	14
packing and other materials	4	18
fruit bushes, seeds	1	14
Services: fuel, machinery upkeep, contract work	4	43
Overheads: business expenses	5	31
Total, current expenditure	38	262
Total expenditure	53	461
Revenue per acre		
Arable crops	—	23
Top fruit	33	117
Other items	5	45
Total revenue	38	185
Investment per acre (expenditure minus revenue)	15	276

Operational Costs Per Acre of Fruit*

Operation	for year £	up to 1954 £
Planting (including trees)	—	55
Gapping, re-tying	—	1
Pruning	3	10
Manuring (including mulching)	9	56
Spraying	9	34
Cultivations (or mowing)	5	47
Other work	3	12
Harvesting	2	7
Total operations	31	222
Overheads (share of)	5	31
Total	36	253
Yield (marketed bushels/acre)	43	119·5

* On 124 acres of apples and pears. Average 120 trees an acre.

Comment

This year the trees made good growth, and both pruning and spraying costs were definitely higher from this time onwards. Manuring had become the most costly operation at this stage (£56 in aggregate).

The yield increased slightly, but a lower price per bushel depleted revenue per acre. Revenue from fruit was about equivalent to costs.

Share of investment in form of:

Land and buildings	28 per cent.
Machinery	8 per cent.
Trees, cultivations and residue	64 per cent.

NINTH YEAR—OCTOBER 1954 TO SEPTEMBER 1955

Comment

It was in this, the ninth year after planting, that the revenue on the whole farm exceeded the expenditure by a considerable margin.

Five acres of Williams' pears were taken out in the winter of 1954/55 and the land fallowed. Not all trees had been double-worked, and some stocks were unsuitable.

In spite of having a much bigger crop to harvest than previously, expenditure remained steady. Thus the crop was grown and harvested with less hours of labour than in any year since 1948. More was spent on materials than previously but there was no need to augment the machinery bought in the previous year. The only change in the mechanical inventory was an exchange of gang mowers. Additional nitrogen was provided on the bearing crops. Epsom salts was applied all round to overcome the magnesium deficiency which was becoming apparent in places. Greater use of Captan (amply justified by results) increased the cost of spray materials.

Exclusive of interest, total expenditure at this point was greater than revenue by £246 an acre.

A 71-bushel crop gave a revenue of £81 an acre: accumulated revenue was now £198 an acre.

Total revenue per acre amounted to £83, which left a surplus of £30 an acre over the year's expenditure and of £43 over the year's cost.

Financial Summary

	for year £	up to 1955 £
Expenditure per acre of land		
Land	—	70
Buildings	4	64
Machinery	2	40
Trees	1	32
Total, fixed assets	7	206
Manual labour	12	116
Materials: manures, mulches	7	45
spray materials and water	8	22
packing and other materials	8	26
fruit bushes, seeds	—	14
Services: fuel, machinery upkeep, contract work	6	49
Overheads: business expenses	5	36
Total, current expenditure	46	308
Total expenditure	53	514
Revenue per acre		
Arable crops	—	23
Top fruit	81	198
Other items	2	47
Total revenue	83	268
Investment per acre (expenditure minus revenue)	30	246

Operational Costs Per Acre of Fruit*

Operation	for year £	up to 1955 £
Planting (including trees)	—	55
Gapping, re-tying	—	1
Pruning	3	13
Manuring (including mulching)	10	66
Spraying	12	46
Cultivations (or mowing)	5	52
Other work	2	14
Harvesting	3	10
Total operations	35	257
Overheads (share of)	5	36
Total	40	293
Yield (marketed bushels/acre)	71	190·5

* On 119 acres of apples and pears. Average 120 trees an acre.

Comment

Increases in costs of spraying, manuring and harvesting occurred this year, but total costs were only £40 an acre. Accumulated cost was £293 an acre.

Excluding planting, three operations—manuring, cultivations and spraying (in that order)—accounted for 80 per cent. of all operational costs.

Accumulated yield was 190·5 bushels an acre.

Share of investment in form of:

Land and buildings	26 per cent.
Machinery	8 per cent.
Trees, cultivations and residue	66 per cent.

Summary

The difference between the amount of money spent and the amount of money received on the farm until the venture was self-financing for the first time, was £326 an acre. This is derived as follows:—

	£
Accrued deficit to October 1954	276
Expenditure, other than harvesting, in 1955	50
Total	326

This rate of investment provided for purchase of land, provision of farm cottages and buildings, preparing the land for fruit growing, and allowed for raising, planting and looking after the trees for almost nine years. A charge for interest on either borrowed or private capital has not been included so far; neither has any provision been made for capital expenditure on marketing the fruit.

Two-fifths (£206 an acre) of all expenditure in the first nine years was on items of a capital nature. This sum was roughly equally divided between land, buildings, and machinery and trees. Three-fifths (a gross £308 an acre) was spent on current items like labour, materials, use of equipment and overhead costs in bringing the trees up to the point of economic establishment. If all revenue be credited against this current expenditure, the net sum remaining is £123 an acre. It is worth noting that in this case only three quarters of the revenue was from sales of apples and pears; arable and other fruit crops provided the remainder.

A more natural distinction to the fruit grower is between the trees and the other assets. On this basis, one third of all expenditure was on land, buildings and machinery, and two-thirds on trees and operating expenses.

Investment per tree and per acre at economic establishment are re-stated below:—

	Investment (expenditure—revenue) per tree (120/acre)	per statute acre.
	£ s. d.	£
(1) All items included	2 14 4	326
(2) Machinery, trees and operating expenses	1 12 0	192
(3) Trees and operating expenses ..	1 5 10	155

Looking back over the nine years it is clear that large-scale working and good management gave reasonable economy of operation. When the M.II trees were nine years old and had an

average span of 10 ft., total annual costs were only £40 an acre. The harvesting figures in that year—9d. a bushel—are a great tribute to mechanical handling.

The outlays on land, buildings and machinery, although heavy in themselves, were by no means excessive, and there is no wasted accommodation. It is worth noting too, that the capital expenditure shown has equipped the farm to carry on for several more years without big additional expense. The number of mowers, sprayers and tractors is adequate to work bigger trees, though more trailers may be needed when crops increase.

In other words, the cost shown is not the bare cost of bringing the orchards into bearing: it also contains a useful reserve for future economic working.

Once the land, buildings and some initial equipment have been provided, a modern fruit plantation can be brought into bearing for moderate cost if it is not encumbered with ancillary crops, and normal cropping is not upset by late frosts. As its fruiting head develops, the tree's demands for labour and materials increase, but it is possible to manage nowadays with a much smaller staff than was possible ten years ago. This improvement has made it now worthwhile to plan on the man-unit basis.

Automatic low-volume spraying has much reduced the peak demand for labour and if hire purchase of machinery is resorted to, a share of the machine cost can be passed on to later crops.

Economy in establishment is treated at greater length towards the end of the report, but for the present it may be said that a full-time man, if provided with labour-saving machinery, can bring up to 20 acres of young trees (according to spacing) on to the sixth or seventh year. Some individuals have been known to cope with the cultural operations on more than 20 acres for the first nine years. Where a team of workers is available, the area can be raised to 25 acres per regular man excluding picking. The limiting factor is pruning. If there is part-time help available in the winter, one man will cope with the spring and summer operations quite well on his own, and the proprietor will not have to spend on machinery any more than he would have had to spend on the labour the machinery replaces.

Interest charges.—It has already been stated that in most circumstances many operational costs will be higher than those recorded, and the accrued investment per acre will be higher, too, unless a more clement site induces heavier early cropping. Smaller-scale working must often mean greater attention to individual trees and consequently higher costs per acre. Also, there will usually be interest charges on borrowed capital to be met.

The cost of borrowing money for a nine-year period looms so large that it cannot be passed by. Were the fruit farm concerned to have been entirely financed on capital borrowed at 5 per cent. interest, the interest on the additional working capital needed each year plus the accrued interest on the money already invested, would, in nine years have added up to a sum of £111 an acre, which is more than the initial cost of the land and trees, and is equal to a surcharge of 34 per cent. on all other costs.

It is not over-representing the situation, therefore, to say that in addition to the £326 an acre previously calculated, additional payments of up to £55 an acre can also be involved where half the capital is borrowed. That is, at its maximum point the book-investment in a newly-established fruit farm could well be £381 an acre irrespective of the loss of any interest payments on the private half of the capital, which a grower surrenders when he sinks personal capital in the business. All told, the true measure of the peak investment in this new fruit farm was £437 an acre towards the end of the ninth year, with more to come.

CHAPTER II

MEASURING THE COST OF ESTABLISHMENT

What is "establishment"?

THERE will be different views about what constitutes orchard establishment.

The pomologist might say an orchard is established when the fruit tree is seen to be growing away, developing a shapely head and showing promise of filling up the space in the orchard. It is clear to him that at this stage in the life of the tree the natural hazards of establishment have been overcome. The orchard is then established physically.

The investor or financier-turned-fruit-grower might think the term appropriate when his accounts show him that his venture has succeeded financially. When there is a good prospect that the book losses, which have been accumulating for the first seven years, are about to be recouped, he will think of the orchards as having developed into a saleable asset. At this stage in the orchard's life the investment hazards have been successfully overcome.

The commercial fruit-grower, on the other hand, particularly if he started from scratch, is likely to take a different point of view from the pomologist or the investor. He may agree that a third concept of establishment is possible—the one now followed out and called economic establishment. The general line of argument is this: the investment aspect is important, but if the orchards are to provide a living and not lump sum augmentation of personal capital, then the income aspect is most important. When will the orchard make a profit, and how big will the first annual profit be? The size, and rate of advance of the annual profits in the early years are all-important.

There is a change of feeling on a new fruit farm when the orchards come into profit. The first profitable crop is certainly a milestone which all new fruit growers are glad to reach. It does not follow, however, that after the first profitable crop the grower has nothing else to worry about. A closely-planted orchard will often show a profit in the fourth or fifth year if there is a good season; but a grower will not be misled at this stage into thinking that the next

year's crop will be equally, or more profitable. He will be mentally prepared to go on putting more capital into his business for a few years to come.

The first annual profit on a fruit farm, if it comes early, is generally small and is insufficient to finance production of the following year's crop. In these circumstances more working capital has to be provided and it is not forthcoming from within the business: consequently the farm business cannot be considered established or self-financing.

In the economic sense, therefore, a new orchard can be said to be established as a business when there is no longer any need for additional working capital from outside the business to maintain the trees. Whatever the subsequent history of the farm—whether it expands, acquires a packing shed and other installations—there is a time when the farm in its original state carries (a) orchards old enough to be self-financing (b) enough equipment for working the farm economically. When this state has been reached the venture is established economically, and the grower can mentally sit back and plan the next capital developments.

The time to establishment and the cost of establishment will in many cases be measured at the point of maximum investment (expenditure minus revenue). In all cases, however, whether the accrued investment is high or low, establishment will be determined by the year's profit, and for most practical purposes the need for additional capital for the trees will cease when the profit on one year's crop is more than sufficient to finance the following year's crop. This is the definition of establishment adopted in this report. It can be demonstrated by referring to the figures for the case study described in Chapter I.

By the end of the eighth year after planting, investment had reached £276 an acre. Expenditure in the ninth year was £50 an acre up to the time of harvesting, and thereafter revenue started coming in and reducing the accumulated deficit. The point of maximum investment was reached in the ninth year, just prior to harvesting and the magnitude of the investment was then £326 an acre. Revenue in the ninth year, £83 an acre, was within a small margin, sufficient to pay for both the current and ensuing crops.*

Capital may still be needed after economic establishment as defined above—and for the same purpose in the event of, say, a crop failure—but the need will be for short-term borrowing as distinct from the original longer-term borrowing. On the farm taken as

* The margin of £30 an acre over the year's expenditure of £53 is available to meet anticipated expenses (without further capital expenditure) of £37 an acre before the ensuing harvest.

example two crop failures in succession in the 11th and 12th years lifted the investment in the farm by some £18 an acre.

It must be emphasized that the capital required for establishment is not a good guide to the total investment ultimately required. As hinted earlier, once or even before the establishment phase is over, a secondary investment cycle begins, because efficient means of handling full crops have to be provided, and many fruit farms run for twenty years or more before all indebtedness is overcome. A crop failure in one year can delay for two or three years the progress in paying-off business creditors.

What is "cost" ?

There will also be different interpretations of the term "cost". In applied economics, "cost" differs from "expenditure". If £100 has been spent in any year on any item, and £50 worth of it remains at the end of the year, "expenditure" would be recorded as £100 and "cost" as £50. Cost is thus the money measure of loss of value in a given time. In a strict sense, therefore, the cost of establishing a fruit farm is the total expenditure up to the point of establishment minus the value of fixed and current assets either created or only partially used up at that point. A farm and its buildings, once purchased, can sustain several successive plantings of fruit trees. Land and buildings remain in the accounts at their original value (purchase price): their costs, to the owner-occupier, are the fencing and draining to keep the land productive, and the repairs to keep the buildings in good condition. In this sense, the purchase price of land and buildings is no part of the cost of establishing an orchard.

That, however, is not as the new grower sees it: land, buildings, trees, machinery, even sundries, all cost something. In buying them he adds to the amount of money sunk in his business. His concern —how much money he needs to have—is more properly defined as "net expenditure", or the difference between expenditure and revenue, expenditure being always the greater. This concept of cost, having more practical bearing than the precise concept, has been followed out in this report, but it is usually called "investment" or "net expenditure", unless it is combined in the easy phrase "cost of establishment".

The "normal" cost of establishment

The example in Chapter I gave actual costs of establishing a *fruit farm* in one particular case. It would be wrong to argue from the particular to the general, and to say that a majority of new

fruit growers will incur costs similar to those given, without first testing whether or not this is likely to be true.

As will be shown later, the cost per acre depends partly upon the number of trees planted to the acre, but at any one density of planting, the factor most likely to lead to early establishment is a quickly-developing yield. The costs previously given will be out of line if, for the same density of planting, the yields on the example farm were lower than those realized on many farms elsewhere. This is in fact the case: the crops in the first eight years averaged less than a bushel a tree, which is about half the normal expectation from trees set out at 18 ft. square.

Yields.—In order to find out what average initial yields of dessert apples were, the Department asked a number of growers in Kent known to have planted-out dessert apples since 1945 to supply records of yields (in picked bushels) from these trees in the first ten years. Figures covering 29 plantations on 22 farms were obtained in this way. On average, these farms had planted trees at the rate of 136 to the acre. About half the farms had records covering only the first eight years: but from these figures a yield *per tree* for the first eight years was obtained.* This compares with the yield on the example farm as follows:—

COMPARATIVE INITIAL YIELDS (lbs. a tree)

Years after planting	3	4	5	6	7	8	Total	
Example farm (120 trees an acre)	—	—	2·7	9·5	11·3	14·4	37·9	(marketed)
Average, 29 plantations (136 trees an acre)	—	2·9	9·0	14·8	32·1	28·4	87·2	(picked)

To average the results from 29 plantations planted in different years has the effect of smoothing out the year-to-year fluctuation in yield on individual farms. A grower would be fortunate indeed to get so regular a rate of growth in yield as this average. The check in the eighth year adds a touch of realism to the figures.

Many growers, it seems, may expect to pick about 2 bushels a tree in total in the first eight seasons, and to have a yield of four-fifths of a bushel a tree once during that period. This is the size of crop that will establish the farm commercially. On the farm in question, the accumulated marketed yield was relatively low and the highest yield in any pre-establishment year was 14·4 lbs. a tree, though one block of trees reached a figure of 24 lbs. a tree. This tardiness in cropping has the effect of increasing the time taken for

* See also Fig. 4 (page 57).

economic establishment and also, to a lesser extent, the cost of establishment.

Prices, as well as yields, must be reviewed in any attempt to arrive at normality. With marketing costs taken off, the average price per bushel on the farm in question for a crop consisting of 62-68 per cent. Cox's, was:

in 1952, 26s. 0d. in 1954, 19s. 2d.
in 1953, 25s. 0d. in 1955, 28s. 6d.

—making an average of 24s. 8d. a bushel. This is higher than the figure of 24s. 2d. calculated from the prices received on the Department's costed farms.

Costs.—Thirdly, the operational costs on the example farm may need modifying. The typical new fruit farm would be smaller than the example, and working costs per acre would tend to be higher. The Department has again drawn on its resources of accounting material to provide an estimate of average operational costs on young trees on smaller acreages. Average annual costs,* excluding overheads, on four farms establishing between 10 and 40 acres of fruit were 7 per cent. higher than in the example, as follows:—

OPERATIONAL COSTS, YEARS 3 TO 7 (£ an acre)

Year after planting	3	4	5	6	7	Total
Example farm	18	21	25	28	26	118
Average, 4 farms	18	21	23	30	34	126

Most of the £8 an acre excess was the cost of harvesting bigger crops: the higher number of trees to the acre made very little difference. Overhead costs were significantly higher, indicating that general business expenses would be a higher proportion of total expenditure than on the example farm. In each case, only the costs *on the orchards* have been taken account of.

The three factors of yield, price and cost per acre appropriate to a more normal case of establishment are assembled in the following table, operational cost being now converted to a related expenditure per acre.

After making this calculation it becomes evident that higher yields in years 5-7 will effectively reduce the period prior to establishment, but that in the absence of arable or soft fruit crops the peak capital requirement will be very little altered. Without the £70 an

* *Costs* have been used for comparison at this stage because the *expenditure* totals on the example farm include purchases of fruit bushes, and the like. For the same reason, costs for the first and second years have not been included.

TABLE 1

COMPUTED EXPENDITURE AND REVENUE FOR THE FIRST EIGHT YEARS ON A MODERN 40-ACRE FRUIT FARM
(136 trees an acre: no intercropping)

Year after planting	1 & 2	3	4	5	6	7	8	Total
				£ per acre				
Expenditure	206	40	42	44	42	51	74	499
Revenue	1	4	11	33	58	115	80	302
Net expenditure	205	241	272	283	267	203	197	197
Yield of fruit (bushels marketed per acre)	—	—	9	27	45	98	86	256

acre from arable and soft fruit crops realized on the example farm, the investment will build up to £320 an acre* by harvest time in the sixth year. £375 an acre (£320+£55 interest paid away) may therefore be considered a maximum capital requirement by the prudent intending fruit grower.

By the time of economic establishment the investment will have been reduced. The new figures comparable to those given in Chapter I are as follows:—

INVESTMENT (EXPENDITURE—REVENUE) AT ECONOMIC ESTABLISHMENT

	PER TREE (136/acre.) (excluding interest) £ s. d.	PER STATUTE ACRE (excluding interest) £	PER STATUTE ACRE (including interest at 5% a year on half the capital) £
(1) All items included	2 4 5	302	345
(2) Machinery, trees and operating expenses	1 6 10	182	—
(3) Trees and operating expenses (i.e. no capital items other than trees)	1 0 2	137	—

* Obtained as follows:—

	£
Net expenditure to end of fifth year	283
Expenditure in sixth year up to harvest (£42—£5)	37
	320

CHAPTER III

ECONOMY IN ESTABLISHMENT

IF £326 an acre, as given on page 20, was the customary cost of new orchards, the 55,000 acres of apples and pears planted out in Britain since 1944 would represent an investment of nearly £18 million merely to get started in fruit-growing. Fortunately, this is not the case, but the figure quoted has some value if all it does is to make growers study to see how it can be reduced.

Broadly speaking, there are three ways in which a grower might plan to reduce net expenditure on new orchards. These are:—

(*a*) by extending his present orchard area,

(*b*) by judicious intercropping,

(*c*) by planting widely.

Extending the orchard area

The established fruitgrower who can expand by planting-up suitable land on his own farm is obviously spared the expenditure on additional land, on machinery, business overheads and perhaps buildings. The established grower who acquires land close to his present farm and works it with the same equipment and from the same office is saved expenditure on new equipment and business overheads. Moreover, if in these circumstances the newly planted area is a relatively small part of the whole orchard area, and the additional expenditure can be used to reduce taxable profits on the bearing orchards, new orchards need not be a drain on a grower's private means.

Potential savings in expanding fruit-growing businesses by extending the area of orchards on farms already equipped for fruit growing (apart from any tax-saving effect) may be gauged from the figures in Chapter I. For if the cost-of-establishment procedure is repeated, using operational costs instead of expenditure, and revenue from fruit instead of all revenue, the margin between accumulated costs and accumulated revenue, at the time of establishment, is £164—half the sum required to establish the orchards on a new fruit farm.

This is worked out as follows:—

	£	
Costs accumulated to end of eighth year	253	*an acre
add costs in ninth year up to harvesting	37	
Accumulated cost at time of establishment ..	290	
subtract revenue *per acre in fruit* up to end of eighth year	126	
Difference, being net cost	164	

Moreover, if the extension of an orchard can be carried out without recourse to borrowing, compared to planting on a new farm and borrowing half the capital required, the *savings* in requirement of ready capital to the farmer concerned could amount to £219 (£164 plus £55 interest) an acre.†

Savings on this scale, of course, will be realized in only two kinds of circumstances:

(*a*) where the work on the extension is within the capacity of the existing labour and machinery, and

(*b*) where the extension fully occupies additional labour and machinery brought in to handle it.

On the other hand, if a few more acres leads to full utilization of labour and machinery on the farm, the only additional costs are

TABLE 2

NET COSTS (OPERATIONAL COST MINUS REVENUE) OF ESTABLISHING NEW ORCHARDS ON EXISTING FRUIT FARMS

Case no.	Details	Cost per acre and age of trees at 31st October 1957
1.	Pears, 5 acres. 171 trees/acre.	£90 at 3 years.
2.	Culinary apples, 4 acres. 86 trees/acre.	£110 at 4 years.
3.	Dessert apples, 36 acres. 134 trees/acre.	£164 at 7 years.
4.	Apples and pears, 23 acres. 142 trees/acre.	£182 at 7 years.
5.	Dessert apples, 8 acres. 150 trees/acre.	£295 at 7 years.
6.	Pears, 3 acres. 96 trees/acre.	£151 at 8 years.

* Overheads, which should not be included, have been replaced by a rent charge, which should be included, of £4 an acre, leaving the sum unchanged at £36 for the whole period.

†A practical point. Not all local Inspectors of Taxes may agree that extensions distant from the original orchards are in fact part of the same fruit farm.

Contrasts in fruit tree spacing: in the foreground, permanent Cox's Orange on M.II at 25½ ft. square: in the background the same plant with one M.VII filler per permanent tree, 13 years after planting.

Photos: East Malling Research Station

Extremes in spacing: Cox's Orange on M.II, age 13 years, planted at 25½ ft. square.

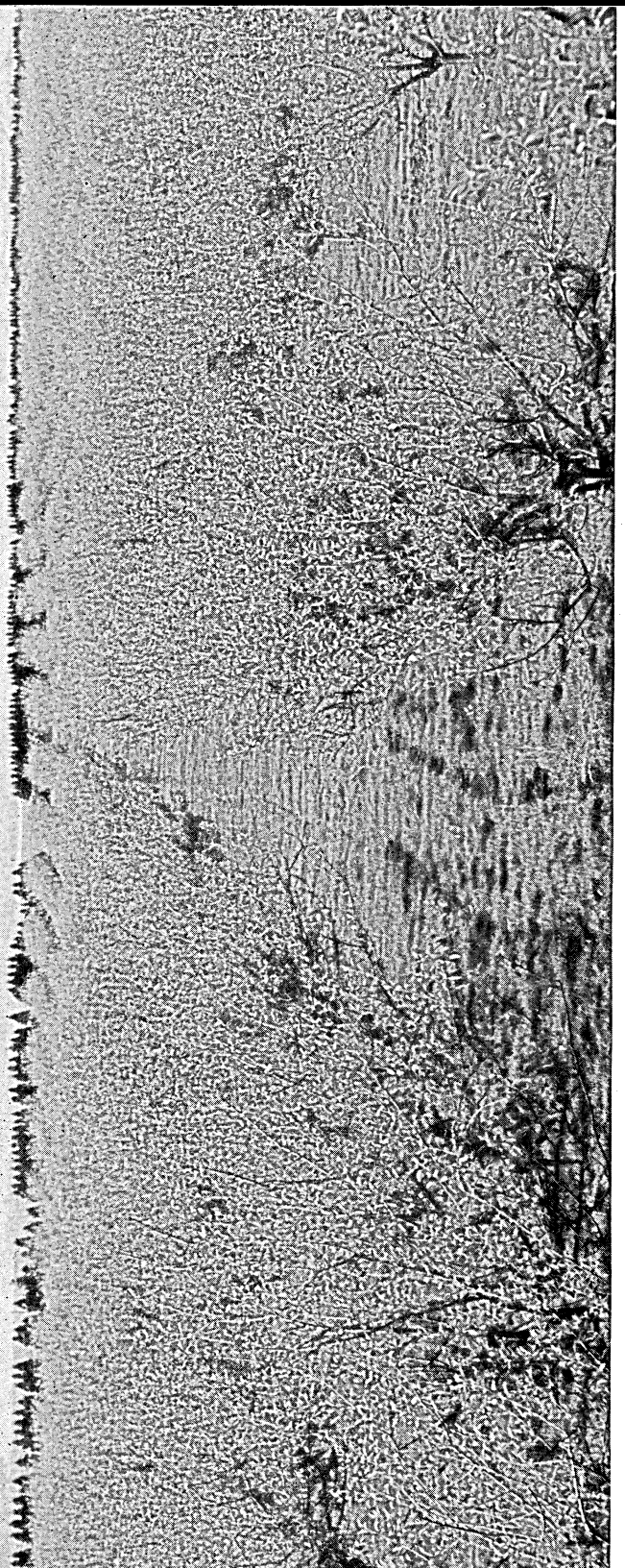


Photo: East Malling Research Station

A general view of the experimental plots.

for materials, costing about £100 an acre over the period. These computed savings are confirmed by the Department's cost account data. Extension planting on six farms has been costed for varying lengths of time, with results as shown in Table 2. When overheads* other than rent were excluded, the investment per acre was in most cases below £200 an acre by the end of the seventh year.

Intercropping

The pros and cons of interplanting are often hotly debated as a husbandry question. Pears undercropped with blackcurrants has been a favourite recommendation, and where the pears have been slow to come into bearing the currants have recently been a boon to the grower. When the price was £70 a ton, however, the revenue from blackcurrants was little in advance of that from pears: as an undercrop they failed to provide the early profits expected of them. At £200 a ton, of course, the revenue situation is transformed.

The Department has little systematic knowledge of the net financial effect of an undercrop, but from experience with a number of cases where it has been tried it appears that:—

(*a*) assuming normal prices, any soft fruit crop interplanted cannot be relied upon to provide significant profits in the first *two or three* years.

(*b*) in the first few years, surplus labour is well employed on an undercrop if there is not enough land to keep the labour engaged on orchard crops.

(*c*) with the above in mind, a new grower should not plant fruit trees widely for the sake of an intercrop: apart from other considerations, wide planting will prolong the time to establishment.

(*d*) close planting of trees will have the same effect as an intercrop.

(*e*) a soft fruit (or a small arable) plot in conjunction with a young orchard is more likely to be beneficial than an intercrop even if trees subsequently occupy this area.

(*f*) three types of annual crop—cereals, roots and vegetables—can profitably be shown as an intercrop in districts where they are widely cultivated, provided spacings allow. To avoid competition with the trees' roots, however, the width of row will be contracted each year, and after a third or fourth year may become too narrow to be profitable. Some

* Business overheads were levied on bearing orchards only.

soft fruit crops persist too long, and the rate of repayment on them has been too slow for them to have reduced very greatly either the time or cost of establishment.

(*g*) the value of an undercrop depends upon the relation between available labour, density of planting of trees and available land. In the extreme case of a small farm in a market gardening district, which had to be fully planted to provide a reasonable size of business, intercropping might be a necessity. Until the trees come in to full bearing the intercrop would be the grower's mainstay.

Planting widely

Whether or not planting widely will produce the economy the grower is seeking, depends upon whether he is seeking economy of capital or economy of time. Wide planting will save him money, but it will keep him longer in debt. When this question of tree spacing is looked into, it is seen to be somewhat complicated, and has been given a chapter to itself. The differences resulting from wide (some critics say over-wide!) planting and close planting revealed in Chapter IV are sufficiently striking to provoke attempts to discover what is the best policy in planting if, say, only a limited amount of capital is available or, again, what policy will lead to quickest recoupment of capital.

Within limits a widely-spaced orchard can be established with less expenditure an acre than a closely-planted orchard. Ultimately, the size of a grower's business depends upon the number of permanent trees he has, and the same size of business can be developed on a given acreage irrespective of the number of trees originally planted: but at wide spacings the business will be slower to develop. Wide spacing, therefore, is not suitable for the new grower who is going to specialize in top fruit. It is, however, an insurance against poor yields, in the sense that, if revenue fails, the deficit will be lower than otherwise. Between the ages of 4 and 7 years about 16s. is spent on maintaining a fruit tree and if there is no return, some £44 an acre may be saved by planting at say, 20 ft. square instead of 16 ft. square: but this is not a constructive basis for planning.

The case for wide planting in pursuit of economy rests upon the results from the three ten-acre experimental plots referred to in the Introduction. These results show that, for any given yield per tree, the net expenditure *per acre* in the first nine years was less where there were 68 trees to the acre than where there were 136

trees or 258 trees to the acre. This is demonstrated in Table 10 and also in Figure 1 (both in the appendix).

In practical terms, to plant only permanent trees economizes on capital (but entails forgoing profits) in establishing orchards. It is probable that a spacing of 25½ ft. square is near the limit for which this principle holds good.

CHAPTER IV

SOME PRINCIPLES OF ORCHARD ESTABLISHMENT

IT was hinted at the end of the previous chapter that a variable planting distance introduces an element of fluidity and control into the cost of establishing new orchards. Extremes in spacing, and compromises in spacing, all have something in their favour.

A first question for the grower to resolve is whether or not to minimize the actual *cost* of the establishment process. It will probably be the better plan in most cases to concentrate on reasonably quick development of the business, giving an annual profit after five or six years, and to invest (perhaps by borrowing) a little more per acre in order to do so. In practice, this may mean curtailing for a start the acreage of orchard originally intended. Too great economy in costs will lose more in profits in the first five years of bearing than it will save in the non-bearing period.

Whether or not quick establishment is a long-term advantage as well as a short-term advantage and should be pursued for its own sake remains to be seen: this point cannot be fully developed in this report, because the after-effects of grubbing on the remaining trees cannot be anticipated. Not until the experimental plots referred to in the Introduction are in their final form, each carrying only 676 permanent trees, will the full Profit and Loss Account for the different original spacings be available.

As a practical issue it is becoming apparent, from a general acquaintance with financial results of orchard practice, that pruning systems have a great bearing upon yields in middle life. There are doubts as to whether the tree which is largely left alone to come into fuller cropping earlier in its life, will be as prolific in later life as a tree which has been consistently harder pruned. On this score alone it would seem to be good policy to have in a new orchard a number of temporary trees lightly pruned to provide revenue in the early years, and a number of permanent trees pruned with future bearing rather than present bearing in view.

The economics of filler trees

Continuing the economic approach, the effect of different spacings on the cost of establishment can now be demonstrated. To this end,

the experimental results have been adapted where necessary so as to apply more closely to the medium-sized orchard in a favourable topographical situation.

The underlying situation is this: as more trees are planted to the acre, the higher will be costs *per acre* but the lower will be costs *per tree*: revenue per tree being virtually a constant in the pre-establishment period, the lower costs mean higher average margins per tree as the number of trees to the acre is increased. With labour and apples at their 1955/6 price, a spacing of 120 trees an acre led to revenue exceeding cost in the ninth year: at a spacing of 258 trees an acre this situation was reached in six years. Revenue from the filler trees exceeded their costs, and they began making annual profits in their fourth season (see Table 10, p. 52 and Figs. 1 and 2, pp. 55-56).

The analysis on which these conclusions are based is set out below. The extent and nature of additional costs and additional revenue on plantations carrying filler trees are examined. Thereafter, working with average costs and revenues, the relationship between time, cost and density of planting is more fully explored.

Table 3 shows how a close plant of trees, incorporating fillers, disposed towards earlier profits.

TABLE 3

YEARLY MARGIN PER ACRE, YEARS 3 TO 9, ON THREE APPLE PLANTATIONS HAVING DIFFERENT TREE SPACINGS.

	PLOT A	PLOT B	PLOT C
	10 acres. 68 trees an acre.	10 acres. 130 trees an acre.	10 acres. 258 trees an acre.
	£	£	£
Year 3	−13·6	−18·6	−28·9
Year 4	−10·7	−15·9	− 6·7
Year 5	−18·3	−18·4	− 8·2
Year 6	−23·6	−21·2	+19·6
Year 7	− 1·1	+25·2	+50·2
Year 8	− 7·6	+ 0·4	+ 27·1
Year 9	+18·8	+89·9	+175·7

Where filler trees are planted, the operating costs an acre are bound to increase, because more time will be spent on tying, pruning and mulching the larger number of trees: in addition, some general cultivations (e.g. hoeing, manuring) will take longer. Only in the case of planting, and, perhaps, staking and tying, however, does the cost increase in the same proportion as the number of trees per acre—twice the cost for twice the number of

trees. Filler trees are given little pruning, and help to reduce walking time between permanent trees: to spray them, when the team and the tackle have to pass alongside anyway, costs, in the first few years, only a little more for water and chemicals. In short, the *additional* costs of keeping a young filler tree are less than the costs of keeping a young permanent tree.

How this worked out in practice on the experimental plots can be seen in Table 4. Plot C had almost four times as many trees as Plot A, but the four major operations listed cost only 18s. 11d. a tree on Plot C as against 40s. 7d. on Plot A; costs per tree on Plot B, having twice the number of trees were, to a less degree, lower at 28s. 7d.

TABLE 4

OPERATIONAL COSTS, YEARS 1 TO 9 INCLUSIVE, ACCORDING TO DENSITY OF PLANTING

	PLOT A				PLOT B				PLOT C			
	10 acs. 68 trees/ac.				10 acs. 130 trees/ac.				10 acs. 258 trees/ac.			
	Cost per acre		Cost per tree		Cost per acre		Cost per tree		Cost per acre		Cost per tree	
	£	s.	s.	d.	£	s.	s.	d.	£	s.	s.	d.
Pruning	5	9	1	7	13	15	2	1	16	3	1	3
Manuring and mulching	51	8	15	3	68	14	10	7	79	4	6	2
Cultivations	47	6	14	0	49	13	7	8	78	9	6	1
Spraying	33	2	9	9	53	16	8	3	70	1	5	5
Total	137	5	40	7	185	18	28	7	243	17	18	11

To offset the savings in operational costs on filler trees there are certain extra expenses, the latter being mainly a result of having more fruit to handle and more money invested. The obvious next step is to see how cost per filler tree compares with revenue per filler tree. What is pertinent here is the *additional* cost and revenue due to the presence of the filler trees. These quantities can be determined by calculating the excess cost and revenue on the plots carrying fillers, because the same number of permanent trees was common to all three plots.

Operations on the permanent trees were assumed to cost the same, whether or not there were filler trees in the plantation: then the following formula applies:—

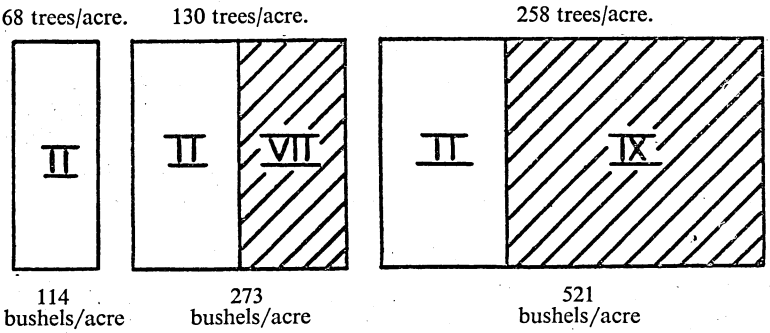
Cost of filler trees = cost of all trees − cost of permanent trees.

Revenue was handled in the same way as cost.

Direct and indirect effects of filler trees

Filler trees can contribute indirectly as well as directly to higher yields per acre if the permanent trees are far enough apart to benefit from the protection of the fillers. Preston* has shown that in the same plantations the "shelter effect" of close planting on the plots carrying fillers materially increased the yield of the permanent trees also. The diagram below shows (to scale) how much greater was the yield per acre on the plots carrying fillers. Average yield *per tree* was very similar on the interplanted plots, but depressed where the trees were most widely spaced.

YIELD PER ACRE, YEARS 4 TO 9 INCLUSIVE, FOR THREE DIFFERENT SPACINGS OF TREES



The yield of a M.II tree in the four years prior to economic establishment was 69 per cent. higher where surrounded by M.IX, than where the M.IIs stood alone. This feature may well be one result of the exposure of the site, and of the over-wide spacing (25½ ft. square) in the "control" plantation: the same effect was not apparent in the smaller Long Ashton trials where the exposure was much reduced.

These experimental results can hardly be used as a general guide to the increase in yield in permanent trees to be derived from interplanting with fillers; but if all the increase in yield be credited to the filler trees, in the case in question the economic argument is decidedly in favour of having filler trees for the first nine years. The method of analysis does not make clear how much of the extra cost on the plots concerned was incurred on the fillers, and how much on the permanent trees—the latter were slightly larger than those on the

* A. P. Preston, Orchard Tree Spacing in relation to Wind and Cropping. *Journal of Horticultural Science*, October 1956.

widely-spaced plot, and were carrying heavier crops. However, revenue was increased more than cost where there were filler trees, and the margin, after charging enlarged overhead and interest costs, was 18s. 6d. a tree with M.VII and 17s. 0d. with M.IX, thus:—

MARGIN ON PLANTATIONS CARRYING FILLER TREES, YEARS 1 TO 9

	WITH M.VII		WITH M.IX	
	per acre	per filler tree	per acre	per filler tree
	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Additional revenue	183 17 0	2 18 10	475 16 0	2 10 1
Additional costs	126 1 0	2 0 4	315 1 0	1 13 1
Margin for grubbing and profit	57 16 0	18 6	160 15 0	17 0

A margin of £57 16s. an acre (with M.VII) might be largely dissipated by the costs of grubbing the trees when ten or more years old, but if it were common policy to take out the trees in good time and plant them elsewhere, these filler trees would be well worthwhile. About the adequacy of the margin on the M.IX plot there can be no doubt.

There will come a time, of course, if the fillers are left in, when the *relative* benefits of retaining them are likely to decline, and the costs, both direct and consequential, of grubbing them will increase. The point of maximum advantage will only be found by experience, but it is just as desirable to know when to take filler trees out as it is to know in what circumstances to plant them.

Direct effects of filler trees

To avoid overstating the case for fillers, the cost and revenue analysis is now repeated, in greater detail, assuming that there was no "shelter effect". Are filler trees worth planting in circumstances where their effect on the permanent trees is negligible? The answer to this question, of course, boils down into a plain cost:benefit statement for the filler trees themselves.

In this second analysis, the filler trees, already burdened with their full share of overhead costs and interest charges, have to carry the additional handicap of the cost of any additional work on the M.II associated with them (which is concealed in the additional costs for the plot as a whole). In this way the lower limit of advantage from filler trees will be determined whereas the first analysis gave a measure of the upper limit of advantage.

Even under this new handicap the M.IX trees made a good

TABLE 5

COST AND REVENUE FROM TWO TYPES OF FILLER TREE, 1946-55

PART A. FOR THE TREES AS A WHOLE

	M.VII (625 trees)				M.IX (1,900 trees)			
Yield (40 lb. bushels)*	1,114				3,315			
	£	s.	d.	£ s. d.	£	s.	d.	£ s. d.
Revenue								
Net returns from sales				1,313 16 0				3,950 8 0
Cost								
Operating costs	969	1	11		2,343	1	9	
Packing—materials and labour	174	10	0		524	17	6	
Interest on additional working capital	121	0	0	1,264 11 11	286	0	0	3,153 19 3
Margin for grubbing and profit				49 4 1				796 8 9
Margin per tree				1 7½				8 5

PART B. PER TREE, YEARLY

	M.VII			M.IX		
	Operating cost	Revenue	Cumulative difference	Operating cost	Revenue	Cumulative difference
	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.
1946-48	8 10½	—	— 8 10½	9 7	—	— 9 7
1948-49	1 7	—	—10 5½	1 8	—	—11 3
1949-50	2 5	1 3½	—11 7	1 10	2 7½	—10 5½
1950-51†	1 6	1 5½	—11 7½	1 6	3 6	— 8 5½
1951-52	3 8	4 0	—11 3½	1 4½	4 0½	— 5 9½
1952-53	2 9½	8 0	— 6 1	2 2	6 11½	— 1 0
1953-54†	4 3	5 10	— 4 6	2 8	5 10½	+ 2 2½
1954-55	5 10	21 5	+11 1	3 10½	18 7	+16 11
Total	30 11	42 0		24 8	41 7	
Packing	5 7			5 6½		
Interest	3 10			2 11		
	Total cost	40 4		Total cost	33 1½	
Margin		1 8			8 5½	
	Accumulated yield: 1·77 bushels a tree			Accumulated yield: 1·75 bushels a tree		

* Converted from trays assumed to hold 28 lbs. of apples.
† Crop of low overall quality.

showing. Table 5 shows, first in summary form, and then separately for each year, that both types of filler trees earned more than their costs by the end of 1955. The average margin on a M.IX tree was 8s. 5½d. and on a M.VII tree 1s. 8d. .

The M.VIIs made their first annual profit in their sixth year (1952 crop; revenue 4s. a tree, operating costs 3s. 8d.) and had paid off operating costs one year before economic establishment of the associated M.IIs. The M.IXs made their first annual profit in their fourth year (1950 crop; revenue 2s. 7½d., operating costs 1s. 10d.) and had virtually paid off operating costs two years before economic establishment. These minimized results were realized in spite of the fact that two of the first five crops were of low quality, with Cox's fetching about 17s. 6d. a bushel after paying market charges but not grading and packing costs.

Both types of filler tree cost less than 3s. a year to maintain between 2 years and 5 years old. Investment per tree built up to almost 12s. at the end of 5 years; thereafter returns, amounting to 40s. a tree, quickly overtook investment and left a deficit of 4s. 6d. a tree to be extinguished by the "establishment crop". To put it another way, if (dessert) apples were worth 1½d. each on the farm, 16 marketed apples a tree each year paid the keep of a M.IX filler tree between the second and sixth years. At the time the trees began cropping, the deficit was equivalent to 96 market apples a tree. By the end of nine years, each M.IX filler had cost the equivalent of 266 market apples. If 24 apples more are required in order to pay for grubbing, any yield above 290 market apples a tree in the first nine years was a clear gain to the grower.

Regarding the M.IIs, maintenance costs a tree on the widely-spaced plot averaged twice those on the M.VII fillers. Annual costs varied from 4s. 1d. a tree in the third year to 10s. 1d. a tree in the establishment year. These costs per tree are high because there were few trees to the acre. At a later stage, when the economy of M.II as a filler tree is computed, costs more appropriate to a full plant are given: from these (Table 7, p. 43) it would seem that a revenue of 15s. a tree (£100 an acre) would suffice for economic establishment of the orchard at age 7 or 8 years because costs at this stage averaged 6s.-7s. a tree (£45 an acre).

To sum up, the benefits of quick-maturing filler trees in this case were:—

(*a*) increased yields per acre, directly and indirectly,

(*b*) annual profits 3 to 4 years earlier than on the permanent trees, and

(*c*) additional costs more than repaid nine years after planting.

Making capital productive

It is clear now that up to a certain point, additional investment per acre can create more than an equivalent capacity to repay: if rightly invested, the additional capital will help to raise the average level of return (or capacity to repay) on the entire investment. If the additional capital takes the form of filler trees, the proportion of circulating (or productive) capital is increased and the proportion of fixed (or unproductive) capital is decreased. It is shown below (Table 6) that an expenditure of £613 an acre earned a bigger total surplus over 9 years than an expenditure of £378. At the higher rate of expenditure, all operating costs had been paid for, and £101 an acre accumulated to repay capital and interest after 9 years, whereas at the lower rate of expenditure all operating expenses had not then been covered.

This situation offers some scope for a new grower to deflect, if necessary, some of the capital intended for permanent trees into short-term use in filler trees, with re-investment of the proceeds later: he may reach his objective in acreage more comfortably by adopting this method.

TABLE 6

PRODUCTIVITY OF CAPITAL AT DIFFERENT RATES OF INVESTMENT PER ACRE

	at 68 trees an acre	at 130 trees an acre	at 258 trees an acre
	£	£	£
Fixed investment per acre	171	171	171
Operating expenditure per acre	207	304	442
Total	378	475	613
Revenue (fruit sales) per acre	116	280	543
Margin available for return on fixed investment (revenue minus operating expenditure)	— 91	— 24	101

What if apple prices fall and costs rise?

The degree of success of the filler trees was, obviously, decided by the relative costs of labour and chemicals on the one hand, and the price of apples on the other. In the situation just analysed, each £'s worth of labour produced £11 10s. worth of apples: more importantly, each £1 of cost produced £1 16s. worth of apples. With farm wage rates going up, and apple prices falling, the relationship is likely to be less favourable in the future than in the past. To what extent does this change invalidate the economic argument for filler trees?

The higher the average level of inescapable costs, the more urgent the need for commensurate revenue. A fall in the value of apples should entail, if anything, a closer plant still, so as to maintain revenue per acre at the same level as before. The principle of close planting for earlier establishment is not affected by an adverse change in the price relationship of apples to labour, but the extent of the financial advantages from close planting would be reduced by such a change, and some growers might be unwilling to make the higher investment necessary, and revert to wider planting, possibly with an intercrop added.

The type—or even the variety—of apple planted can have the same affect on establishment as changes in the value of apples as a whole. Where 16 *Cox* apples will pay for a year's keep of a young filler tree, 16 *Worcester* apples will not. This situation is likely to be corrected, when the trees are older, by the higher and steadier yield of *Worcester*. As between dessert varieties and culinary varieties, however, the difference in value of a single apple is likely to be more significant. At wide spacings, the cost of cultivations and of overheads, not to mention the work on the tree itself, is likely to delay the emergence of a surplus on a culinary apple orchard for more than nine years: in which case a grower needs to be either exceptionally long-sighted, or else to plant more closely. Intercropping is often not so practicable in a culinary-apple location.

M.II as a filler tree

Whether M.VII or M.IX—or M.II—makes the best filler tree cannot be established from the records of this one experiment, bedevilled as they are by the different performances of the permanent M.II trees and the difference in numbers per acre of the two alternative types of filler tree.

On average, each M.VII bore 1·77 bushels of fruit in the first nine years, and each M.IX 1·75 bushels. By the start of the tenth year after planting the M.VII had earned a profit of at least 1s. 8d. a tree, and M.IX one of 8s. 5d. a tree. On these two counts there is no difficulty in choosing between the two.

In this one case, the plant of M.IX was clearly superior to the plant of M.VII. A paper profit of £5·2 an acre was made on the ground not wanted by the permanent trees in the first nine years when it was occupied by one M.VII; when occupied by three M.IXs the profit was £80.

An alternative to either "plant" is an additional M.II. The permanent M.IIs yielded more, but cost more to maintain than either M.VII or M.IX. Comparative yields per acre were as follows:—

AGGREGATE YIELDS PER TREE, YEARS 1 TO 9

M.II alone	M.II with M.VII	M.II with M.IX	M.VII	M.IX
		bushels of 40 lb.		
1·68	2·4	2·8	1·77	1·75

There are two possibilities to be assessed in the cost aspect of M.II fillers:—

(*a*) using them as an alternative to the M.VII in the experimental circumstances previously described, and

(*b*) using them to "thicken up" a normal plant of about 120 permanent trees to the acre.

The effect of an increasingly close plant of M.II is demonstrated in Table 7 below. Cost and revenue comparable to those given for M.VII and M.IX in Table 5 are shown for:—

(*a*) the permanent trees at 25½ ft. square;

(*b*) 62 additional M.II (substituted for M.VII);

(*c*) 62 additional M.II per acre in a hypothetical original plant of 130 trees an acre (192 trees in all).

TABLE 7

ESTIMATED YEARLY COST AND REVENUE PER TREE, M.II FILLERS

	at 68 trees an acre	for 62 trees an acre addnl. to 68 trees		for 62 trees an acre addnl. to 130 trees	
	Operating cost	Operating cost	Revenue	Operating cost	Revenue
	s. d.	s. d.	s. d.	s. d.	s. d.
1946-48	10 6½	8 10½	—	8 4½	—
1948-49	4 1	1 8	—	1 0½	—
1949-50	4 11	2 6	2 4	1 5½	2 4
1950-51	7 0½	1 8½	1 5½	3 9½	1 5½
1951-52	10 7	3 9½	4 9	2 10	4 9
1952-53	6 2½	2 11½	9 7	3 4	9 7
1953-54	7 10	4 5½	7 8	3 10	7 8
1954-55	10 1	6 6	23 10	5 0½	23 10
Total	61 3½	32 5½	49 7½	29 8½	49 7½
Packing		7 7½		7 7½	
Interest		4 3		3 10	
		Total cost	44 4	Total cost	41 4
		Margin for grubbing and profit	5 3½	Margin for grubbing and profit	8 3½

Accumulated yield: 2·4 bushels a tree in both cases.

The margin on a substitute M.II is thus estimated to come between that on a M.VII (1s. 8d.) and that on a M.IX (8s. 5d.). Investment per tree and time to first annual surplus would have been very similar to those of M.VII, and the computed profit on the fillers becomes £17 an acre.

The results in the third column may have wider interest. The cost of an extra M.II on an otherwise full plant is shown to be 41s. 4d. a year over nine years. In return, the tree has yielded 2·4 bushels of apples, valued at 49s. 7½d. Considering that many a grower may expect to harvest two bushels of apples a tree in eight years, the balance of advantage seems again to be with filler trees.

The results as a whole tend to confirm the value of the precocious tree—its first early crops are psychologically welcome, and its small areal requirements enable good profits to be made on the "unused" space in the orchards.

Wasted space, and its economic effects

In the next decade replacement planting, as distinct from extension or new planting, will become more important and this tendency will make the principles of economic establishment lose some of their force, because a quick return from the young trees will not necessarily be required, and there will not be a big investment at stake. Furthermore, the few additional acres of land required for medium spacing, as opposed to close spacing, will be of little moment; the scarce factor will more usually be either labour or capital.

Looking farther ahead, however, there may well be a considerable number of growers who will want to maximize output from the land available during a re-establishment period. The economic defects of middle-aged trees are influencing growers to take trees out of cropping much earlier than previously. A grower on a 25-year period of cropping (after an 8-year waiting period) will need to have $\frac{8}{33}$—24 per cent.—of his orchards technically out-of-bearing. In these circumstances he cannot afford to overlook his replacement costs, and he will be concerned either to cut down the actual area involved, or to maximize production from the normal area: in either case, he will opt for a close plant.

The grower with a minimum economic acreage of orchards, however, is already in much the same position as the new grower: land, to him, is a scarce factor. What happens in the first eight years on the area he has taken out of bearing is important, and he has to study how best to make the small area of land available for replanting serve his purpose.

Measurement of trees in orchards that have produced an "establishment" crop leads to the opinion that, for practical purposes, yield per tree in the early years can be related to size of tree, according to its rootstock. Taking M.II as an example, the establishment crop on five different orchards in Kent and Sussex was picked from Cox orchards in which the trees, when allowance is made for annual variations in the cropping, had very similar average dimensions (Table 8).

TABLE 8

AVERAGE SIZE OF M.II TREE PRODUCING AN ESTABLISHMENT CROP OF COX'S ORANGE PIPPIN APPLES—FIVE EXAMPLES

	Span (ft.)	Height (ft.)	Level of seasonal yield in year of establishment
Case 1	9×8	7	high
Case 2	9×9	8	average
Case 3	10×10	7·5	average
Case 4	9·5×9	8·6	low
Case 5	10×9·5	7·5	low

(*Note:* The two measures of span were taken at 90° to each other and the distance measured was the *estimate of the obstruction to passage*—not the actual limits of growth: similarly the height given is the height of the topmost stratum of fruit not the limit of upward growth. Measurements were taken in late summer, before the full expansion of the trees. The average dimensions are the mean of the dimensions of not less than 20 systematically selected trees.)

Once a grower has decided upon his main plant, it is open to him to aim to profit as much as he can from the land not taken up by the permanent trees in the early years. When planning the programme for filler trees, however, it will hardly ever be worthwhile modifying the main plant for the sake of the fillers. The *mature* orchard must always be first in the grower's mind.

The space requirements for economic establishment (i.e. the area over which the tree impedes progress) of bush trees of moderately vigorous dessert varieties of apple on three popular rootstocks, are, on the above reckoning, as follows:—

Root stock	Orchards on the square	Quincunx and triangular plants
	(square of span)	(πr^2)
M.II	90 sq. ft.	65 sq. ft.
M.VII	64 sq. ft.	50 sq. ft.
M.IX	30 sq. ft.	27 sq. ft.

A calculation of the space unused by fruit trees at different densities of planting soon indicates the extent of the limitations

that technical matters, such as access for spraying, put upon closer spacing in the early years. Overhead spraying might help to overcome some of these limitations, whilst a second line of approach is to allow access to each tree from two sides only, instead of from all round.

At the time of establishment—nine years after planting—the closest plant of 258 trees an acre was still occupying less than half ground. The position at three different experimental spacings was :—

(*a*) at 68 trees an acre (25½ ft. sq.) 84 per cent. of the land was unused.

(*b*) at 130 trees an acre (equivalent to 18½ ft. sq.) 76 per cent. of the land was unused.

(*c*) at 258 trees an acre (equivalent to 13 ft. sq.) 60 per cent. of the land was unused.

Land is the cheapest of the factors of production, but there seems to be plenty of scope for more intensive use of it. Will there be a need for smaller machines as well as for large ones?

On a small area, where big tackle will not ultimately be required, attention to close initial spacing could conceivably increase revenue in the establishment period. Allowing for a 3ft. wide passage between the branches at 8-9 years the permanent plant could be reduced to 21 ft. sq., and the filler plant of M.IXs still maintained. The full plant would now be:—

99 permanent trees (M.II)
297 filler trees (M.IX),

making 396 trees to the acre. Transposing and rounding the revenue figures from Table 5, the computed revenue per acre from this plant in the eighth year would be £327, made up of:

	£
99 M.II at 18s. a tree ..	89
297 M.IX at 16s. a tree ..	238
396	327

£327 an acre is £60 more than was realized in practice in the trees' ninth year. Additional costs resulting from the closer spacing are estimated to be less than £20 an acre, leaving an additional margin of £40 an acre. Technicalities must have their place; but too great a conformity to practice on large orchards may not be the best economic policy on small orchards.

In the experiment in question, the M.VII trees "established" themselves on 40 sq. ft. (this is the mean of three varieties, Cox,

Worcester and Sunset)—some two or three years before the M.II trees. The M.IX trees "established" themselves on an area of 25 sq. ft. (mean of two varieties, Cox and Worcester) and had four years' profitable cropping more than the permanent M.II. Where space allows of an M.II filler, results superior to those actually recorded for M.VII may be expected. M.II fillers are likely to make a small profit in their fifth or sixth year, and to establish themselves in the sixth or seventh year. This performance may be conditional upon the tree growing to cover (impede) an area of 56 sq. ft.

The economic attributes of filler trees are largely concerned with the time element, notably:—

(*a*) time to first profitable crop

(*b*) time to self-establishment

(*c*) time to outright profit

(*d*) size of outright profit in relation to area available.

In this respect, the results of the experiment stand out clearly. The M.IX tree, being quickest off the mark, is the first choice on the first three counts, as well as on the fourth (see Table 9 below). M.VII showed no advantage over M.II on the first two counts, and was equivalent to it on the third. The advantage on the fourth count is shared, with M.VII relegated to literally filling a gap which is too small for two M.IX or for one M.II, but too large for one M.IX. M.VII might suit, for example, the growers planting out permanents at 16 ft. sq. and wishing to fill up the rows one way.

In most circumstances there will be two alternative policies—(*a*) to plant fillers singly, or (*b*) to plant them to fill up the open area. As regards the first, M.II asserted its claim: as regards the second there was nothing to compare with M.IX. The figures below make this clear.

TABLE 9

MARGIN PER UNIT OF AREA FROM FILLER TREES IN THE FIRST NINE YEARS, AT 68 PERMANENT TREES TO THE ACRE

Rootstock	Revenue minus expenditure per tree, years 1 to 9	Area impeded by each tree	Margin per sq. yd.	Margin per acre from area available to filler trees
	s. d.	sq. ft.	s. d.	£ s.
M.II (one)	5 3	65	9	16 11
M.VII (one)	1 8	50	3½	5 5
M.IX (three)	8 5	27	2 10	79 19

Intensive systems

The important principle in orchard establishment is, that revenue per tree is a constant, whilst costs per tree decline as the number of trees per unit of area increases. This is known to apply within the accepted upper and lower limits in density of planting set by modern cultural methods. The intensive cultural systems—dwarf pyramids and cordons—show exaggerated conditions. It is possible, therefore, that the establishment period could be further reduced if cultivation methods were adapted to closer spacings than those normally used. Procedure of this sort is more suited to small areas than to large. Given certainty of average cropping, for example, a plant of 1,000 trees an acre would begin to earn annual profits after three years, but the investment would previously have exceeded £500 an acre excluding interest.

There is insufficient documentary evidence of yields and costs in the intensive systems of production to enable them to be directly compared with those of closely-planted bush trees, but limited experience of dwarf pyramids has been fitted into the general relationships affecting planting density, cost of, and time taken to establishment in Figs. 2 and 3, pp. 56-57. The results included for dwarf pyramids resembled those at Long Ashton. The establishment crop came in the fifth year.

Planting to suit private circumstances

Policy for establishment will be of most interest to the growers planting-up for the first time. Matters like capital requirement and the length of the waiting period are of lesser concern to the established grower.

From the knowledge now acquired, the density of planting appropriate to prescribed requirements can be suggested. Take three hypothetical cases, in which a potential grower has:—

(*a*) a limited amount of capital to be used to best effect, or
(*b*) to get started in fruit growing, money no object, or
(*c*) to make maximum profit over the first twelve years.

It is understood that in each case the ultimate size of the business will be determined by the number of permanent trees the grower plants.

Case a.—The choice is between buying a little more land and fewer trees and a little less land and more trees, that is, between quick development and slow development. This grower should not use filler trees because he will make his capital go farthest if he plants only permanent trees and waits for them to develop, because it would be exceptional for the profits in the first ten years to be large enough to finance 25 per cent. more orchard.

For example, assuming that no more land need be bought than is required, and its cost is £100 an acre (to include some buildings), £5,000 would finance 12½ acres of trees at 257 an acre, or 16⅔ acres at 68 trees an acre.* Assuming a net return of £300 an acre, in the first case the business would have an annual turnover of £4,000; in the second case £5,000.

If a large slice of the capital has necessarily to be sunk in the form of land, economy in tree-capital may be enforced willy-nilly.

Case b.—If money is no object—or, as is more likely, if the size of orchard planned is well within the means of the prospective proprietor—the site should be the best possible; there should be a close plant of trees, and land available on which to plant the crowded-out trees. Strawberries or raspberries, in a separate plantation, will bring in revenue before any tree fruit crop. Blackcurrants, at prices approaching £200 a ton, will make good profits, but the revenue earned will come little, if at all earlier than that from M.IX trees.

In the circumstances prescribed, the permanent plantation could have filler trees on, say, M.VII. Some M.IXs could be cultivated on a separate plot for perhaps 10 years, and then replaced by trees on M.II or whatever the grower's preference is. It is no bad thing to have one section of an orchard ten years younger than the rest. When all is sacrificed to speed, a fruit farm could be made to pay in its third of fourth year, but the investment would need to be of the order of £500 an acre (including land and buildings).†

* The distributions of capital are:—

At 258 trees/acre		At 68 trees/acre	
12·5 acres land at £100/acre	£1,250	16·7 acres land at £100/acre	£1,670
12·5 acres trees at £300/acre	£3,750	16·7 acres trees at £200/acre	£3,330
	£5,000		£5,000

† The assumptions here are that the permanent plantation would occupy 65 per cent. of the area, and that it would be supplemented by a temporary plantation on 25 per cent. of the acreage and by soft fruit (strawberries or raspberries) on 10 per cent. of the area. After three years, investment and annual cost and revenue would be like this:—

	Investment		Annual cost, revenue and margin		
	Share of acreage per cent.	Average investment per acre	Average cost per acre	Average revenue per acre	Average margin per crop acre
		£	£	£	£
Land and buildings	—	120	—	—	—
Permanent plantation	65	195	35	10	— 16·25
Temporary plantation	25	100	40	50	+ 2·5
Soft fruit	10	30	300	475	+ 17·5
Total	100	445		Margin per acre	+ 3·75

To put a larger share of the investment in quick-maturing plantations would of course, tend to increase profits.

Case c.—It is possible to conceive a system which, at only slight reduction in the ultimate business will make early profits. To this end, the "free" space in the orchard is kept to a minimum and filler trees retained as long as possible: this can only be done if the permanent trees are set out at slightly wider distances than they otherwise would be. By minimizing the unused space the capital per acre will be high, but *the capacity to repay* will be much higher still.

On small acreages, there might be opportunities for increasing profits by economy in expenditure, as well as by increasing revenue.

Equipment which was both small in size and in capacity would have to be used for the first few years. If all went to plan, the purchase of higher capacity equipment could be made largely out of profits. In general, the capital requirement per acre decreases progressively as the number of trees planted increases. The investment per acre at rates of 500 trees an acre is less than five times the investment per acre at rates of 100 trees an acre. The slope of the curve relating capital per acre and trees per acre indicates that benefits from closer planting will begin to tail off once the rate of 500 trees an acre has been passed. Establishment capital is likely to be most profitably employed when initial spacings are about 12 ft. by 12 ft. or the equivalent thereof (see Figure 3).

Summary

The fruit-grower has to plan his production policy to cover a long period. Initial mistakes may take years to rectify, and the results of his planting policy may be with him for forty years or more.

The evidence obtained from establishment records suggests that the grower can use filler trees to advantage. To use them to the *best* advantage may involve having one pruning policy for the filler trees and one for the permanent trees. To a certain extent, the grower can have the best of both worlds, if he allows the filler trees to develop quickly and fill up the spaces, and concentrates on the filler trees for his early profits. Such a policy agrees well with one of cutting the permanent trees much harder, delaying cropping, and to some extent reducing their "spread", for the sake of heavier crops per tree in early middle life, and of delayed thinning-out.

As with most things, there is more in establishing an orchard than is obvious at first sight. After nine years' experience with orchards having different planting densities, it has become apparent that the grower can to a certain extent adapt his methods to suit

his policy if he is on a good site. Nature is liable to interfere with his plans: crop failure in one year may delay the realization of the grower's aims, but only chronically low yields or persistent accidental damage will nullify the general economic principles now formulated and expressed diagrammatically in the Appendix.

To plant trees relatively close together induces higher initial yields per tree but also, by filling up the space, makes the trees additional to the permanent plant relatively cheap to cultivate. This is true of filler trees on three popular rootstocks. If the filler trees are also early-maturing, additional benefits of either earlier profits, or, if a relatively large number of fillers are planted, of a shortened waiting-time for economic establishment, will accrue.

In most circumstances the filler tree, if treated as such, will more than pay for itself before it has to be taken out. The point at which it is best to grub has not yet been decided. Rightly used, the beneficial effects of filler trees on the permanent trees may be felt for a long time, provided the fillers are not allowed to become competitive.

The economic advantages of close initial planting are considerable, and warrant adaptation of standard practices in certain circumstances.

APPENDIX

TABLE 10

ANNUAL OPERATING COSTS PER TREE, YEARS 1 TO 9, FOR TREES IN DIFFERENTLY-SPACED ORCHARDS

No. of trees per acre	Years after planting 1-2	3	4	5	6	7	8	9
	Costs per tree (d.)							
68	126	49	61	88	132	86	101	139
103	not separable				86	111	111	128
123	151	30	35	46	51	65	not known	
130	117	35	46	55	93	66	86	121
134	99	34	38	50	48	69	77	110
257	118	27	33	40	52	50	58	87

Although these costs are drawn from four different farms, costs per tree tend to be lower as the number of trees to the acre is higher (i.e. decrease from the top line of the table to the bottom line).

TABLE 11

ANNUAL COSTS AND REVENUE PER ACRE, YEARS 1 TO 9, FOR DIFFERENTLY-SPACED ORCHARDS

Year(s)		68 trees an acre	130 trees an acre	258 trees an acre
		£	£	£
1 and 2	Expenditure	35·6	63·5	126·6
	Revenue	—	—	—
	Cumulative difference	— 35·6	— 63·5	— 126·6
3	Expenditure	13·8	18·8	29·5
	Revenue	0·2	0·2	0·6
	Cumulative difference	— 49·2	— 82·1	— 155·5
4	Expenditure	16·7	24·2	34·0
	Revenue	6·0	8·2	27·3
	Cumulative difference	— 59·9	— 98·0	— 162·2
5	Expenditure	23·9	28·5	38·1
	Revenue	5·6	10·1	29·9
	Cumulative difference	— 78·2	— 116·4	— **170·4**
6	Expenditure	35·8	47·5	48·8
	Revenue	12·2	26·3	68·4
	Cumulative difference	— 101·8	— **137·6**	— 150·8
7	Expenditure	21·0	29·5	41·6
	Revenue	19·9	54·7	91·8
	Cumulative difference	— 102·9	— 112·4	— 100·6
8	Expenditure	26·6	39·9	51·9
	Revenue	19·0	40·3	79·0
	Cumulative difference	— **110·5**	— 112·0	— 73·5
9	Expenditure	34·1	52·3	71·1
	Revenue	52·9	142·2	246·8
	Cumulative difference	— 91·7	— 22·1	+ 102·2

The point of maximum deficit is shown in heavy type. Interest on capital not charged (see also Fig. 1).

A record of an "establishment" crop of dessert apples

Though somewhat akin to "counting chickens before they are hatched", an "establishment" crop can be predicted before picking begins.

Costs and cropping of several different types of tree were examined in order to find out what the relationship was between the value of the crop and the cost of maintenance of the tree for the year.

Bearing in mind that an establishment crop had to pay for two years' costs, known costs per tree were doubled, and a calculation made of the number of apples required to produce the same amount in revenue. Then, in the orchard, trees were classified on appearance, into low, medium and high yield classes. Typical trees in each class were selected and the number of apples they carried was counted.

By this test, only the low-yield trees of *Worcester* and *Sunset* failed to set an establishment crop in the year of economic establishment for the orchards as a whole.

A RECORD OF AN ESTABLISHMENT CROP

Variety	Root-stock	Yield status	No. of apples carried	Economic status*	Tree Growth
Worcester	IX	Low	30	N	Good
,,	,,	Medium	90	E	Poor
,,	,,	High	145	E	Good
Cox	,,	Low	38	E	Good
,,	,,	Medium	110	E	Good
,,	,,	High	256	E	Good
Sunset	,,	Low	35	N	Good
,,	,,	Medium	100	E	Good
,,	,,	High	225	E	Good
Worcester	VII	Low	75	E	Good
,,	,,	Medium	145	E	Good
,,	,,	High	244	E	Bad
Cox	,,	Low	72	E	Fair
,,	,,	Medium	145	E	Good
,,	,,	High	360	E	Good
Sunset	,,	Low	70	E	Fair
,,	,,	Medium	180	E	Good
,,	,,	High	243	E	Fair
Worcester	II	Low	95	E	Poor
,,	,,	Medium	125	E	Good
,,	,,	High	230	E	Good
Cox	,,	Low	85	E	Good
,,	,,	Medium	140	E	Fair
,,	,,	High	450	E	Fair
Sunset	,,	Low	110	E	Poor
,,	,,	Medium	160	E	Good
,,	,,	High	480	E	Good

* N—not established. E—established.

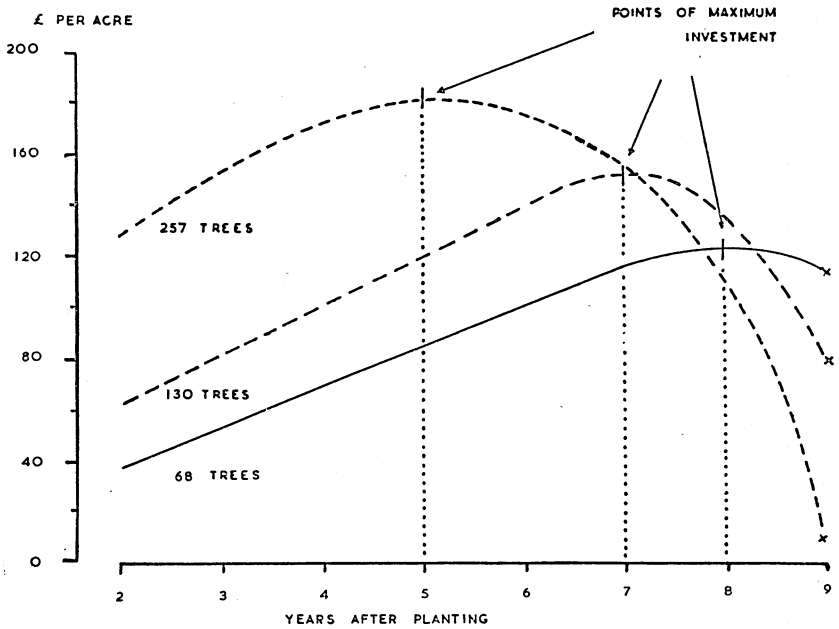


FIG. 1.

THE EFFECT OF FILLER TREES UPON COST OF ESTABLISHMENT OF DESSERT APPLE ORCHARDS.

Net cost per acre (operational costs minus revenue from fruit) at yearly intervals, years 1 to 9.

Note: interest on net cost included in costs; trees included, but no other capital items.

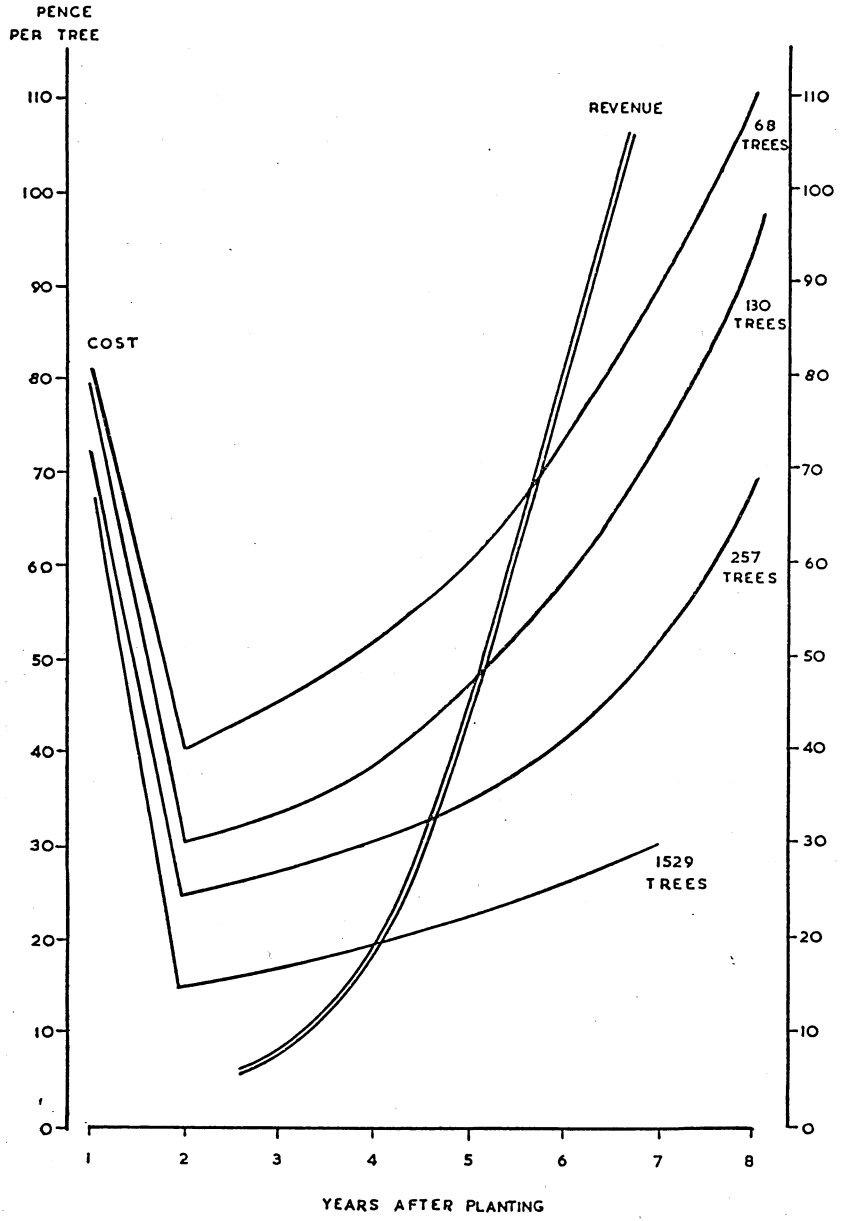


FIG. 2.

THE EFFECT OF DENSITY OF PLANTING UPON THE TIME TO FIRST ANNUAL PROFIT FROM A DESSERT APPLE ORCHARD (ASSUMING M.IX FILLERS USED AT DENSITIES OF 150 TO 400 TREES AN ACRE).

This is a combination of (a) recorded costs and (b) "normal" revenue of 6d. a lb. The first profit is unlikely to be big enough to establish the business.

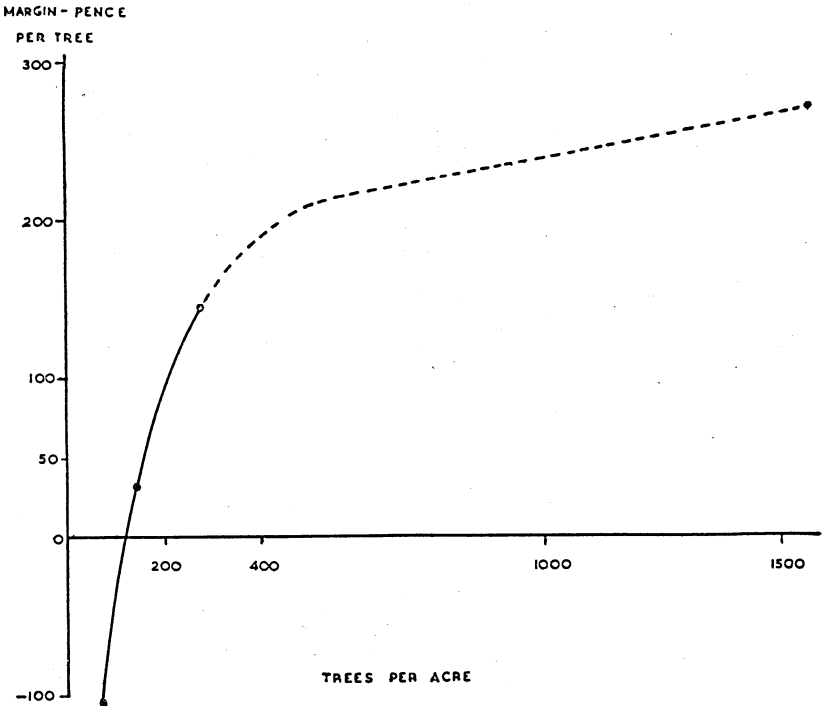


FIG. 3.

ESTIMATED AVERAGE MARGIN PER TREE IN FIRST 9 YEARS IN RELATION TO DENSITY OF PLANTING OF FILLER TREES.
i.e. margin per tree at 200 trees per acre is 80d. (6s. 8d.), equivalent to £67 an acre before grubbing.

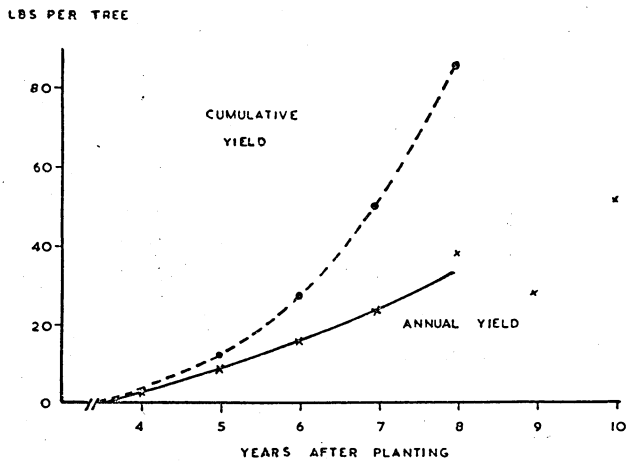


FIG. 4.

"NORMAL" DEVELOPMENT OF YIELD PER TREE, YEARS 1 TO 8, FOR DESSERT APPLE ORCHARDS AVERAGING 136 TREES AN ACRE.

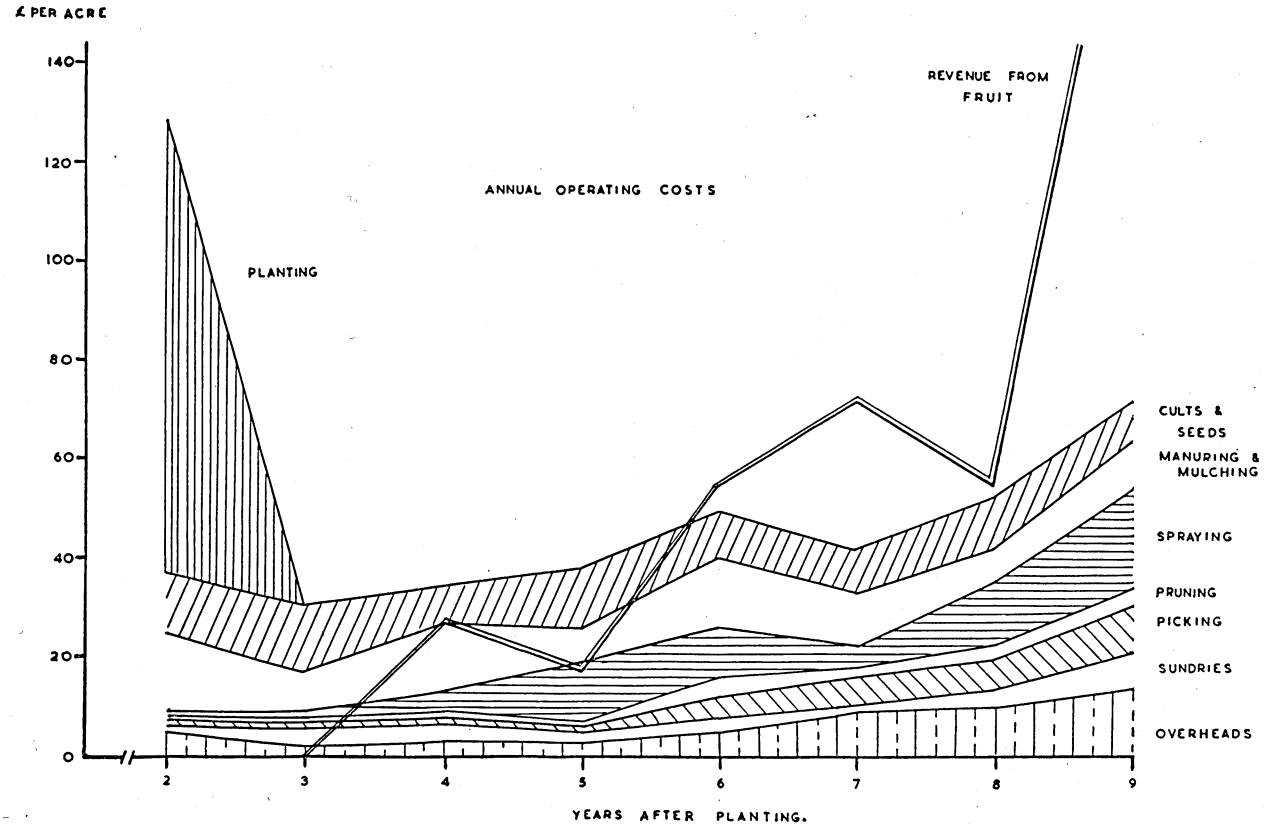


FIG. 5.

AN ANALYSIS OF OPERATING COSTS, YEARS 1 TO 9, ON AN APPLE ORCHARD AVERAGING 258 TREES TO THE ACRE.

HEADLEY BROTHERS LTD
109 Kingsway London WC2
and Ashford Kent

HEADLEY BROTHERS LTD
109 Kingsway London WC2
and Ashford Kent