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MANAGEMENT OF HEATED GLASSHOUSE TOMATOES

A Study of Gross Margins, Yields and Labour Requirements Based on a Survey of 34 Crops in the East Midlands in 1962

by

J. A. H. NICHOLSON, B.Sc. (Hort.)

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ACKNOWLEDGMENTS

The data in this report were supplied to this Department by growers of heated tomatoes in the East Midlands and neighbouring counties. Very detailed records were required for this survey, sometimes more so than would normally be recommended to those growers in the course of horticultural management advice. This Department is most grateful to those growers who assisted by keeping diaries or by allowing access to their own management records. If in places the text is critical of East Midlands practices in tomato growing, the author's intentions are only constructive.

The help of various National Agricultural Advisory Service officers and of several scientists and economists, which enabled a sample to be obtained and the results to be better reported, is gratefully acknowledged.

J. A. H. NICHOLSON

November, 1964

INTRODUCTION AND OBJECTIVES

Horticultural producers find increasing difficulty in securing an income which is both stable and an adequate reward for their labour, management and investment. This report does not seek to analyse the reasons for this malaise or to appraise the various remedies which regularly receive space in the pages of the industry's press. It may be remarked, however, that constant debate on the state of horticultural markets and the industry's need for tariff protection and grant aid does the industry at least one disservice, namely that the individual grower's attention is diverted away from the personal part he can play in determining the level of his income. Weaknesses in organisation and management are the responsibility of the grower alone.

There is an increasing body of circumstantial evidence that the level of organisation and management in many glasshouse and other horticultural businesses is indeed capable of considerable improvement. Even where shortage of capital may limit the opportunities for the modernisation of glasshouses and equipment, and in spite of the year to year variability in most horticultural product prices and yields, there are probably few growers who would fail to benefit from horticultural management advice. One of the functions of the N.A.A.S., as has been widely publicised, is to help growers who request management advice, free of charge and in strict confidence. These facilities are being increasingly used although the growth of this type of work is somewhat slow: it may well be felt outside the horticultural industry that growers who do not avail themselves of these facilities have no valid claim for continued political sympathy in the form of tariff protection and grant aid.

The success of management advice is largely dependent on the reliability and volume of available financial and physical data relevant to appraisals of past performance and to forward planning. One objective in the surveys discussed in this report has been to add to such data on behalf of the N.A.A.S. and growers in the East Midlands.

Tomatoes were chosen for study because the crop is an important one in the economy of the glasshouse businesses found in the East Midlands, which are mainly small and generally produce mixed crops for local outlets. Although the gross output of the East Midlands growers is unimportant in national terms, it is nonetheless likely that these businesses are representative of the majority in England and Wales in the quality of their available resources of glasshouses, equipment and management. It is expected that the data reported hereafter will thus be of use and interest in other localities.

Another factor prompted this study. Some economic appraisal of cultural techniques appeared overdue. On the one hand, the evident

present decline in the acreage of heated tomato production has received publicity: at the time of British negotiations for entry into the E.E.C., pessimists prophesied a crisis among glasshouse tomato growers analogous to that of their forebears who first established the commercial glasshouse industry by growing vines. At the same time, the N.A.A.S. Experimental Stations have tried out new 'precision-growing' techniques for tomato culture, which offer, where feasible in commercial practice, hope of efficient and profitable production for growers with the necessary capital and skill.

Accordingly, the economic aspects of heated tomato production in the East Midlands were studied by means of surveys in 1961 and 1962. This report is a companion to an account of the 1961 survey already published.(1) The records obtained in these surveys have allowed a detailed analysis to be carried out on the gross margins, yields and seasonal labour inputs of the crops concerned. Many readers are likely to be unfamiliar with the interpretation of these expressions: an account of the use and interpretation of management records will be found in Appendix I.

THE 1962 SURVEY SAMPLE

A. LOCATION

In 1961 eleven complete records were available for analysis at the conclusion of the preliminary survey. It was evident that a much larger sample of records would be needed to confirm and elucidate the tentative conclusions of that study. Further lists of names were supplied by the N.A.A.S. and these growers were approached with the object of amassing a much greater body of data which might permit a classification by the seasons of production and the different market outlets of the growers. Because of the relatively limited 'universe' of potential co-operators in the region covered by the Department's activities, the factor of willing co-operation outweighed any statistical considerations in obtaining the sample. Records of 43 growers were promised for the 1962 season, and of these, 34 materialised in sufficient detail for use in this report.

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(1) J. A. H. NICHOLSON, Tomato Growing in the East Midlands: A Preliminary Study of Costs and Returns in 1961. University of Nottingham, Department of Agricultural Economics, December, 1961. (Out of print).

Almost all these growers were unable to supply their own records and they attempted to complete diaries provided by the Department. All the growers who had assisted in the 1961 survey continued to co-operate.

In order to obtain additional records of early crops, growers were approached in counties neighbouring the East Midlands. The geographical distribution of the growers is shown in Table 1. The sample was deliberately biased in favour of early growers: the ratio of early to other growers is thus probably higher in this sample that in the East Midlands industry as a whole.(1) This bias was introduced because it was felt essential to obtain representative data from earlier growers in view of the swing in this direction that N.A.A.S. Experimental Stations and advisory staff have prompted. Furthermore, the advantages of earlier production had been suggested by the 1961 survey and this point particularly merited confirmation.

GEOGRAPHICAL DISTRIBUTION

Table 1

County	Number of Records
Nottingham	3
Derby	4
Leicester	11
Northampton	3
Lincoln (Lindsey)	4
Lincoln (Kesteven)	4
Isle of Ely	2
West Norfolk	2
Yorkshire (West Riding)	1
TOTAL	34

(1) Use of the term "early" does not imply that the first harvest of tomatoes by early growers is gathered as soon as it might be in more favoured areas such as Guernsey or the South Coast.

SIZE GROUP DISTRIBUTION

Table 2

Size group	Number of Records
Sq. ft. of glasshouse	
0-4,999	16
5,000-9,999	12
10,000-39,999	5
40,000 and over	1
TOTAL	34

1 acre = 43,560 sq. ft.

B. PRACTICES

Most of the 1962 records related to very small-scale methods of production, as is shown in Table 2. Only one crop was over an acre in extent and the smallest was grown in a glasshouse of 900 sq. ft. The average gross glasshouse area occupied was 8,696 sq. ft., i.e. approximately one fifth of an acre. The basic area measurement most used in this report is 1,000 sq. ft., to include pathways, pipework and purlin posts; this is the most convenient unit for analysis and budgeting on small nurseries.

In growing and marketing tomatoes there are many alternative practices for the grower to consider. A wide range of grower's choices of these was encountered and only a brief indication of the frequency of some of the more important practices and types of equipment is given below.

The actual range of plant population to which the records applied was from 252 to 12,800, with an average of 2,350. The distribution of crops according to plant density per acre is shown in Table 3. The average for the whole sample was 11,630 plants/acre, again recalling that this is based on the practices of small-scale growers. The average number of plants per 1,000 sq. ft. was 267.

A considerable range of varieties was noted and often several were grown in the same house or block. 'Ware Cross', the 'Eurocross' forms, 'Syston Cross', 'Moneymaker', 'J.R. 6' and 'Ailsa Craig' were the most popular. The almost complete absence of 'Potentate' was notable, for emphasis was placed by most of the growers on the need for quality production. This was doubtless associated with the mainly local nature of their marketing.

DENSITY DISTRIBUTION

Table 3

Density per acre (Number of plants/acre)	Number of Records
Less than 11,000	3
11,000 to 11,999	5
12,000 to 12,999	9
13,000 to 13,999	10
14,000 to 14,999	5
15,000 and over	2
TOTAL	34

Twenty crops were grown in soil which was partially sterilized, primarily for the benefit of the recorded crops of tomatoes. In some cases, it was the practice for lettuce or forced bulbs to occupy the borders after sterilization yet prior to the tomato crop.

Some 20 crops were watered and liquid-fed by means of 'trickle' harness. Even where hand watering was practised, liquid-feeding with the aid of a dilutor was usual. A preference for hand watering on the largest nurseries in the survey was notable.

The types of heating system have been summarised in Table 4. Several growers had different installations for heating their propagation and crop houses. Twenty-seven of these systems were of a semi-automatic nature, the most usual being a sectional boiler fired by a worm-type underfeed stoker, controlled by a thermostat and with the stoker powered electrically. Piping of 4" diameter was most commonly used in the crop houses.

Little useful information could be obtained on the temperature regimes maintained by the growers, almost none of whom kept any record of daily and nightly temperatures. Although a few growers tried to fulfil the recommendations of the Lee Valley Experimental Horticulture Station, it appeared that relatively few of the growers had a specific heating policy for their crops. Of those who had, most were not in control of the temperatures in their houses.

Nineteen crops were primarily grown for sale in the wholesale markets by commission salesmen though some retail sales or sales direct to shops were recorded in most cases. On only seven holdings did the growers rely on their own retailing. The other eight crops were mainly

HEATING SYSTEMS

Table 4

System	Number of Records
Hot water or steam boiler fired with underfeed stoker using washed singles	22
Hot water boilers fired by oil	3
Space heaters fired by paraffin	2
Hot water boilers, fired by coke, hand stoked	9
Hot water boiler, fired by anthracite, hand stoked	1

sold to local shops. Very few growers used non-returnable containers. Grading was usually carried out by hand, to effect a simple classification of the fruit by size and to separate poor quality produce.

Although some of the growers were insistent that their tomatoes were a catch crop and were insignificant in the economy of their business, it may be noted that the employment of casual labour was not recorded. The grower and his most skilled regular workers were usually in charge of tomato operations, even on nurseries where casual labour was employed for other purposes.

In Figure 1 the relationship between dates of planting and first harvest is shown. This point is discussed in the following sections.

C. CLASSIFICATION INTO GROUPS

Before any useful analysis of the results was possible, the 34 crops recorded in 1962 needed to be classified into groups of crops with major characteristics in common. The season of production was one of the more obvious bases for this classification.

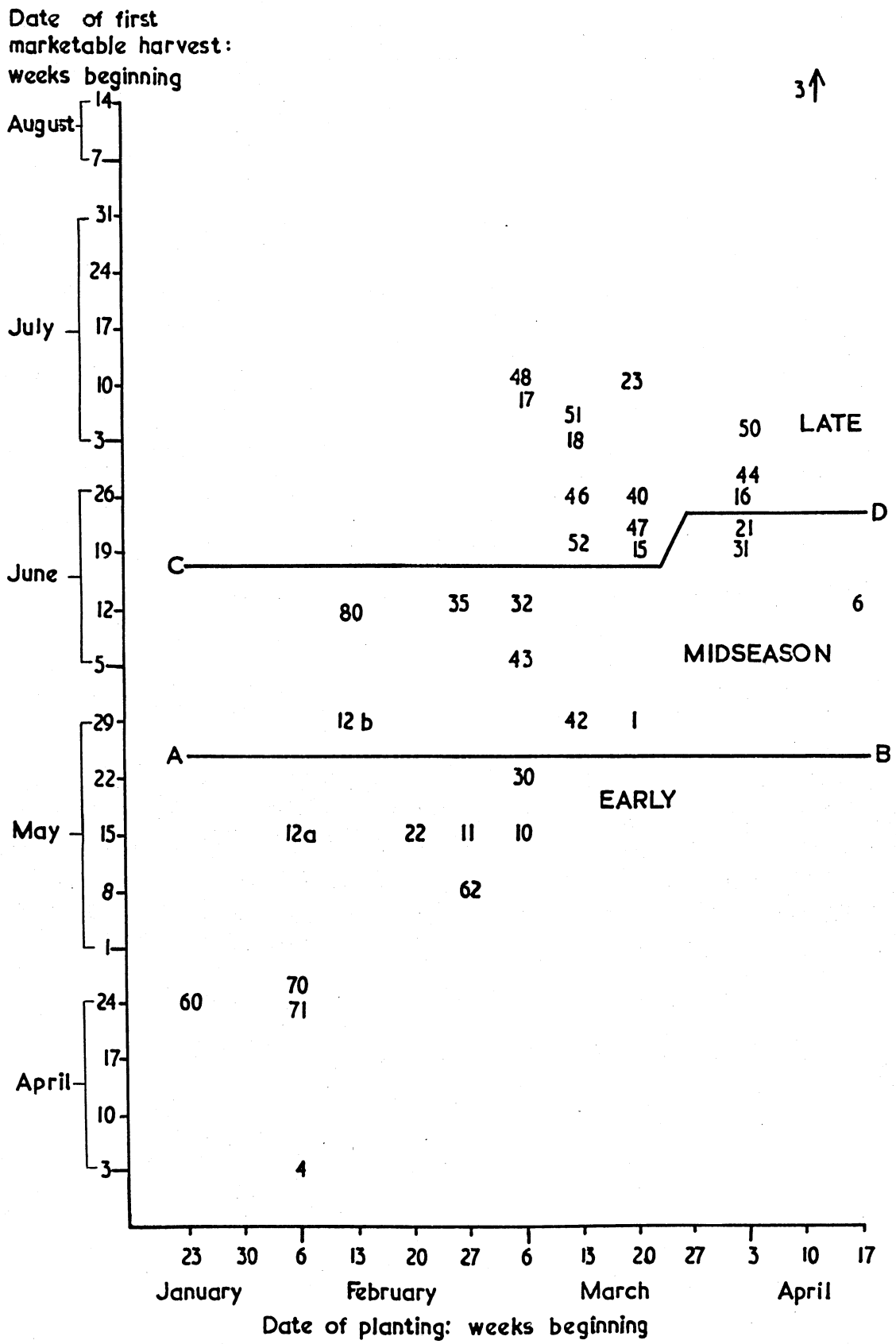
In Figure 1 the hortizontal axis shows dates of planting and the vertical axis shows the date of first marketable harvest. The correlation between these two dates does not appear to be particularly high, See, for example, the six crops planted in the week beginning March 6th. There are three probable reasons for this :

(a) Growers planted their crops at different stages of development of the young plant.

Figure 1

RELATIONSHIP BETWEEN DATES OF PLANTING AND FIRST HARVEST, 1962

(Code numbers of crops)



(b) Growers picked their first fruit at varying stages of maturity by reason of the different demand characteristics of the various market outlets.

(c) The intensity of inputs applied to the crops varied, in particular the input of fuel and the way it was used, i.e. the temperature regimes and number of weeks in which the crop was heated.

It is likely that date of first harvest is the more significant variable in determining the profitability of production, and accordingly the crops have been arbitrarily classified as 'early', 'midseason' or 'late', according to the point in time at which marketing was commenced. The 'early' crops were first picked over on or before 23rd May. 'midseason' crops were first harvested on or between 31st May and 25th June. The remainder were harvested first on or after 21st June. There is an anomaly in these dates. Two crops, Nos. 21 and 31 were considered to belong to the midseason group, although they were first picked just after the earliest 'late' crops. It was considered that these two crops had more in common with the more intensive midseason group than with the very extensive late crops, particularly with reference to the heat input.

Although this classification is very arbitrary, in practice it has enabled the crops to be placed in three fairly homogeneous groups with respect to two important variables in tomato culture, for in addition to the seasonal characteristics, each group largely had two measures of input intensity in common. Thus, growers of the crops in the early group each expended more than £25 per 1,000 sq. ft. glass on the heating of the crop after planting and similar expenditure was recorded on all but two of the crops in the midseason group: none of the late crops were heated so intensively. Out of the two groups of intensive crops, all except three were heated at night to 1st June or later: only four late season crops were heated after this date.

Classification of crops by market outlets

Because of the higher prices which were obtained for crops which were not marketed through wholesale outlets, the seasonal groups were further subdivided into those sold "wholesale" and "retail/shops" (i.e. direct sale from grower to final purchaser or sale from grower to retailer). Out of a total of 34 records, it will be appreciated that valid tests of statistical significance could not be made on the differences between the average financial and yield results of these six sub-groups of the sample. Nonetheless, it has been considered useful to present the average results of these sub-groups in this report in detail, for it is likely that management advisers and growers will in future need access to data related both to the earliness and marketing of glasshouse tomatoes.

In Table 5, the code numbers of the crops in each sub-group have been shown.

CLASSIFICATION OF 1962 SAMPLE

Table 5

Group	Season	Market outlet	Code numbers of records
1	Early	Wholesale	10, 12a, 60, 62,* 70, 71
2	Early	Retail/shops	4, 11, 22, 30*
3	Mid-season	Wholesale	1, 12b, 21,* 31, 80
4	Mid-season	Retail/shops	6, 32, 35,* 42, 43
5	Late	Wholesale	3, 15, 16, 17, 18, 23, 47,* 48
6	Late	Retail/shops	40, 44,* 46, 50, 51, 52

* Crops with highest gross margins in their group

These group numbers are referred to throughout the remainder of this report, and individual crops are also indicated by code numbers.

THE 1962 RESULTS ANALYSED BY GROUPS

A. GROSS OUTPUTS, REALISED PRICES AND YIELDS

Two definitions of gross output have been used in this report:

a. For crops sold in the wholesale market, gross output equals total sales less commission, market handling charges and any charges for carriage.

b. For all crops in groups 2, 4 and 6, which were sold retail or to shops, gross output equals total sales without deduction.

In neither case have the growers' costs of transport to market been deducted. It is appropriate to consider gross output together with its constituents - average net realised prices and yields.

Table 6 shows weighted averages for total gross output per 1,000 sq. ft., net realised price per 12 lb. for the whole season and yield in 12 lb. trays

per 1,000 sq. ft., for all the crops in the six groups.[1] This table confirms the tentative conclusions of the report on the 1961 survey of East Midlands tomato production referred to above in that it illustrates the advantages with respect to gross output of earliness and sales to shops or by retail. These facts were already conventional wisdom but based on no information systematically collected from growers. However, it is notable that the average differences in gross output between crops sold wholesale and otherwise were not as striking as conversation with growers and advisors had led the writer to expect. Indeed, the difference between the average gross output of groups 5 and 6 is negligible.

Table 6 does not in all cases reveal the expected pattern of average prices; for example, group 5 apparently received better prices than group 3. On the other hand, examination of average yields shows some interesting differences. For each marketing system, the early group recorded the heaviest crops. What might not be expected is the substantial difference in average yield between groups 3 and 4 and between groups 5 and 6. There is a strong suggestion in these figures that growers who were specialized for supplying commission salesmen generally achieved a higher standard of cultural efficiency than the remainder and in this way partly offset their disadvantage with respect to realised prices.

GROUP AVERAGES OF GROSS OUTPUTS, PRICES AND YIELDS

Table 6

Group	1	2	3	4	5	6
	£	£	£	£	£	£
Gross Output per 1,000 sq. ft.	196.2	221.3	120.8	132.6	109.8	110.3
Average Net Realised Price per 12 lb. tray	1.0	1.1	0.7	1.2	0.9	1.2
	No.	No.	No.	No.	No.	No.
12 lb. trays per 1,000 sq. ft.	190.1	205.5	173.2	115.1	125.7	92.4

(1) It is unlikely that Table 6 and following tables completely clarify the relationship between wholesale market returns and those obtained by growers who sell to shops or by retail. In almost all cases some retail sales occurred. Furthermore, some of the growers who relied mainly on non-commission outlets were obliged to make periodic use of commission salesmen.

The small body of results in each group precludes any valid statistical tests on the significance of the differences between the group averages. Furthermore, the above generalizations conceal a great range between the highest and lowest results in the different groups and the overlap between crops in different groups, as will be apparent from the data in Appendix II. In the circumstances, it would be unwise to consider these average results from small groups of growers as standards, unless the data are used with the utmost caution.

Of greater interest and more useful for comparative analyses are the individual results of the highest margin crops in each group. These are shown in Table 7. For each of these crops, total gross output was substantially higher than the relevant group average. In some cases this was mainly attributable to above-average yields, in others to above-average realized prices.

HIGHEST MARGIN CROPS IN GROUPS: GROSS OUTPUTS, AVERAGE PRICES AND YIELDS

Table 7

Crop number	62	30	21	35	47	44
	£	£	£	£	£	£
Gross Output per 1,000 sq. ft.	265.9	354.0	178.1	228.1	156.2	178.3
Average Net Realised Price per 12 lb. tray	1.1	1.7	1.0	1.2	1.0	1.8
	No.	No.	No.	No.	No.	No.
12 lb. trays per 1,000 sq. ft.	249.3	210.2	187.5	189.6	163.9	102.0

Although the "best crop" results are more valuable for comparative purposes, these too have their limitations. The use of any comparative data, whether or not they be called "standards", for purposes of management analysis of tomato crops is likely to give misleading results if the data used are expressed only in terms of <u>total</u> gross output, <u>average</u> net prices for the whole season and <u>total</u> yield. This is for two reasons:

a. As the season progresses, there is a pronounced downward trend in tomato prices realized in wholesale markets: a corresponding but less pronounced trend characterizes retail prices.

b. It is in the nature of tomato growing that the grower has a choice of preceding and succeeding crops. Thus there is a wide range of planting dates and clearing dates for the grower to select.

Any comparative data which are used for the appraisal of past performance of a tomato crop's output, yield and realized prices should thus:

1. relate to crops first marketed at a similar period of the season,
2. relate to a similar system of marketing to that used by the grower,
3. be of a nature that monthly gross output, net prices and yield are detailed, so that a comparison can be effected over the length of season selected by the grower.

The data summarized in Tables 6 and 7 have been set out more fully in Tables 8 and 9 to illustrate the range of standard data which appear to be desirable for sound output appraisals of tomato crops by advisers or growers. Unfortunately, a monthly breakdown was not obtainable for every crop in the 1962 survey, including one of the higher margin crops. Weighted whole season totals in Table 6 and 8 are thus not identical. Crop number 31 has been substituted for number 21 in Table 9: as it happens the gross margin of this crop was only slightly lower than that of number 21.

In general it appears that monthly tomato yields rise to a mid-season peak and fall thereafter, but examination of individual crop results has revealed great variability in the pattern of monthly yields. The seasonality of prices realized for the fruit is more clearly shown in Tables 8 and 9. The advantage of earliness has already been pointed out. It is interesting, therefore, that the two early crops in Table 9, numbers 62 and 30, were in neither case the earliest in their groups.

Table 10 shows that four of these highest margin crops 'bulked' earlier than the weighted averages of their respective groups, while the other two were about average in this respect. In each of these six crops, cumulative gross output to 31st July substantially exceeded the group averages. In the cases of crops No. 30 and 31, this premium performance was attributable to their higher than average realized prices in the first half of the season.

Reference to Tables 8 and 9 shows that the six highest margin crops each realized above-average gross outputs in the month of August. In each case, the crop was heavier than the average of the group. In some instances, prices were also above the group average. Continued heavy cropping at the 'tail-end' of the season, however low market prices have fallen, is obviously likely to be conducive to a high gross output.

GROUP MONTHLY AVERAGES OF GROSS OUTPUTS, PRICES AND YIELDS

Table 8

Group	1	2	3	4	5	6
Gross Output per 1,000 sq. ft.	£	£	£	£	£	£
April	1.6	7.9	-	-	-	-
May	40.5	41.0	-	-	-	-
June	79.8	95.9	18.9	19.8	4.6	2.3
July	53.7	55.6	47.0	63.9	43.7	44.6
August	15.8	35.9	30.9	36.6	57.3	53.8
September	3.6	7.5	14.4	8.4	11.5	14.2
October	1.2	1.4	4.3	3.8	5.8	1.1
November	-	-	0.4	-	0.5	-
WHOLE SEASON	196.2	245.2	115.9	132.5	123.4	116.0
Average Net Realised Price per 12 lb. tray						
April	2.4	2.6	-	-	-	-
May	1.5	2.3	-	-	-	-
June	1.3	1.7	1.2	1.7	1.5	2.1
July	0.9	1.5	0.8	1.2	1.0	1.6
August	0.7	1.4	0.6	1.0	0.9	1.2
September	0.4	1.4	0.4	0.8	0.6	0.9
October	0.4	0.7	0.4	0.6	0.6	0.5
November	-	-	0.2	-	0.4	-
WHOLE SEASON	1.0	1.6	0.7	1.2	0.9	1.3
Yield: 12 lb. trays per 1,000 sq. ft.	No.	No.	No.	No.	No.	No.
April	0.7	3.0	-	-	-	-
May	27.0	18.1	-	-	-	-
June	63.2	57.6	16.0	11.8	3.1	1.1
July	62.9	36.9	59.6	51.5	42.5	28.2
August	24.2	25.5	49.7	35.1	63.9	43.1
September	8.7	5.6	33.7	10.4	17.9	16.5
October	3.4	2.1	10.9	6.3	9.5	2.1
November	-	-	2.1	-	1.3	-
WHOLE SEASON	190.1	148.8	172.0	115.1	138.2	91.0
Lb. per plant	7.6	6.2	7.0	5.0	5.6	3.5
Tons per acre	44.4	34.8	40.2	26.9	32.3	21.2
No. of records	6	3	4	5	5	5

HIGHEST MARGIN CROPS IN GROUPS:

GROSS OUTPUTS, AVERAGE PRICES AND YIELDS

Table 9

Crop number	62	30	31	35	47	44
Gross Output per 1,000 sq. ft.	£	£	£	£	£	£
April	-	-	-	-	-	-
May	18.5	16.3	-	-	-	-
June	100.4	68.4	9.7	26.1	7.4	10.0
July	110.0	137.8	90.1	94.4	56.2	80.0
August	37.0	105.9	56.8	86.0	73.6	76.3
September	-	22.9	26.5	20.6	13.3	12.0
October	-	2.7	-	1.0	5.3	-
November	-	-	-	-	0.4	-
WHOLE SEASON	265.9	354.0	183.1	228.1	156.2	178.3
Average Net Realized Price per 12 lb. tray						
April	-	-	-	-	-	-
May	1.9	2.5	-	-	-	-
June	1.4	2.1	1.7	1.6	1.5	2.3
July	1.0	1.8	1.4	1.3	1.1	2.1
August	0.7	1.4	1.1	1.2	0.9	1.7
September	-	1.4	0.9	0.9	0.7	0.9
October	-	0.6	-	1.1	0.9	-
November	-	-	-	-	0.7	-
WHOLE SEASON	1.1	1.7	1.2	1.2	1.0	1.8
Yield: 12 lb. trays per 1,000 sq. ft.	No.	No.	No.	No.	No.	No.
April	-	-	-	-	-	-
May	9.7	6.4	-	-	-	-
June	71.3	31.9	5.8	16.7	4.8	4.4
July	113.3	76.5	64.8	74.6	52.0	38.3
August	55.0	74.4	51.0	74.6	82.1	46.0
September	-	16.2	29.0	22.7	18.8	13.3
October	-	4.8	-	1.0	5.6	-
November	-	-	-	-	0.6	-
WHOLE SEASON	249.3	210.2	150.6	189.6	163.9	102.0
Lb. per plant	8.3	9.9	6.7	8.3	6.5	4.3
Tons per acre	55.6	49.0	35.2	44.2	38.2	23.8

EARLY BULKING OF GROUPS AND HIGHEST MARGIN CROPS

Table 10

Group	1	2	3	4	5	6
Average Yield in 12 lb. trays per 1,000 sq. ft. to 31st July, 1962	No. 153.8	No. 115.6	No. 75.6	No. 63.3	No. 45.6	No. 29.3
Gross Output per 1,000 sq. ft. to 31st July, 1962	£ 175.6	£ 200.4	£ 65.9	£ 83.7	£ 48.3	£ 46.9

Crop number	62	30	31	35	47	44
Average Yield in 12 lb. trays per 1,000 sq. ft. to 31st July, 1962	No. 194.3	No. 114.8	No. 70.6	No. 91.3	No. 56.8	No. 42.7
Gross Output per 1,000 sq. ft. to 31st July, 1962	£ 228.9	£ 222.5	£ 99.8	£ 120.5	£ 63.6	£ 90.0

The significance of high gross output in profitable production is discussed fully in subsequent parts of this bulletin.

B. VARIABLE COSTS

This section concerns those costs which were generally considered to be variable in the sense that changes in their levels could be attributed to the growers' choice of the area planted and intensity.

Table 11 shows the average amounts spent by each group on the various items classified as variable costs. Some of these items are alternatives; they are not all essential for tomato growing. However, each item, even if it was not recorded on all holdings, has been averaged over the total area of the group.

Propagation costs other than labour have been presented in two ways. Where it was practicable to record the quantities and cost of the materials used, they have been shown under the appropriate headings such as 'seed' or 'compost'. Some growers bought in plants which were charged at cost. Quite a few growers were not able to record their variable costs of propagation and have accordingly estimated the prevailing market prices they would have had to pay if their plants had been bought in.

Heating costs, where possible, have been separated into 'fuel for propagation', 'fuel for growing' and 'fuel for steaming'. On a number of holdings where a centralized heating system was used to produce several other crops alongside the tomatoes, heating costs for the tomato crop were calculated. (See Appendix III for the methods of calculation).

GROUP AVERAGE VARIABLE COSTS

Table 11 — £ per 1,000 sq. ft.

Group	1	2	3	4	5	6
Cost of plants	0.7	0.7	2.9	4.3	4.6	4.4
Fuel for propagation	2.1	4.4	1.3	2.2	0.5	0.7
Fuel for growing	41.3	37.4	37.9	18.7	13.5	11.0
Fuel for steaming	4.9	5.1	1.0	1.4	-	-
Compost, peat	0.8	5.6	0.4	1.1	1.2	0.7
Manures, fertilisers	3.5	7.5	1.7	2.8	3.9	2.5
Pots and boxes	2.9	3.6	0.7	0.9	2.4	0.5
Seeds	0.3	0.5	0.1	0.2	0.1	0.1
Sterilizers	1.5	0.2	2.4	1.2	1.7	0.6
Fungicides	0.3	0.2	0.2	..	0.1	0.1
Fillis	0.6	0.3	0.5	0.6	0.6	1.5
Water	1.7	2.8	1.0	0.8	1.0	1.2
Insulation	0.2	-	0.1	..	0.5	-
Market packs	6.0	4.7	5.2	1.4	1.9	0.7
Tractor costs	0.1	0.2	0.1	0.1	0.2	.1
T.C.M.B. levy	0.4	0.5	0.4	0.4	0.4	0.4
Other	..	0.2	-	-	0.1	0.1
TOTAL	67.3	73.9	55.9	36.1	32.7	24.5

Most of the other headings in the accompanying tables should be self-explanatory. Cost of 'market packs' refers to containers and paper where the fruit was sold wholesale or to shops, and to bags where sales were retail. 'Tractor costs' were charged at the standard rates of 3s. Od. per hour for small horticultural tractors and 4s. Od. per hour for farm tractors. Possibly these rates are too high but it is highly improbable that any such bias would significantly distort the total of variable costs for the crops concerned.

Labour costs do not appear in Table 11. On most of the holdings in the Survey there was a regular labour force which would be stable irrespective of the area planted with tomatoes and which would not vary if production became more intensive. Consequently labour has been treated as a fixed cost throughout this analysis. However, in certain cases a different treatment would have been justified, particularly for purposes of management analysis on the individual holdings. Thus, supposing that on a large holding a major change had taken place affecting the organization of the business, and particularly the place of tomatoes on that business, there might have been changes in the employment of labour directly associated with the tomato crop.

VARIABLE COSTS OF HIGHEST MARGIN CROPS

Table 12 — £ per 1,000 sq. ft.

Crop number	62	30	21	35	47	44
Cost of plants	-	-	5.4	-	-	-
Fuel for propagation	13.4	3.8	-	6.4	2.1	0.9
Fuel for growing	39.0	34.4	29.2	28.4	5.1	9.7
Fuel for steaming	-	3.7	-	0.9	-	-
Compost, peat	0.9	0.8	-	0.9	0.1	3.7
Manures, fertilizers	1.7	0.5	3.3	0.7	2.6	7.3
Pots and boxes	-	3.2	-	3.7	-	3.6
Seeds	0.4	0.1	-	0.1	0.5	0.3
Sterilizers	-	0.9	6.0	4.4	-	-
Fungicides	-	-	-	0.2	-	-
Fillis	0.1	0.7	0.7	0.5	0.6	0.3
Water	1.1	0.9	1.7	-	1.2	-
Insulation	0.5	-	-	-	0.3	-
Market packs	9.7	2.2	3.3	4.8	0.2	1.0
Tractor costs	0.2	..	0.4	-	0.1	-
T.C.M.B. levy	0.4	0.3	0.6	0.4	0.4	0.4
Other	2.0	-	-	-	-	-
TOTAL	69.4	51.5	50.6	51.4	13.2	27.2

As would be expected, the levels of variable costs were highest for the early groups and lowest for the late groups, mainly because of differences in fuel expenditure. Variable costs of the two early groups were essentially similar. For those marketing later in the season, higher costs were incurred on nurseries where the produce was sold through wholesale outlets.

In principle, the only item which might be expected to have varied appreciably between the groups of growers selling wholesale and the others was the cost of market packs. In practice, however, expenditure in 1962 on 'fuel for growing' by growers selling retail or to shops was generally lower than by those growers who used commission salesmen. It is likely that the lower average yields obtained by the retailing growers, especially in groups 4 and 6, were partly associated with this apparent reluctance to use their heating systems. None of the late growers practised steam sterilization.

Table 12 shows the variable costs for the highest margin crops in each of the six groups. 'Fuel for growing' costs were clearly an important influence on the levels of total costs. For crop 35 the 'fuel for growing' and total variable costs were well above the average of the group. Crop 47 was the only crop recorded where the total variable costs were so strikingly below average as to explain the high gross margin.

It will be appreciated that the ideal method of presentation of the above data as a guide to management analysis would involve the preparation of tables of monthly heating and other costs. Unfortunately this has not proved practicable for representative numbers of crops in the 1962 survey.

C. GROSS MARGINS

Table 13 summarizes the data of tables 6 and 11: it shows the average gross margins, i.e. differences between average gross outputs and average total variable costs. The best results for each crop are shown in Table 14.

Table 13 shows a clear advantage in the favour of the earliest growers, whatever the method of sale. Results for the mid season and late season growers were not consistent. The higher margin realized by mid season growers selling retail or to shops conforms to the pattern which might have been predicted. However, mid season crops were rather less profitable than late crops where wholesale market outlets were used.

The latter anomaly may, in part, be attributable to the small sample size in each of the six groups. Table 13 also conceals a very wide range of individual holding results within and between groups. (For individual results see Appendix II).

GROUP AVERAGE GROSS MARGINS

Table 13

Group	1	2	3	4	5	6
	£	£	£	£	£	£
Gross Output per 1,000 sq. ft.	196.2	221.3	120.8	132.6	109.8	110.3
Total Variable Costs per 1,000 sq. ft.	67.3	73.9	55.9	36.1	32.7	24.5
GROSS MARGIN per 1,000 sq. ft.	128.9	147.4	64.9	96.5	77.1	85.8

HIGHEST MARGINS IN GROUPS

Table 14

Crop number	62	30	21	35	47	44
	£	£	£	£	£	£
Gross Output per 1,000 sq. ft.	265.9	354.0	178.1	228.1	156.2	178.3
Total Variable Costs per 1,000 sq. ft.	69.4	51.5	50.6	51.4	13.2	27.2
GROSS MARGIN per 1,000 sq. ft.	196.5	302.5	127.5	176.7	143.0	151.1

The results in Table 13 and 14 illustrate the great difference between best and average results in the 1962 groups. Both these tables show a considerable association between the levels of gross output and gross margin. The conclusions of the 1961 report (referred to above) are supported by Table 13 in that the advantages of earliness and retail marketing, as represented by the magnitude of gross margins, are confirmed.

It must be borne in mind that a high or low gross margin is not necessarily indicative of a high or low level of final profitability, which takes account of the level of fixed costs in the same business. Thus, although retailing is conducive to a higher gross margin than would be obtained with the use of a commission salesman, it by no means follows that retailing is the right policy for every business to adopt, as the level of total fixed costs in the grower-retailing business is often disproportionately high.

SOME CRITICAL FACTORS IN PROFITABLE HEATED TOMATO PRODUCTION

It is assumed that the grower's objective is to maximize the gross margin from his heated tomato enterprise, considered in isolation, without the regard to the other enterprises on the holding. Some factors affecting the gross margin therefore merit further attention, as it is evident that profitability is not a function of earliness and market outlets alone.

Because of the low number of individual crop records in each group, no attempt has been made to test the statistical significance of the differences in group results. However, the correlations betweem gross output, yield and gross margin have been examined for all crops sold wholesale, and all crops sold retail/shops. The correlation between gross output and gross margin has been found to be very highly significant for the 1962 season for both methods of sale. Similarly, the correlation between yield and gross output was highly significant. No evidence of a significant relationship between the levels of gross output and total variable costs or heat input for growing could be adduced from the 1962 data. This latter point is receiving further attention in a survey initiated in 1964, in which further data on yields and gross output are also being collected.

It is likely that the following factors were among those which masked any relationship between heating costs and gross output:

(a) Growers planted at different stages of development in the young plant.

(b) In spite of a high input of fuel, some growers had light crops due to some other adverse feature in their cultural management.

(c) Fuel unit costs for similar types and grades of fuel varied considerably between districts.

(d) Some bias was introduced by the estimation of heating costs on many holdings, where actual costs had not been recorded.

(e) A few growers, who had a low fuel input had a high standard of cultural management and produced above-average yields.

A brief discussion of some of the many factors conducive to a high gross output follows.

Earliness

Two successive years' surveys of East Midlands tomato growing have suggested that the average gross margins obtained by producers who market early are higher than those operating at later periods in the season. Furthermore, it it also evident that many growers who aspire to early production do not succeed with it. This factor thus needs careful consideration.

Traditionally, there have been relatively few attempts in the East Midlands at early heated tomato production. Among the reasons for this, the following stand out:

(a) Conventional moderate temperature regimes have not permitted satisfactory setting of the bottom trusses with the poor early season light intensity which is characteristic of the region.

(b) Standards of heating equipment and other facilities for precision growing are low on very many East Midlands nurseries.

(c) Higher fuel costs and attendant risks have discouraged early plantings.

Nonetheless, growers have long been aware of the seasonal variations in realised prices, with a downward trend from very high market prices in April and May in all years. The prices they received in 1962 were indicated in Tables 8 and 9 on a monthly basis. Table 15 shows some weekly prices in Covent Garden market which further illustrate this trend,(1) and which would be broadly indicative of price movements throughout the country.

In Figure 2, individual growers' seasonal price trends in 1962 for two wholesale markets (prices realised by the same grower), a shop outlet and a retail outlet are compared. A similar downward movement characterised each grower's prices, and similar relationships were noted in 1961. For each market outlet, the high early season prices are attractive to growers.

In recent years, the N.A.A.S. Experimental Horticulture Stations and other centres have conducted trials concerned with efficient early tomato production. It now seems fairly clear that high day temperatures are essential early in the season, although these should not be allowed to exceed 70°F when the fruit is ripening. Experimental evidence on night temperature responses has been conflicting. At Fairfield, there seems to be no advantage where night temperatures are raised above 56°F in the early

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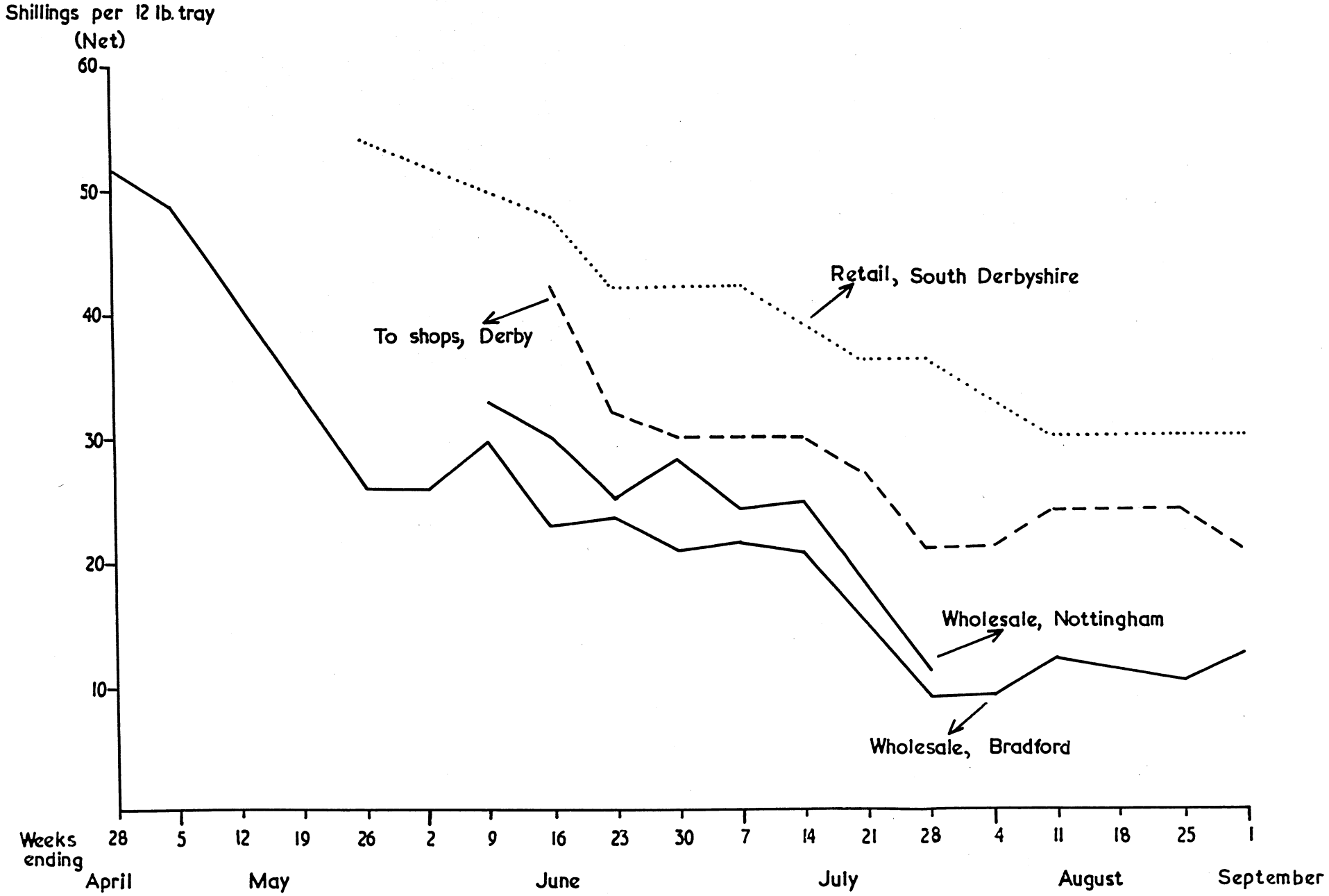
(1) It is evident that in 1962 the seasonal decline in Covent Garden prices was longer delayed than in 1961 giving particularly favourable prices in late June. One grower reported an increase in average price per (ton less commission, etc.) of £30.2 in 1962. This grower produced similar yields with similar practices in each year, yet this price increase was responsible for an increase in gross output of about £2,000 an acre.

Figure 2

WHOLESALE AND OTHER PRICES COMPARED, 1962 All grades



WEEKLY AVERAGE PRICES IN COVENT GARDEN

1956-62. PINK AND WHITE GRADE

Table 15 per 12 lb.

Week ending	Weekly Average Prices 1956-60		Weekly Average Prices - 1961		Weekly Average Prices - 1962	
	s.	d.	s.	d.	s.	d.
May 7	43.	11.	40.	2	39.	0.
May 14	39.	4.	33.	4.	36.	0.
May 21	33.	3.	34.	10.	32.	6.
May 28	29.	11.	23.	2.	27.	6.
June 4	26.	7.	21.	8.	27.	6.
June 11	25.	4.	21.	8.	26.	6.
June 18	20.	10.	19.	5.	24.	6.
June 25	21.	10.	16.	11.	24.	0.
July 2	17.	10.	17.	11.	23.	0.
July 9	16.	3.	17.	11.	21.	0.
July 16	15.	10.	15.	10.	19.	6.
July 23	13.	9.	19.	4.	14.	6.
July 30	12.	5.	19.	6.	13.	0.
Aug. 6	14.	4.	15.	6.	12.	6.
Aug. 13	12.	6.	13.	5.	17.	6.
Aug. 20	11.	2.	12.	6.	15.	6.
Aug. 27	10.	4.	12.	1.	14.	6.
Sept. 3	10.	4.	11.	10.	9.	6.
Sept. 10	10.	0.	10.	8.	9.	6.
Sept. 17	11.	2.	8.	0.	9.	0.
Sept. 24	10.	5.	9.	0.	13.	0.
Oct. 1	9.	7.	12.	8.	15.	6.
Oct. 8	10.	1.	14.	5.	13.	0.
Oct. 15	13.	2.	12.	1.	7.	0.
Oct. 22	13.	4.	10.	8.	7.	6.

SOURCE : Tomato and Cucumber Marketing Board.

part of the season. At Hoddesdon and Efford, economic responses to higher night temperatures have been shown experimentally.

In particular the work of the Lee Valley E.H.S. at Hoddesdon has been publicised in the East Midlands, for it has been argued that early season light intensities in the Lee Valley are not dissimilar to those in the East Midlands. The techniques for early tomato production developed at this station havethus been recommended to East Midlands

growers, subject to their satisfying all details in the recommendations on night and day temperatures, nutrition and crop hygiene.

Both the experimental results and the individual results in this survey have indicated that early tomato production is only worth attempting where the N.A.A.S. recommendations can be fulfilled closely. In particular the need for a heating system that will maintain the requisite temperatures in the coldest weather has been emphasised. (These remarks refer, of course, to N.A.A.S. recommendations prior to the sudden recent interest in atmospheric enrichment with carbon dioxide: none of the growers in 1962 used this practice).

As shown in Figure I, early planting did not necessarily result in early picking in 1962. It is understood that efficient growers in the more specialist areas expect the interval between these dates to be no more than 12 weeks in a normal season. Analysis of the 1962 crops showed that about two thirds of the sample were not operating at this conventional level of efficiency. There were a number of likely reasons for this:

(a) Some growers attempted a level of earliness that was beyond the capacity of their heating system.

(b) Some growers were known to have failed to achieve an earlier crop because of mechanical failure in their heating systems.

(c) In many cases, ripening was delayed where immature plants were planted.

(d) On quite a few holdings, especially where a hand-fired heating system was used, heating was turned off early in the season.

It is also necessary to point out that the growers' thinking is not over once tomato picking has started. Early crops failed in a few cases in 1962 to yield heavily: consequently they were not as profitable as might reasonably have been expected.

Planting Dates

While analysis of the 1962 survey results has indicated that it is logical for all growers to strive for the earliest production practicable with the resources they have available, little is to be gained by planting too early, thereby possibly losing oppertunities for a more productive succession. As a rule-of-thumb guide, a grower should not plant until he can be confident that the available heating system can maintain 'high' night temperatures of 60-62°F in any weather conditions, so that the crop can grow immediately after planting, without check and under cultural control.

In 1962, three suitable planting times for growers in inland parts of the East Midlands appeared to be:

Week beginning	Heating system
27th February	Semi-automatic and capable of maintaining high night temperatures in any weather.
20th March	Semi-automatic but not capable of maintaining high night temperatures in cold spells, or hand-fired and capable of high temperature lift and with circulating equipment.
10th April	Hand-fired installations, capable of only moderate temperature lift.

Early season light conditions in the coastal strip of Lincolnshire and in the counties around the Wash are usually rather better than inland and planting up to 15 days earlier than these dates would not have been criticised in these areas in 1962.

Further information on dates of planting and first harvest is being collected and the above dates are not offered as final recommendations until some further evidence is available. It would appear likely that it is essential to maintain high temperatures at least until picking has started if a grower wishes to exploit the maximum earliness possible with his heating system: there is little point in planting relatively early and then ceasing to heat the crop after a few weeks.

The N.A.A.S. now recommends that early crops should be planted as mature plants, out of $4\frac{1}{2}$" pots, with flowers open on the bottom trusses before planting. Feeding and appropriate spacing out in the propagation house must not be neglected. Such plants, if space is available and no more productive use for it can be foreseen, may be used to reduce the interval between planting and first harvest, whatever the planting date.

Use of summer night heat to preserve crop vigour and prevent disease

Advantages derived from earliness may be partly lost if cultural management does not preserve crop vigour and control diseases in the latter part of the harvesting season. Inspection of the 1962 survey crops suggested that on many nurseries, late season cultural management was not of a high order. One aspect of this which might easily be remedied concerns the use of some night heat throughout the growing and harvesting season.

Many growers evidently suppose that natural solar radiation in the East Midlands provides sufficient heat to maintain the vigour of tomato growth adequately after various arbitrary dates of their own choosing.

These coincide usually with fine spells, during which the supposition may indeed be temporarily true.

In recent years, East Midlands summers have been characterised by prolonged periods in which day conditions have been cool and overcast; at such times night conditions are likely to be even cooler. In such weather growth of crops from which heat has been withheld compares unfavourably with the vigour obtained in tomato crops planted in cold houses in more favourable parts of the country. It seems that slight boiler heat by day and night at such times would be likely to convey the following advantages:

(a) Crop vigour would be enhanced.

(b) Green fruit would ripen faster and perhaps thus be saleable in a higher price period of the season.

(c) Mould diseases of the fruit would be much less likely to occur due to reduction of condensation and better air circulation. Casual observations have suggested that these may cause a loss of 1 lb. of fruit per plant or more.

(d) Prevention of condensation would favour picking on the day of sale via local outlets, which would permit a higher quality fruit to be marketed with respect to flavour. One grower in the 1962 survey partly attributed his premium prices to this practice: in this and other seasons, his realised prices have sometimes been 25% higher than those prevailing in the market.

It does not appear that very high temperature lifts are needed for these effects once picking has started. Unfortunately, it has not been possible to quantifythe above argument with economic data collected entirely in the 1962 survey. Suitable monthly information on heating costs (per 1/10th acre) is to hand from the Lee Valley E.H.S., although it is understood that the data in Table 16 were estimated rather than observed.

This table suggests that late summer heat irputs are likely to be an insignificant proportion of the total. Similar patterns are demonstrable with other classes of fuel. In the East Midlands washed singles in 1962 were in no case as expensive as £6 18s. Od. per ton; unit costs were normally in the range £5 to 6. Using the Lee Valley data and price data collected in the East Midlands in 1962 it has been possible to construct some hypothetical break-even yields on late summer heating costs in that year. These are shown in Table 17.

In calculating this table, it has been assumed that heating costs were the same in July, August and September and that average daily temperatures were 62° F. Total fuel consumption per 1,000 sq. ft. would thus be 0.6 tons. At a unit cost of £6, this would indicate total fuel costs over these three months of £3 12s. Od. Rounded off break even yields have been expressed

in trays per 1,000 sq. ft. and lb. per plant, with an assumed plant density of 300 per 1,000 sq. ft.

HEATING COSTS per 1/10 ACRE FOR THREE TEMPERATURE REGIMES

Coal Singles at £6 18s. Od. per ton

Assumed overall efficiency = 65%

Table 16

Temperature Regime	58°F throughout	58°F in December, then 62°F	58°F in December, then 65°F
	£	£	£
December	42	42	42
January	43	53	60
February	38	46	53
March	35	44	51
April	25	33	41
May	12	20	26
June	6	11	16
July	3	6	11
TOTAL	£204	£255	£300

SOURCE : Lee Valley Experimental Horticulture Station. Report for 1961 and 1962.

ADDITIONAL YIELDS NEEDED TO BREAK EVEN ON TOTAL FUEL COSTS OF £3 12s. Od. per 1,000 sq. ft.

Table 17

Month	Assumed wholesale price per 12 lb. tray	Additional yield to break even		Assumed retail price per 12 lb. tray	Additional yield to break even	
	£	12 lb. trays	lb. per plant	£	12 lb. trays	lb. per plant
July	0.8	5	0.2	1.2	3	0.1
August	0.6	6	0.2	1.0	4	0.2
September	0.4	9	0.4	0.8	5	0.2

The break even yields in the table are those additional yields which would be needed to cover the fuel costs for three months if all the additional yield came in one month only. In practice, this would most likely be July.

Comparison of yields of crops which were actually heated and those which were not is liable to mis-interpretation because of other factors such as soil hygiene. The cultural arguments and the illustration above are sufficient to persuade the writer that in most years it is economic to heat tomato crops throughout the harvesting season in the East Midlands, and that those growers who do not do so should give careful consideration to this opportunity to increase their profits.

Experience and observation would suggest that increases in yield to break even such as those indicated above will be comfortably exceeded by most growers. Such a policy, as well as augmenting the profitability of the crop, is a means of insurance against the effects of mould diseases which are favoured by condensation in cool conditions. Of course, where watering is imprecise or where soil hygiene has been neglected, it is doubtful whether the intensification of heating alone is likely to prove very beneficial.

There is, admittedly, no small inconvenience associated with the maintenance of boiler heat with hand-fired installations. Even so, preliminary studies in Lancashire in 1964 have shown that many growers who hand-fire in the Hesketh Bank and Marton areas re not averse to keeping their boilers in later into the season than is usual in East Midlands practice.

While the practice of heating late into the season appears justified, this should not necessarily be interpreted as providing a case for continuing the tomato crop late into the autumn. Such a practice, while contributing to the gross margin of the crop, can sometimes incur high opportunity costs as it may impede the selection of a higher margin crop succession.

Soil Sterilisation and Tomato Grafting

A factor which is undoubtedly important in heavy yield tomato production is the preservation of soil hygiene. A variety of soil-borne fungi and pests may normally be expected to proliferate if steps are not taken to prevent infestation, yet a feature of non-specialist glasshouse areas is the extent to which small growers frequently ignore the oft-repeated advice to practice some control measures.

Earlier studies by the author have suggested that in the East Midlands average variable costs of steam sterilization and metham-sodium injection are similar. However, it is well known that average labour inputs for the chemical treatment, even after including comparable cultivations to those in traditional steaming techniques, are much lower than for steaming.

Useful additional information was collected in the 1962 survey. In Table 18 are shown average variable costs and labour inputs per 1,000 sq. ft. for steam sterilization with Hoddesdon pipes and chemical treatment with metham-sodium and formaldehyde. Also in Table 18 are some similar data for single observations of steaming with "combs", sheet steaming, steam ploughing and D.D. injection.

VARIABLE COSTS AND LABOUR INPUTS FOR SOIL STERILZATION

Table 18

Method	Steam				Chemical injection		
	Pipes	Combs	Plough	Sheet	Metham -sodium	Formal -dehyde	D.D.
Variable costs £ per 1,000 sq. ft.							
Coal/Coke	5.3	7.2	4.5	6.2	-	-	-
Water	0.3	0.5	0.1	0.1	-	-	-
Chemicals	-	-	-	-	3.9	1.6	0.7
Other	0.1	0.1	0.1	0.2	0.3	0.7	-
TOTAL	5.7	7.8	4.7	6.5	4.2	2.3	0.7
Labour input in hours per 1,000 sq. ft.	27.0	53.2	11.0	15.0	6.4	6.4	9.0
No. of records	7	1	1	1	5	2	1

In each of the columns in the Table 18 the labour input covers comparable cultivations: in particular, it includes digging time prior to chemical injection. "Other" variable costs were mainly tractor costs. It has been assumed that fixed costs of sterilization e.g., regular labour, depreciation and interest on capital equipment, repairs, were normally shared by all crops. Accordingly, no fixed costs are included in Table 18. This item would be negligible for chemical equipment.

The data of Table 18 are illustrative rather than definitive. The several records obtained for pipe steaming and for metham-sodium injection showed considerable variation, and the single instances of other treatments are obviously an insufficient basis for firm conclusions.

Metham-sodium variable costs were the highest of the chemical treatments, all of which were non-intensive in the use of labour when compared with the Hoddesdon pipe techniques. All the steam practices were characterised by somewhat higher variable costs than the average for metham-sodium injection, although the actual input was a relatively low proportion of total variable costs. Single records of the more modern steaming techniques using a sheet for surface steaming and a steam plough suggested a useful reduction in labour requirements.

It is generally accepted by advisers that the use of formaldehyde or D.D. appears to be of limited value in most situations and growers cannot normally be recommended to use these materials as a substitute for the more expensive metham-sodium.

Whereas metham-sodium injection is apparently a more attractive practice than steam sterilization by virtue of its low variable costs and low fixed costs it must be borne in mind that high opportunity costs are associated with its use. A delay of up to 10 weeks following the use of this material may necessitate the loss of a crop in the grower's succession.

An alternative means of soil sterilization used by one grower in 1962 involved the use of a rotating drum flash sterilizer. Earlier results with this portable machine had shown promise but this was not fulfilled in 1962: it now seems doubtful that soil border sterilization is really a very appropriate task for this machine. Variable costs of operation - paraffin, petrol and rotavator operating costs - were £3.7 in total per 1,000 sq. ft.: the labour input was 38 hours per 1,000 sq. ft.

A much more likely substitute for sterilization by steam or chemicals on small nurseries is the grafting practice which has recently received wide interest. No data pertaining to this practice were available in the 1962 survey. A number of growers in the East Midlands have used this technique in 1963 and 1964 and initial results are highly promising. Some figures calculated by the N.A.A.S. in Somerset have been widely publicised. The variable costs of propagating rootstocks, which are additional to the crop plant propagation costs, appear to be in the order of £2.2 for every 1,000 sq. ft. of glasshouse planted. The additional labour input, based on the N.A.A.S. data, would be about 8 hours per 1,000 sq. ft. planted. No figures collected from growers have yet been published to verify the N.A.A.S. evidence.

It has not been possible to identify the benefits obtained from sterilization treatments in the 1962 survey data, although there is no shortage of suitable information collected in experiments. A yield increase of up to one third over untreated crops growing in the same but disease-infected soil seems likely following steam sterilization or metham-sodium injection. The additional yield required to break even on variable costs is relatively slight, although the fixed costs must, of course, be carried by the whole crop succession.

Choice of varieties and method of nutrition

Little useful information under this heading has been obtained under the 1962 survey. Concerning varieties, it is likely that information on varietal performance is a form of planning data which is always more likely to be obtained from experiments that from economic surveys. Ultimately the grower, with his cultural advisers' help, can only resolve this for himself under his own conditions.

Table 11 shows that the costs of manures and fertilisers was a relatively small proportion of total variable costs. Much experimental work has been carried out by the N.A.A.S. and commercial firms which has indicated the importance of precise application of fertilisers, and growers are recommended to seek N.A.A.S. advice on tomato feeding and watering. There is little scope for cost saving under this item.

The potential reward for better husbandry by the grower-retailer

Much of the text of this report has been directed towards growers who evidently were not making the best use of the opportunities presented by tomato growing in the East Midlands. This applied particularly to growers with outlets of a sales-to-shop or retail nature but there were, of course, important exceptions within those groups.

A number of reasons appear to explain the lower average yields realised by the growers in groups 2, 4 and 6 (Table 8):-

(a) Some growers may be led into complacency by the high levels of realised prices for their products with consequent below optimum working capital investment.

(b) Overdiversification of crops is typical of retailing growers and this generates neglect of husbandry and management.

(c) Retailing growers are usually "small" business men: it is conceivable that they are more conscious of risk than specialist growers, hence a reluctance to spend money on fuel, etc.

(d) The desire to maintain a source of revenue all the year round is characteristic of many retailing growers. This militates against chemical sterilization techniques.

To strengthen the argument that many grower-retailers might improve on their levels of profit by paying more attention to cultural management, a hypothetical calculation has been included. The following assumptions

have been made:

(a) A grower-retailer in 1962 realised the same average prices per month as the growers in group 4 in Table 8. His monthly yields were the same as group 4. Accordingly, his total gross output per 1,000 sq. ft. was £132.5.

(b) If his monthly yields had been the same as the averages of Group 3 in this table, no difficulty in selling the extra fruit would have arisen.

Supposing that by superior technology, this grower could have obtained the same yield as the average of group 3 in Table 8, but that his realised prices remained as before, a useful increase in total gross output and gross margin would have resulted, as is shown below in Table 19, even supposing as this table does that no increase in earliness was achieved. £49.4 (i.e. the difference between £181.9 and £132.5) was the potential increase in gross output if the above assumptions were fulfilled.

THE REWARD FOR BETTER HUSBANDRY

Table 19

Month	Actual Average Net realized Prices	Actual Average Yield	Actual Gross Output	Assumed Higher Yield	Resulting Higher Gross Output
	£ per 12 lb. tray	12 lb. trays per 1,000 sq. ft.	£ per 1,000 sq. ft.	12 lb. trays per 1,000 sq. ft.	£ per 1,000 sq. ft.
June	1.7	11.8	19.8	16.0	27.2
July	1.2	51.5	63.9	59.6	71.5
August	1.0	35.1	36.6	49.7	49.7
September	0.8	10.4	8.4	33.7	27.0
October	0.6	6.3	3.8	10.9	6.5
TOTAL	1.2	115.1	132.5	169.9	181.9

Table 11 shows that average total variable costs of group 4 in 1962 were £36.1 per 1,000 sq. ft. Had the grower in this example found it necessary to double this average expenditure to achieve the potential increase in gross output, there would still have remained an addition to gross margin. In practice, such a high level of increased expenditure would be improbable unless the grower aimed for a much earlier crop. Had the grower's variable costs risen by £19.8 to the average of group 3, his additional gross margin as the result of better husbandry would have been

£29.6 per 1,000 sq. ft. Where practicable, increased earliness might be expected to increase gross margin further.

It is frequently claimed that tomato growing does not pay. Is this argument used by some growers who could do better? A grower who achieved the yield increases budgeted above would be obtaining no more than 40 tons per acre total yield, which is unremarkable in itself.

LABOUR REQUIREMENTS OF HEATED TOMATOES IN 1962

In this report it has been assumed that all regular and other labour costs were fixed and that the costs of regular labour did not affect the relative profitability of heated tomatoes to other crops. A factor which partly undermines some growers' and advisers' confidence in the use of the gross margin approach in horticulture is the high proportion of total costs usually represented by labour costs in horticultural businesses. In any circumstances, growers are interested in increasing the productivity of this resource which costs them more year by year. Furthermore, information on the seasonality of labour inputs is desirable for the best use to be made of gross margins of crops for planning purposes. Accordingly, a discussion has been included of the detailed labour records which were collected from most holdings in the 1962 survey. The recording of this item caused the greatest difficulty to the larger scale growers whose crops mainly fell into groups 1 and 2. Accordingly, data for all early crops have been combined in subsequent tables of group results. Previous tables did not suggest striking differences in the yields and total variable costs of groups 1 and 2 and this method of presentation would thus seem legitimate.

Table 20 shows group weighted average seasonal requirements in worker hours per 1,000 sq. ft. Operations associated with propagation and maintenance of glasshouses have been omitted from this and subsequent tables. Table 21 shows the individual results of the highest margin crops in each group: the data from Number 31 have again been used in this table, and crop Number 40 had to be substituted for Number 44.

No very coherent pattern has emerged from the study of seasonal labour inputs in the 1962 survey data. This is probably due to the wide range of alternative practices which were available to the growers. Furthermore there was great inter-holding variation in the months in which some jobs were tackled - especially work on sterilization and house preparation.

In general, it was exceptional for monthly input to exceed 20 hours per month per 1,000 sq. ft. of glasshouse.

GROUP AVERAGE MONTHLY LABOUR REQUIREMENTS

Table 20

Group	1 and 2	3	4	5	6
Hours per 1,000 sq. ft.					
January	11.1	3.3	1.0	2.9	9.4
February	20.4	1.9	21.6	1.3	3.3
March	17.1	7.9	10.8	14.6	5.7
April	13.1	14.9	9.9	15.2	16.3
May	17.6	11.7	10.0	17.4	11.0
June	22.0	15.4	8.4	15.4	12.0
July	15.5	15.0	16.3	18.1	15.0
August	7.0	11.4	14.8	20.7	16.8
September	0.8	7.0	10.2	11.5	11.6
October	-	4.1	-	2.9	0.5
November	-	7.9	-	0.7	-
TOTAL	124.6	100.5	103.0	120.7	101.6
Number of Crops	6	4	5	8	6

A different approach to the analysis of the labour inputs in 1962 has been adopted in Tables 22 and 23. These show weighted group averages and "best holding" data for six categories of work in hours per 1,000 sq. ft. for the whole season. As with the other data examined, it was apparent that group average results in the above tables concealed a wide range of growers' attainments with respect to labour use.

In Table 22 the greater inputs for watering and feeding in groups5 and 6 are striking. In this table, all the records of early crops were for trickle watering and feeding. Only one of the crops in groups 3 and 4 was hand watered, the remainder in each group being equipped with trickle harness. Most of the crops in group 5 and all crops in group 6 were hand watered. Of the individual records in Table 23, only that of crop number 40 relates to hand watering.

These tables confirm the popular view that hand watering is much more demanding in its labour requirements. It was of interest to note that almost all the larger scale crops in the survey were hand watered. Table 23 would suggest that the most profitable crops can be grown with semi-

MONTHLY LABOUR REQUIREMENTS OF HIGHEST MARGIN CROPS

Table 21

Crop number	62	30	31	35	47	40
Hours per 1,000 sq. ft.						
January	-	-	-	7.9	4.3	-
February	14.3	42.7	-	10.0	4.1	-
March	21.0	16.9	-	24.2	10.6	10.2
April	9.3	3.0	15.4	11.7	10.0	14.0
May	18.7	4.0	2.4	11.7	13.8	13.4
June	24.3	17.2	17.2	12.7	16.7	9.8
July	44.3	14.5	15.7	20.2	17.4	18.0
August	4.3	9.1	10.9	15.8	17.7	13.5
September	-	9.1	6.0	14.3	10.6	9.6
October	-	-	9.7	0.2	1.5	-
November	-	-	23.2	-	-	-
TOTAL	136.2	116.5	100.5	128.7	106.7	88.5

GROUP AVERAGE ANALYSIS OF LABOUR INPUTS

Table 22

Group	1 and 2	3	4	5	6
Hours per 1,000 sq. ft.					
Preparation and planting(1)	23.0	15.3	32.1	18.6	20.0
Training(2)	30.4	41.8	29.0	32.3	24.7
Watering and feeding	9.8	4.4	8.3	26.7	24.6
Ventilating and stoking	8.6	9.8	5.4	10.3	8.6
Picking and packing	24.1	22.2	23.4	23.9	16.5
Miscellaneous	4.6	7.0	4.8	8.9	7.2
TOTAL	100.5	100.5	103.0	120.7	101.6
Number of crops	5	4	5	8	5

(1) "Preparation and planting" includes sterilization, ball watering and laying trickle harness.

(2) "Training" includes stringing, tieing and deleafing.

ANALYSIS OF LABOUR INPUTS OF HIGHEST MARGIN CROPS

Table 23

Crop number	62	30	31	35	47	40
Hours per 1,000 sq. ft.						
Preparation and planting	18.0	55.6	28.5	35.2	22.0	7.6
Training	43.6	25.5	35.5	25.4	31.4	18.7
Watering and feeding	12.6	4.6	2.9	6.7	9.8	20.2
Ventilating and stoking	3.0	4.6	5.3	11.2	5.1	16.0
Picking and packing	53.3	19.8	18.6	40.6	30.3	18.3
Miscellaneous	5.7	6.4	9.7	9.6	8.1	7.7
TOTAL	136.2	116.5	100.5	128.7	106.7	88.5

automatic watering. However, where the larger scale growers were practising hand watering, the reason was not so much one of prejudice against modern practices as the need to occupy the regular labour force all the year round and to provide a certain amount of overtime work so as to retain the services of skilled labour.

The labour requirements of steam sterilization and chemical sterilization were discussed in an earlier section.

The figures for ventilating and stoking are of interest. Table 22 shows no striking reduction in this labour input for the later grown crops, although it has been remarked earlier that most of these crops were not heated late into the season. It so happened that most of the crops grown with hand-fired installations were in the late groups. The difference in labour input with oil-burning installations and hand-fired coke burning boilers was very apparent in the records of two of the crops included in Table 23. Crop number 62 was oil-fired from 28th February to 31st July. Crop number 40 required over five times as much labour per 1,000 sq. ft.: it was heated by hand firing methods from 20th March until 31st May. Quite apart from this reduction in labour input, growers who have semi-automatic installations are much better equipped to control their temperature regimes. Remaining crops in Table 23 were produced with an underfeed stoker and sectional boiler, burning washed singles. This type of installation saves much labour over hand firing but evidently did require rather more attention than oil burners.

A major item for all growers was the labour input for training. All the operations in that category require hand work. It was interesting to find that only one grower in the survey sample used piecework rates for these operations: labour incentives of other kinds were not evident on many of the nurseries although in some cases regular skilled staff were paid somewhat more than basic wages.

SUMMARY

The 1962 survey described in this report followed an initial enquiry in 1961. Data were collected and have been presented in this report for weighted average and best individual results of six groups of growers, classified by earliness of production and types of market outlet. The information has been presented in a form useful for management advisory purposes, although it cannot be claimed that the data are sufficiently representative or based on an adequate time-span for any use as standards without the most cautious interpretation.

In general the advantages of early production with respect to increased gross margin per 1,000 sq. ft. have been confirmed. It has been shown that only properly equipped and skilled growers should attempt really early production in an area as unfavoured as the East Midlands. Other growers would seem better advised to produce fairly late planted crops. It appears that all growers can derive benefit by keeping their heating system in use throughout the season; by careful attention to the control of soil pests and diseases (or by use of grafting techniques) and by careful pursuit of N.A.A.S. advice on feeding and watering. Where a grower is not in a position to grow early tomatoes, the survey results have suggested that sound cultural management can still realize a high gross margin: in particular most growers with retail outlets might pay much more attention to their opportunities, which they largely lost in 1962 through poor cultural standards.

Regular labour costs were treated as fixed for all holdings. Data of seasonal labour inputs and the inputs for various tasks have been analysed in terms of hours per 1,000 sq. ft. Modern systems of stoking, watering and soil sterilization with chemicals or steam would appear to offer considerable potential reductions in labour.

Further studies have been initated in 1964, in which additional data on crop weights, gross outputs and heating costs are being collected.

APPENDIX I

MANAGEMENT RECORDS AND THEIR INTERPRETATION IN THE GLASSHOUSE BUSINESS

In recent years farmers have increasingly turned to their N.A.A.S. advisers for management advice. Although this tendency is only slowly appearing in the horticultural industry, it is probable that growers in the future will find nothing strange in keeping financial and physical records and discussing these regularly with their county horticultural officers and university economists.

Of course, all growers already have some simple records, from which their accountants prepare annual statements of income and expenditure. Many growers regard even this elementary book-keeping with evident displeasure as a necessary evil required for negotiations with the Inspector of Taxes and the bank manager, yet if nothing more is available than these annual financial accounts, the management adviser can make only slight headway with any business. He can advise the grower how the past performance of the whole business compares with the best managed businesses with respect to output and the use of various resources. Past major weaknesses in organisation can be detected, but such an analysis does not usually identify the enterprises which may be contributing to any inefficiency. This means that the adviser must rely on his experience to develop a solution; he can draw on the data in his advisory manual and his knowledge of the organization and cropping programmes in other known local successful businesses. How much better if he can propose a solution based on detailed physical and financial data which the grower can provide for each crop grown in previous years! The better the records, the better the quality of the advice.

Most growers are well aware of these facts. They appreciate that they are forfeiting opportunities for higher incomes if they cannot provide detailed management records. Yet it has become part of the folklore of horticulture that most growers will avoid paperwork whenever they can and, of course, there are a number of reasons for this.

1. The level of wages rises steadily and very many growers appear to undertake manual work comparable with that expected of their hired workers, with overtime, in order to minimize this item of cash outlay. Hard manual work is a poor preparation for even an hour's attention to the management records. Yet often, the need for him to engage in such manual work is a symptom of poor organization by the grower.

2. Horticultural businesses sometimes produce a wide range of crops. A system of recording suited to a simple farm organization may be impracticable in many glasshouse businesses.

3. Recording difficulties are particularly acute where concerned with small scale operations in propagation houses and where produce is retailed.

4. Allocation of heating costs where a centralized heating system is being used with a mixed cropping programme is a complex and not particularly accurate procedure. (See Appendix III). Unfortunately centralization of the heating system is a frequent outcome of sound management advice!

5. Many growers do not understand the economic principles involved in keeping records, which they may confuse with total cost accounting. It is only recently that any clear guidance has been available in print, in the form of N.A.A.S. leaflets. While it is possible to sympathize with these arguments, some of them are more real than others. In fact, because horticultural businesses are very heterogeneous in size, layout and available resources and because growers do not all have the same financial and other ambitions, different situations arise which demand different levels of detail in the records which a management adviser would recommend. These notes do not attempt to explain <u>how</u> records should be kept but it is intended to show <u>what</u> different types of record can be useful.

No records are worth keeping unless they either:

(1) enable the grower and his adviser to check on the efficiency of past cropping, or

(2) provide a basis for forward planning.

The grower who seeks to increase his income cannot escape some effort in this direction.

<u>The Grower's Diary</u>

There are two possible pathways to increasing many growers' income: one is to refine methods and techniques of growing crops; the other is to improve organization. A simple diary of events and quantities provides an important starting point for each pathway. It is frequently found in management advisory work that the grower cannot make available any precise information even concerning the area or number of crops grown. This

information is obviously basic to any discussion of the cropping programme. Further physical data which is useful concerns such items as the dates of sowing, planting and harvesting and the dates between which the heating system is in use. Management studies of heated tomato crops in the East Midlands have illustrated the importance of these elementary data.

Records of Gross Output and Yield

Where a grower can break down his cash returns and allocate these accurately to the various crops produced, he has available data which are both useful for checking back and for budgeting forward. The adviser can examine the variance between the growers' actual gross outputs and the standard data. This analysis is strengthened where records of yield, i.e. numbers or quantities sold, can be examined at the same time. Yield records are particularly useful to the adviser as a guide to technical performance - some "management" problems may be solved by reference to these alone. Some measures of the quality of the produce and the efficiency of the growers' marketing practices may be derived from the records of value of gross output and of yield, as average net realized prices can be calculated and these can also be compared with standards.

Most but not all horticultural crops display some correlation between their cash value, i.e. gross output, and profitability, i.e. gross margin. In the absence of detailed costings, data on gross outputs (subject to there being no obvious weaknesses in past attainment) thus provide some basis for selecting crops or successions for the future programme. Commercial horticulture is characterized by wide year to year fluctuations in revenue from individual crops and it is desirable to base forward planning on an average of at least three year's past results with glasshouse crops.

Records of Variable Costs

When a grower effects any change in the organization of his business or in his choice of practices, certain items of expenditure will alter in total as the direct consequence of that change: other items will remain unaffected by the change. The former category of costs are variable, the latter fixed.

Where the change concerns adjustments to the cropping programme it is likely that the following items of expenditure will normally remain fixed: rent, rates, office expenses, vehicle repairs (and depreciation), glasshouse and equipment repairs (and depreciation). These items in total will amount to a fairly stable sum from year to year. Under such circumstances it is likely that all costs of seed and materials, heating fuel and probably casual labour will be variable. Regular labour is most likely to be fixed on a small-scale nursery, but is more likely to be a variable cost on a large establishment.

When a grower embarks on costing his crops, there is no logical point in keeping additional financial records of any fixed costs and allocating these to the crops. Such an exercise could, in fact, be misleading: the total of these fixed costs is not likely to be altered by changes in the future organization of the cropping programme where present resources are employed. The objective in costing is to record those costs which may be expected to alter in total as a direct consequence of the grower's decision to change the area allocated to the production of each crop. These records provide a further basis for checking past performance with advisory standards.

The difference between the gross output of a crop and its total variable costs is its gross margin. The gross margin is the most logical indicator of the profitability of the crop. It is the contribution made by the crop to paying fixed costs and providing a surplus for the grower's labour, management and investment income. Gross margin per unit area indicates the profitability of the crop in relation to other crops grown, bearing in mind that average gross output should be used to calculate average gross margins for use in crop planning.

The objective in crop planning is to maximize the total of gross margins at a given level of fixed costs (which may be predicted with some confidence) by selecting the high margin crops or successions, subject to the grower's attitude to the risks involved, the availability of working capital and seasonal labour to implement the plan and the technical feasibility of the proposals. It follows that at any total of fixed costs, the higher the total of gross margins, the higher the grower's income will be.

Records of Seasonal Labour Inputs

Even though regular labour is normally treated as a fixed cost, there is still a purpose to be served by recording, in physical terms, the seasonal contributions of all labour needed to produce each crop and to harvest known yields. This information provides valuable supplementary data for selecting crops from the hierarchy of gross margins. Furthermore, the records may highlight some season of the year where present methods are capable of improvement to reduce the labour input by method-study techniques. The records may also show seasonal labour bottlenecks which may lead to neglect and hence to poor yield or quality in some crops: this is a matter that might be cured by reorganization.

To sum up, simple records are essential for all growers and are certainly concerned with data which it will pay growers to identify. More detailed records of variable costs allow the determination of gross margins, which are a more sophisticated measure of profitability than gross outputs alone. Seasonal labour data are the ultimate refinement.

Clearly, no grower will be advised to record in an unnecessary depth of detail which he is unlikely to be able to complete and the nature of the precise records needed is a matter for individual advice.

APPENDIX II

INDIVIDUAL RESULTS IN THE 1962 SURVEY :

EARLY CROPS

Group I

Code number	10	12a	60	62	70	71
Yield tons/acre	35.1	20.3	48.9	55.6	36.4	48.0
lb./plant	5.2	3.6	9.9	8.3	5.7	7.4
12 lb./1,000 sq. ft.	150.6	87.0	209.7	249.3	156.1	205.9
Average net realized price per 12 lb. (Wholesale)	£ 1.3	£ 0.9	£ 1.0	£ 1.1	£ 1.2	£ 0.9
Gross Output per 1,000 sq. ft.	190.9	74.0	213.7	265.9	192.6	188.0
Total Variable Costs per 1,000 sq. ft.	67.8	63.8	62.5	69.4	78.3	66.7
GROSS MARGIN per 1,000 sq. ft.	123.1	10.2	151.2	196.5	114.3	121.3

Group 2

Code number	4	11	22	30
Yield tons/acre	35.8	22.9	53.7	49.0
lb./plant	5.9	4.1	7.5	9.9
12 lb./1,000 sq. ft.	153.5	98.0	230.1	210.2
Average net realized price per 12 lb. (Retail/shops)	£ 1.9	£ 1.1	£ 0.9	£ 1.7
Gross Output per 1,000 sq. ft.	288.9	111.3	210.9	354.0
Total Variable Costs per 1,000 sq. ft.	95.1	44.6	76.7	51.5
GROSS MARGIN per 1,000 sq. ft.	193.8	66.7	134.2	302.5

MIDSEASON CROPS

Group 3

Code number	1	12b	21	31	80
Yield tons/acre	23.4	38.4	43.8	35.2	57.3
lb./plant	3.9	6.2	7.7	6.7	11.8
12 lb./1,000 sq. ft.	100.4	164.7	187.5	150.6	245.3
	£	£	£	£	£
Average net realized price per 12 lb. (Wholesale)	0.9	0.6	1.0	1.2	0.5
Gross Output per 1,000 sq. ft.	88.6	103.3	178.1	183.1	116.0
Total Variable Costs per 1,000 sq. ft.	46.4	57.2	50.6	58.7	58.3
GROSS MARGIN per 1,000 sq. ft.	42.2	46.1	127.5	124.4	57.7

Group 4

Code number	6	32	35	42	43
Yield tons/acre	33.6	17.0	44.2	33.5	14.8
lb./plant	6.1	2.7	8.3	6.6	2.8
12 lb./1.000 sq. ft.	143.9	72.8	189.6	143.6	63.4
	£	£	£	£	£
Average net realized price per 12 lb. (Retail/shops)	1.1	1.5	1.2	1.1	1.2
Gross output per 1,000 sq. ft.	150.7	112.4	228.1	156.0	77.4
Total Variable Costs per 1,000 sq. ft.	16.8	65.8	51.4	47.3	28.4
GROSS MARGIN per 1,000 sq. ft.	133.9	46.6	176.7	108.7	49.0

LATE CROPS

Group 5

Crop number	3	15	16	17	18	23	47	48
Yield tons/acre	19.5	31.9	20.2	16.1	35.0	28.9	38.2	32.9
lb./plant	4.0	5.5	3.3	2.8	5.5	5.3	6.5	6.1
12 lb./1,000 sq.ft.	83.8	136.7	86.7	69.0	150.0	123.9	163.9	141.1
Average net realized price per 12 lb. (Wholesale)	£ 0.5	£ 1.0	£ 0.9	£ 1.0	£ 1.0	£ 0.8	£ 1.0	£ 0.7
Gross Output per 1,000 sq. ft.	61.1	135.8	74.9	68.3	149.4	98.1	156.2	101.3
Total Variable Costs per 1,000 sq. ft.	19.9	35.3	30.1	38.6	32.3	46.6	13.2	46.8
GROSS MARGIN per 1,00 sq. ft.	41.2	100.5	44.8	29.7	117.1	51.5	143.0	54.5

Group 6

Crop number	40	44	46	50	51	52
Yield tons/acre	19.2	23.8	22.2	23.6	19.3	21.6
lb./plant	3.1	4.3	3.7	5.3	3.6	3.4
12 lb./1,000 sq. ft.	82.2	102.0	95.3	101.2	82.8	92.7
Average net realized price per 12 lb. (Retail/shops)	£ 1.6	£ 1.8	£ 1.0	£ 0.7	£ 0.9	£ 1.2
Gross Output per 1,000 sq. ft.	129.7	178.3	98.3	74.3	74.4	109.8
Total Variable Costs per 1,000 sq. ft.	27.8	27.2	20.3	18.4	11.1	30.8
GROSS MARGIN per 1,000 sq. ft.	101.9	151.1	78.0	55.9	63.3	79.0

APPENDIX III

METHODS FOR CALCULATION OF GLASSHOUSE HEATING COSTS[1]

One of the greatest obstacles to management recording in small glasshouse businesses is the difficulty associated with allocating heating costs to crops where more than one crop is grown simultaneously with a centralised heating system. Where the crops are grown with different temperature regimes the problem is even more complicated. Under such circumstances, it is impossible to avoid some error in calculating the heating costs for each crop. A number of techniques were used in calculating variable costs of fuel where precise data could not be provided by growers participating in the 1962 Tomato Survey. The two most applicable procedures are described below.

1st Method

This was used where more than one crop was grown with the same heating system but where no intentional temperature differential was maintained between houses. In each case it proved possible to obtain a reasonably accurate estimate of total fuel consumption over the period for which the tomatoes were heated. The proportion of this fuel allocated to tomatoes was based on the percentage of the gross glasshouse area occupied by the tomatoes. Supposing that a grower had a block of glass with different lengths of piping in otherwise similar houses, it would seem better to allocate on the basis of percentage of total length of pipework.

2nd Method

This more complicated method was used where an intentional temperature differential between crops was introduced by the grower. This method was based on a modification of the 'U formula':-

$$U = 1.4T\ (A + \frac{a}{2})$$

where U = Heat loss in British Thermal Units,

T = Temperature lift on ^{o}F,

A = area of glass in sq. ft.

a = area of brickwork in sq. ft.

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(1) The writer particularly wishes to acknowledge the help of Dr. L. G. Bennett of Reading University, and of Mr. R. C. Dale and Mr. G. Smith of the N.A.A.S.

Since the elegant calculations required by heating engineers were not appropriate to this survey, the formula was modified as follows for each crop grown on the heating system:

$$U = 1.4 \times T \times A \times W$$

where U = proportion of total fuel used by the crop,

T = average weekly temperature lift over the crop season, ^{o}F,

A = area of land covered by the crop,

W = the weeks for which the crop was heated.

To use this method, the following datawere required:

1. Total fuel bills for the period.
2. Target temperatures for each crop grown on the heating system, or preferably actual records of mean of minimum and maximum temperatures in the crop houses.
3. Mean of weekly minimum and maximum temperatures out of doors.
4. Information on the areas of each crop and the length of weeks for which it was heated.

For the survey purposes, item 3 was based on meteorological records from one centre in the East Midlands. The following example should illustrate how this technique was employed.

Crop Number 6

1. Total fuel consumption 2,000 gallons 3,500 sec. oil: one boiler.
2. Target temperatures : Block A $60^{o}F$
   Block B $50^{o}F$
   Block C (Tomatoes) $60^{o}F$

3.

Week ending	Rounded Mean weekly temperatures °F	°F lift to 60°F	°F lift to 50°F
23rd April	49	11	1
30th April	47	13	3
7th May	52	8	-
14th May	50	10	-
21st May	49	11	1
28th May	49	11	1
4th June	56	4	-
11th June	59	1	-
18th June	60	-	-
25th June	54	6	-
	Weekly Average =	7.5	0.6

4. All crops were heated throughout the period (hence W is ignored).

Crop areas : Block A 12,000 sq. ft.

B 2,000 sq. ft.

C 7,000 sq. ft.

Block A Fuel used = 1.4 x 7.5 x 12 = 126.0

Block B " " = 1.4 x 0.6 x 2 = 1.7

Block C (tomatoes) " " = 1.4 x 7.5 x 7 = 73.5

201.2

Fuel used for tomatoes = $\frac{73.5}{201.2}$ x 2,000 gallons

Approximately equals 735 gallons, cost £28.8

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