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# A PRELIMINARY ECONOMIC SURVEY OF THE CITRUS INDUSTRY IN NEW ZEALAND.

Vol. I.

W. M. Hamilton

# C O N T E N T S.

## A PRELIMINARY ECONOMIC SURVEY OF THE CITRUS INDUSTRY IN NEW ZEALAND.

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FRONTISPIECE. A fine cluster of St.Michael sweet oranges grown in a commercial North Auckland orchard. New Zealand can produce a type of sweet orange, which, while perhaps not equal to the finest imported is of a sufficiently high standard of quality to meet with consumer approval and could probably supply a large part of the local demand for oranges.

# F O R E W O R D.

This survey was undertaken primarily because it was considered that some comprehensive survey was a necessary preliminary to any sound advancement in the citrus industry in New Zealand. Of necessity it has been subject to limitations of time and of means to collect all the data which would have been desirable; many of the data are not yet available or are of a confidential nature while many of the "facts" frequently quoted with regard to the industry are little more than assumptions - an unsafe foundation for the sound development of the industry. The survey is therefore tendered, not as the last word with respect to the aspects of the industry discussed, but rather as a partial collection of such information as is at present available, presented in fairly logical sequence, and with some attempt to give a balanced and comprehensive, if somewhat sketchy outline of the industry in its various phases.

Much information, of a detailed nature, dealing with particular phases of the industry was, of necessity, excluded, in order to preserve the balance of the whole, while owing to the limitations of time and finance it has not been possible to check as carefully as would have been wished, the tables and statistical analyses. There are doubtless minor errors in computation in some of the tables and some errors in the typing which have escaped detection but it is hoped that these ommissions will not be regarded too critically.

In the sections dealing with factors affecting production, and production costs the analyses deal with only one years figures and it is realised that the analysis of subsequent years data might yield results of quite different magnitude although it is considered unlikely

that general trends would be affected. This weakness has been corrected as far as possible by giving tables in terms of relative yields wherever possible, but in certain cases this has not been possible, e.g. age and production, and surveys conducted over a period of years are necessary in order to form a sound judgment as to average values. Similarly costs per case vary considerably according to the size of crop marketed in any given year, and the figures drawn out for 1934 may be wide of the average. Only a series of surveys can determine points such as these, and such a basis for the development of the industry is very necessary.

Such limitations do not, however, destroy the significance of the analyses, nor seriously detract from the original intention of giving as comprehensive a survey of the field as was possible with the limited time and funds available. It will be serving its purpose if it succeeds in inducing those interested in the industry to undertake a systematic stocktaking, and review the whole problem before embarking on any scheme of greater development to supply the local market.

It is only with some trepidation that the last two chapters dealing with the organisation of the industry and its possible future have been added. This was never intended to be more than a preliminary survey and the conclusions or suggestions which are made in those concluding chapters are, therefore, of a somewhat tentative nature. The writer reserves the right to alter his opinions on the policies suggested there when more complete data are at his disposal and more time is available for consideration of the problems which they present.

August, 1935.



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## PART 1 INTRODUCTORY.

### CHAPTER 1. SCOPE AND METHOD.

A. Introductory. B. Method of Collecting Data.
C. Location of Orchards Visited.

### A. INTRODUCTORY.

With increasing competition in the world's markets for our main primary products and the imposition of quotas and other restrictions to the free flow of international trading the Dominion is faced with a serious economic crisis. A plexus of favourable factors operating over a period of years has resulted in the rapid expansion of our main primary industries. This rapid expansion has been accentuated rather than retarded by the fall in world prices for our primary products, producers having endeavoured to offset the fall in prices by increasing their volume of output, thus tending further to accentuate the drop in prices.

The possible diversification of our primary production therefore assumes fresh importance under the stress of adverse world prices for our staple products and the threat of regulated shipments to our main market, Great Britain. The Dairy Industry Commission in its report states (p.50) "The development of the citrus-fruit industry to supply fully the local market with those types which can be grown in New Zealand is a reasonable objective".

It was therefore felt that the time was opportune for collecting and collating such information as was

available regarding the citrus industry; the types of product that might profitably be produced, the methods of management in vogue, the cost of production, the markets available, a careful study of imports and the possibility of replacing imports, in part or in whole, by locally grown citrus fruits.

## B. METHOD OF COLLECTING DATA.

The information contained in this analysis was collected by personal visits to seventy-two of the larger growers of citrus fruits. These growers kindly consented to supply such information as they had available regarding methods of management, production and prices realised etc. (See Survey form used, Appendix 1.) At the same time visits were made to the establishments curing and marketing citrus fruits, the main growers' and research organisations were approached for information, the wholesale and retail trade in the main centres of the North Island was interviewed while the various Government Departments co-operated in supplying information.

## C. ORCHARDS VISITED.

Of the seventy-two orchards visited twenty-four were situated at Keri Keri, eight at Whangarei, one at Warkworth, twenty-two in the Auckland District, fourteen at Tauranga, two at Gisborne and one at Petane. (Plate 1. shews the position of the groves visited). The wide distribution of the growers visited is recognised as being a distinct disadvantage insofar as the validity of any conclusions in regard to management practices may be concerned, but, owing to this being a preliminary survey, unavoidable. In any case after making due allowance

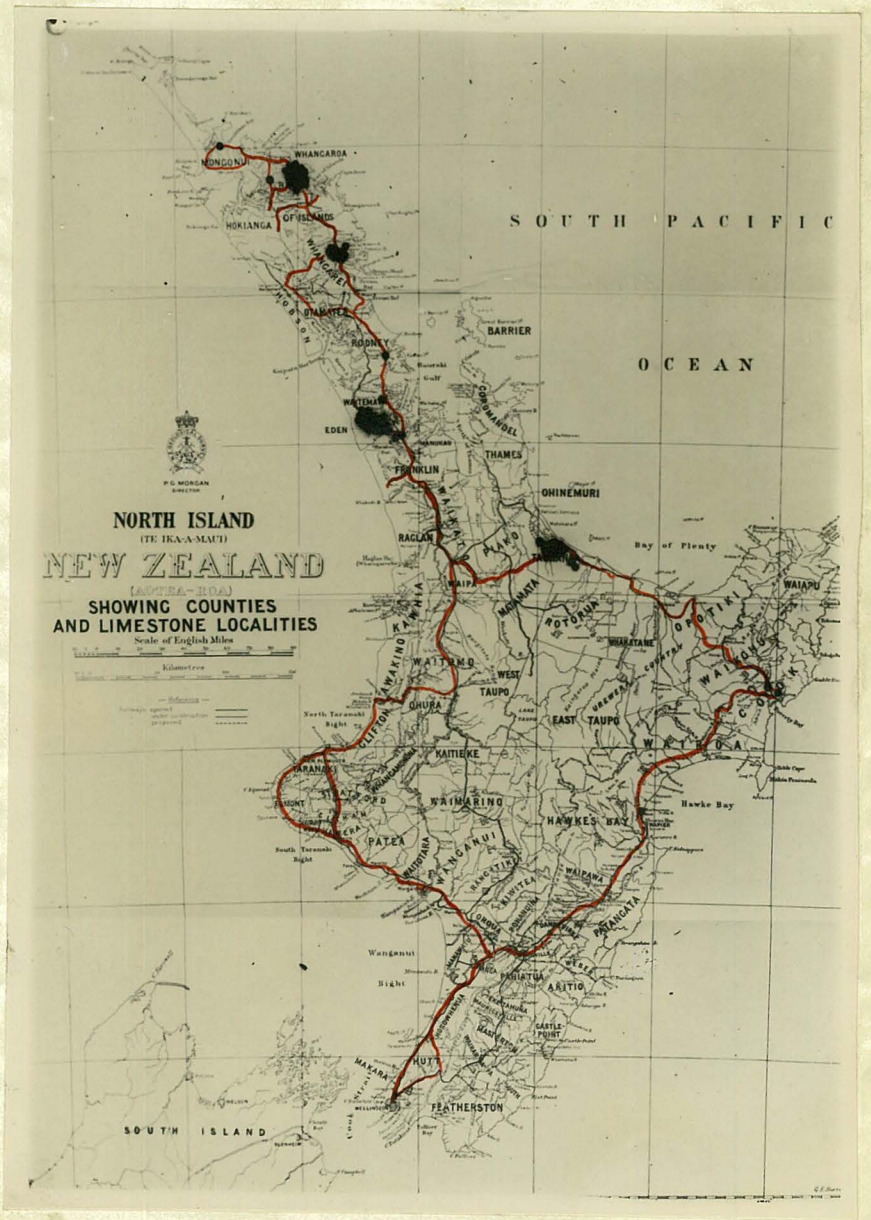


PLATE 1. Pin Map shewing the distribution of the groves visited during the course of the survey, 1934. The red line indicates the main route followed.

for the wide distribution of the growers it must be stated that the growing of citrus fruits demands a set of conditions which can vary only within certain limits, and except in isolated cases such as Keri or Tauranga it is doubtful whether any one district contains sufficient growers working under uniform conditions to warrant the application of the survey method to the study of their problems of management.

For the purposes of this survey, which can be regarded only in the light of a reconnaisance of the position, the returns from the various districts have been treated as a unit with the consequence that the conclusions drawn must not be accepted as final nor as necessarily applicable in individual cases but serve only as an indication of probable trends as a basis for further investigation.

## CHAPTER 11. HISTORICAL SURVEY.

A. Early Development. B. Later Development. C. Present position of the industry.

### A. EARLY DEVELOPMENT.

The early history of the introduction of citrus fruits into New Zealand has received the attention of Mr. Geo. A. Green and I am indebted to him for the following notes culled from a lecture delivered before the Palmerston North Rotary Club.

"As far as is known, the first authenticated introduction of oranges into New Zealand was made by Mrs. James Kemp, one of the missionary party who arrived at Keri Keri, Bay of Islands, in August, 1818, bringing with her a few sweet orange pips from Sydney. It is recorded that these were planted in a box of soil at Keri Keri on August 10th, 1818. Two young trees resulted, both of which are alive and bearing fruit today (1935). One of these is now growing at the residence of the Misses Kemp's, Keri Keri; the other at Waimate North at Mr. W. H. Mountain's.

"Shortly after or before this time the rough lemon (citronelle) was introduced and rapidly spread from the Mission Stations to the Maori settlements throughout the north. A printed record states that in the year 1828 fruiting trees of both lemons and oranges existed at Tauranga.

"Lemons were introduced into Nelson in the early 40's of last century, being planted by a Mr. Pickard at Motupipi.

"About 1850 several commercial nurseries were established in and about Auckland. These introduced both sweet oranges and lemons, mostly from Sydney, and these were widely distributed. Among early nurserymen were Messrs B. T. Hawkins, the late David Hay Senr., and the late C. T. Wren. The late Sir George Grey also imported for his private collection, and among his importations was the original strain of our Poorman orange (N. Z. Grapefruit), which in recent years has been much improved by the selection of superior seedless strains.

"About 1870 considerable interest commenced to develop in the cultivation of citrus trees and commercial named types of both sweet oranges and lemons were introduced in quantity, the lemons being confined to the Lisbon type while the oranges included the St. Michael, Paramatta and Selletta.

"Between 1875 and 1880 several commercial plantings of citrus were made, the largest being those of Mr. H. B. Dobbie and Mr. L. Hanlon, both of Whangarei, the former at one time producing 7,000 bushel cases of sweet oranges a year. In the eighties of last century New Zealand lemons of high quality commenced to feature on the markets of the North Island, while in 1890 Mr. E. Morrison of Warkworth, staged a most comprehensive exhibit of oranges, lemons and grapefruit at the citrus exhibition in Brisbane, for which he was awarded a gold medal.

In 1884, Mr. Geo. E. Alderton published a small "Treatise and Handbook of Orange-Culture in New Zealand", this being printed by the Government Printer with a view of encouraging the more extensive cultivation of Citrus fruits, in the northern portion of New Zealand, and of aiding planters with reliable information on the subject."

"Other varieties such as the Eureka and Villa Franca were introduced from California about 1890 and later a type of Eureka known as "Sweet Rind" was introduced from Sydney. The Genoa was introduced by the Department of Agriculture and planted in the experimental block at Tauranga about twenty years ago."

Probably the largest importer of citrus varieties in later years has been Mr. H. R. Wright of Avondale, who now has probably one of the largest collections of citrus varieties in the Dominion

Latterly also, the Citrus Committee of the Institute of Horticulture, working in conjunction with the Department of Scientific and Industrial Research, has introduced pedigree budwood of the leading standard varieties of oranges and lemons from California and Australia. These have now been "worked" on a variet y of rootstocks and test trees planted in the Mt. Albert Citrus Test Area.

B. LATER DEVELOPMENT OF THE INDUSTRY.

As has been mentioned, considerable plantings of sweet oranges were made during the latter part of last century. With the advent of this century, however, and the improved overseas transport provided, the production of sweet oranges declined largely owing to the increasing competition and cheaper freights on fruit from Australia and the Islands.

A steady development occurred during the next three decades, plantings of lemons and "Poorman" oranges keeping pace with the expanding internal market, while during the latter part of the period sweet oranges have again been widely planted.

The following Tables give an indication of the increase in the number of bearing trees over the period 1922-30 (exclusive of trees planted in Boroughs) and also gives an indication of the amount of fruit harvested each year; the same data are presented graphically in Fig. 1.

Such data as are presented in the "Agricultural and Pastoral Statistics" in respect of the number of bearing citrus trees must be accepted with caution when considering the growth of the industry as a whole, since these figures exclude all trees within Borough boundaries, the number of which must be quite considerable as it includes such areas as the Avondale Flats which are within the Auckland City boundary. Also assuming that fifty per cent of the trees now planted in registered orchards (see Table 111, p.9a and Table 1V p.11 ) are not yet in bearing, the number of bearing citrus trees at 1/10/34 was 61,686; i.e. one would have to assume if the figures given in Table 1 represent accurately the position of the industry as at 1930 that the number of bearing trees has doubled in the period 1930/34. Notwithstanding that the increase may have been rapid over the period it is probably safe to infer that the apparent increase is in some measure at least due to a deficiency in the numbers quoted for 1930.

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TABLE 1.

Shewing the number of bearing orange and lemon trees in the Dominion (exclusive of Boroughs) for the period 1922-30.

| | 1921-2 | 1922-3 | 1923-4 | 1925-6 | 1927-8 | 1928-9 | 1929-30 |
|---|---|---|---|---|---|---|---|
| Orange trees | 2,572 | 2,417 | 3,312 | 5,282 | 6,660 | 8,159 | 6,501 |
| Lemon trees. | 13,661 | 16,223 | 19,971 | 20,606 | 26,403 | 28,795 | 24,907 |
| Total trees | 16,233 | 18,640 | 23,283 | 25,888 | 32,063 | 36,954 | 31,408. |



+

TABLE 11.

Shewing the production of bearing orange and lemon trees in the Dominion (exclusive of Boroughs) in bushels, for the period, 1922-30.

| Production (bushels) | 1921-2 | 1922-3 | 1923-4 | 1925-6 | 1927-8 | 1928-9 | 1929-30. |
|---|---|---|---|---|---|---|---|
| Oranges | 3,439 | 3,738 | 2,623 | 5,649 | 6,311 | 7,971 | 8,390 |
| Lemons | 10,956 | 10,998 | 13,844 | 22,369 | 26,230 | 35,869 | 37,412. |
| Total | 14,404 | 14,736 | 16,467 | 28,018 | 32,541 | 43,840 | 45,802. |

+ Date derived from the Govt. Statistician's figures contained in Agricultural and Pastoral Statictics. Unfortunately owing to economy measures no data are available later than the 1929-30 season.

# FIGURE 1.

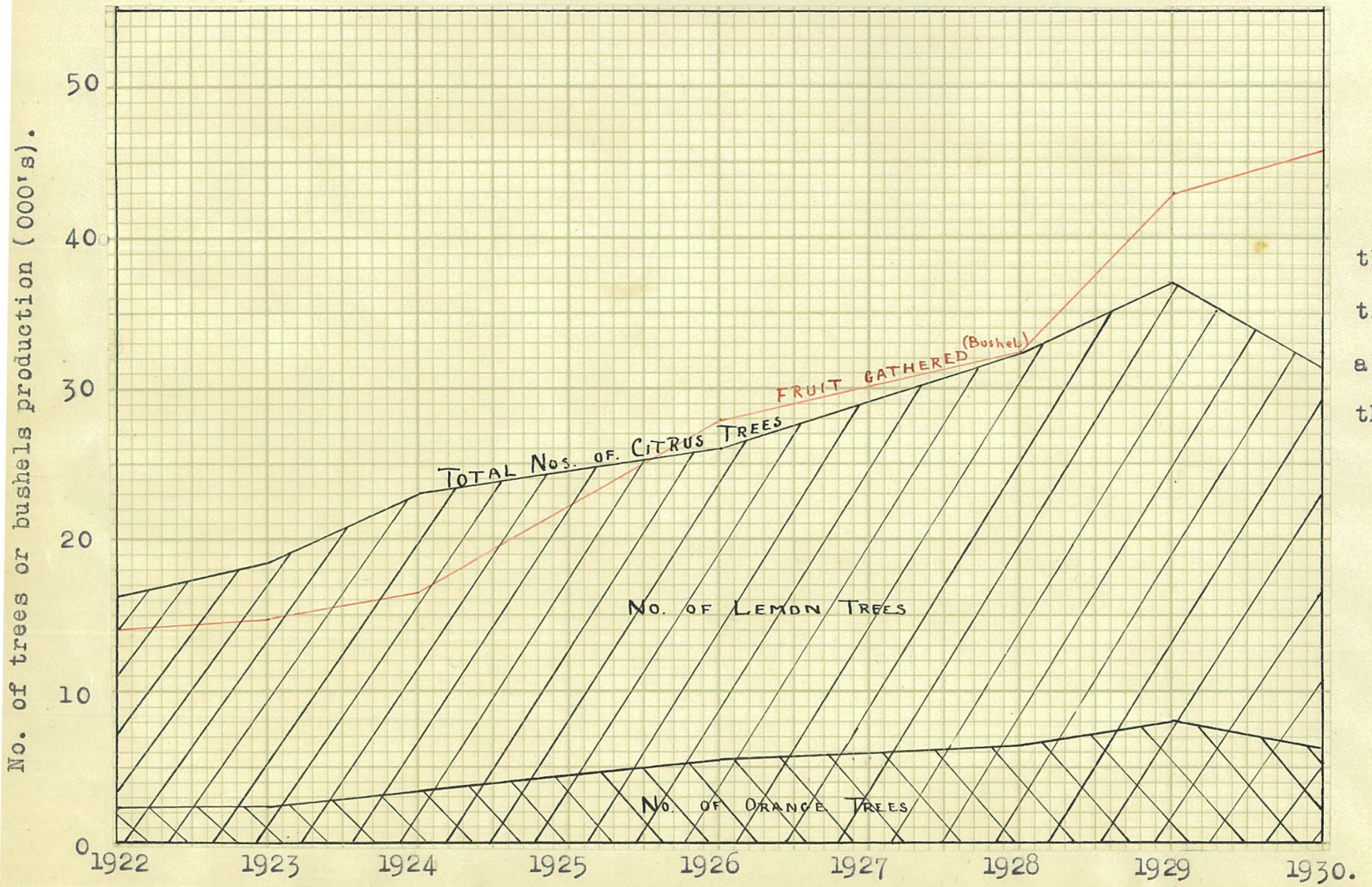


Figure shewing the increase in the number of bearing orange and lemo trees over the period 1922-30 and also the increase in production over the same period.

An interesting feature made apparent by Fig.1 is the general trend towards higher production per tree over the period 1922-30 and would suggest that with payable prices citrus growers have given more attention to their trees with a consequent increase in production; it might of course be suggested that the increase in per tree production is due, in part at least, to the increasing age of the plantings and such is also probably a contributory factor.

## C. PRESENT POSITION OF THE INDUSTRY.

### (1) Total citrus trees planted

By courtesy of the Horticulture Division of the Department of Agriculture a list of the registered+ growers of citrus fruit in the Dominion was made available and the figures have been analysed in Table 111., shewing the number of citrus growers, analysed according to the size of grove.

The Table discloses that at 1/10/34 there were 2,798 "registered growers" of citrus fruits. The analysis discloses however, that a preponderance of the growers can scarcely be considered to be "commercial growers" owing to their small number of trees, 69.5% having less than 21 trees each and controlling only 9.5% of the total number of trees. By including the next group (i.e. 21 -50 trees) the position is that 81.5% of the registered growers have less than 51 citrus trees and of the total number of citrus own only 18.6%.

Considering the larger growers, having over 200 trees, one finds that 153 growers (5.3% of total) own 51.6% of the total citrus trees. These are the only growers who may be considered to be "commercial" growers

+ A registered grower is one licensed to sell fruit, and is not to be confused with a "taxable" grower.

## T A B L E Lll.

Shewing the Number of Registered Citrus Growers in the Dominion Classified According to Size of Orchard, as at 1/10/34.

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| Group No. of trees. | No. of Growers | % of Total. | No. Lemon trees. | No. orange trees. | Total No. trees. | % Total No. | Average in group. |
|---|---|---|---|---|---|---|---|
| 1-20 | 1947 | 69.5 | 8,544 | 3,254 | 11,803 | 9.5 | 6.0 |
| 21-50 | 337 | 12.0 | 8,710 | 2,588 | 11,298 | 9.1 | 33.5 |
| 51-100 | 217 | 7.7 | 12,426 | 3,579 | 16,005 | 12.9 | 73.7 |
| 101-200 | 144 | 5.1 | 16,314 | 4,050 | 20,364 | 16.5 | 141.4 |
| 201-350 | 77 | 2.7 | 14,830 | + 5,069 | 19,899 | 16.1 | 258.4 |
| 351-600 | 58 | 2.0 | 14,689 | 12,498 | 27,187 | 22.0 | 468.7 |
| 601-1000 | 15 | 0.5 | 8,120 | 3,087 | 11,207 | 9.0 | 747.1 |
| Over 1000 | 3 | 0.1 | 2,340 | 3,274 | 5,614 | 4.5 | 1871.3 |
| Totals. | 2,798 | | 85,973 | 37,399 | 123,372 | | 44.0 |

+ This figure for the number of oranges is unusually large due to the fact that the majority of the plantings in the Keri Keri Group Settlement Scheme fall into this group.

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in the sense that they own sufficient citrus to in any way approach giving a sufficient labour reward for one labour unit.

The significance of these figures in relation to their bearing on problems of marketing and organisation of the industry will be further discussed under those headings but it should be borne in mind that of the total of 2,798 registered growers only 153 may be classed as mainly dependant on citrus as a source of income; in the case of growers having fewer than 201 trees citrus culture must be regarded as being chiefly a supplementary source of income and it is the preponderance of this class of grower that renders extremely difficult the organisation of standardised marketing of the product.

The Table shews the total number of lemon trees to be 85,973 (bearing and not bearing) and the number of orange trees (sweet orange and N.Z. Grapefruit) as 37,399 giving the total plantings of citrus in registered orchards as at 1/10/34 as 123,372 trees.

This figure may be taken as substantially correct since a comparison of the numbers planted as shewn on the Horticulture Division's lists and the number found by visits to individual growers shew good aggreement in the aggregate. Of the 56 growers who supplied satisfactory returns in answer to enquiries the listed total of trees was 30,043 while personal enquiries shewed a total number of 31,019 trees, i.e. approx. a 3% variation, which must be regarded as a very satisfactory agreement.

The estimate of The Citrus Committee of the N. Z. Institute of Horticulture (1:1934) that up to the end of 1932, 250,000 citrus trees had been planted must be regarded as grossly overstating the position even after making due allowance for the number of trees in unregistered orchards. Their figures would probably be a much closer approximation to the true position, in respect of plantings, if halved.

(11) Proportion of Bearing to Not Bearing Trees:

Unfortunately no indication is contained in the Horticulture Division's lists as to the proportion of bearing and not bearing trees and no reliable data are available on this point.

An indication of the position may be obtained by an analysis of the groves visited during the present survey but conclusions based on these figures must be regarded as tentative only.

T A B L E IV.

Shewing the numbers and proportion of bearing to "not-bearing" trees in the groves visited during the survey.

| | Bearing Trees. | % of total | "not-bearing" trees. | % | Total trees. |
|---|---|---|---|---|---|
| Lemons (excluding Keri Keri) | 5,892 | 56% | 4,551 | 43% | 10,443 |
| Lemons - total | 5,892 | 34% | 11,352 | 65% | 17,244 |
| N.Z. Grapefruit | 2,626 | 59% | 1,777 | 40% | 4,403 |
| Oranges (exclusive of Keri Keri) | 705 | 75% | 231 | 24% | 936 |
| Oranges (total) | 705 | 7% | 8,252 | 92% | 8,957 |
| Other citrus var. | | | | | 415 |
| Total all varieties | 9,223 | 29.7% | 21,381 | 69% | 31,019. |

It is probable that the percentages shewn above for all varieties is unduly weighted by the inclusion of a large proportion of "not-bearing" trees at Keri Keri. As a basis for estimate it is probably safe to assume that 50% of the plantings of lemons and N. Z. Grapefruit (poor-man orange) are as yet not in bearing and that in respect of sweet oranges the majority of planting are not yet productive.

Utilising this tentative basis for the purposes of estimate would mean that the total number of bearing lemon trees in the Dominion would be in the vicinity of 42,000 trees. The position in regard to sweet oranges and N.Z. Grapefruit provides no satisfatory basis on which to form an estimate since both varieties are grouped together in the lists available.

## PART 11.- GEOGRAPHICAL DISTRIBUTION OF CITRUS INDUSTRY.

### CHAPTER 111 FACTORS AFFECTING DISTRIBUTION OF CITRUS GROWING AREAS.

A. Soil, B. Rainfall. C. Topography
D. Climatic factors: 1. Wind, 2.Temperatures, 3.Humidity,
E. Nearness to market or transport facilities,
F. Proximity to other Growers.

Owing to the susceptibility of citrus trees to damage by other than light frosts, their culture in New Zealand is necessarily limited to the more northerly parts of the Dominion, with the exception of certain localised areas further south where conditions are unusually favourable. Of the citrus trees grown in the Dominion, only 8.6 per cent occur south of the Auckland Provincial area and may for the purposes of this survey be omitted from further consideration.

The commercial growing of citrus demands a certain plexus of factors to ensure its ultimate success and is probably more sensitive in its demands than most other branches of primary production. The attempt to secure all factors in optimum is a difficult one and has led to the localisation of the industry in certain well defined areas.

The important factors are briefly as follows:-

A. Soil

B. Rainfall

C. Topography of the land.

D. Climatic factors:
(1) Wind.
(11) Temperatures.
(111) Humidity

E. Nearness to market or transport facilities.

F. Proximity to other growers.

A. Soil

The primary consideration in choosing a soil for citrus is that it should be exceptionally well drained; it is doubtful whether under our relatively heavy rainfall conditions in New Zealand any soils are sufficiently well drained naturally; practically all New Zealand soils require under-drainage to secure minimum loss of trees from root disease.

The most desirable soil is a medium sandy loam, which, while retentive of moisture during the summer is yet sufficiently light to facilitate good drainage and cultivation operations. Fertility is a secondary consideration to good physical condition and most of the citrus in New Zealand is growing on other than "first-class land" with the exception of the Gisborne District, and the later volcanic soils of the Whangarei District and the Auckland Isthmus (includes only a small proportion of the citrus groves).

Sandy soils of an extremely open porous nature are unsuitable, as they do not hold sufficient moisture, and commercial fertilisers, when applied, leach readily so that the full benefit from their application is not obtained.

The presence of a hardpan of ironstone or impervious clay should be avoided as it leads to waterlogging of the soil during heavy rain and frequently to heavy scouring of the surface soil.

Hume (18:1926) says: "If the surface is good tillable earth, with a fair admixture of sand, , so as to open it up, and the subsoil is somewhat closer so as to hold moisture and prevent leaching, the ideal conditions have been found."

B. Rainfall.

Under New Zealand conditions, where irrigation is not practised, an ample well distributed rainfall is desirable (See Table 1Va). An average of at least fifty inches per annum well distributed over the year is desirable since, with less rain, dry periods are liable to occur, as in 1934, and cause severe losses in production. The effect of such periods of low precipitation during the summer months is accentuated by the fact that insolation is then at its maximum. It has been suggested that irrigation in such seasons would sufficiently increase crops to recoup the cost of installation and leave a substantial margin of profit, but so far as is known no growers in the citrus districts have adopted such a plan, although several growers in the Henderson District are considering using water from the Auckland City mains during exceptionally dry seasons.

C. Topography.

The land should be of level or gently sloping topography to facilitate cultivation and minimise erosion of the soil by heavy rains. The idea that a slope assists drainage is probably in many cases falacious and even much sloping land will be greatly benefitted by artificial drainage.

Level or gently undulating country is also easier to shelter from wind than hilly country and in a region such as New Zealand where winds are often severe, this is a point not to be overlooked.

Topography and elevation in regard to surrounding land surfaces also have an important bearing on the incidence of frost. This is shewn very markedly in the case of

the Waipareira valley

## TABLE 1W (a)

Mean Monthly Rainfalls and Number of Wet Days registered at the principal stations in the citrus areas.

(Rainfall in inches).

| | January: | February: | March: | April: | May: | June: | July: | August: | September: | October: | November: | December: | Year: |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Russell: | 3.09<br>8.6 | 3.05<br>7.1 | 3.26<br>8.8 | 4.11<br>11.8 | 7.29<br>16.1 | 6.38<br>14.3 | 6.12<br>14.9 | 4.94<br>15.2 | 4.12<br>13.1 | 3.93<br>11.6 | 2.63<br>8.6 | 2.47<br>7.9 | 51.39<br>138.0 |
| Kaikohe: | 3.39<br>10.6 | 3.10<br>7.6 | 3.27<br>7.3 | 5.75<br>13.0 | 8.31<br>18.0 | 7.35<br>18.5 | 6.29<br>18.8 | 4.89<br>18.3 | 5.07<br>15.8 | 4.93<br>14.5 | 3.05<br>12.0 | 2.81<br>10.4 | 58.21<br>164.8 |
| Whangarei: | 3.85<br>10.7 | 3.97<br>9.7 | 4.49<br>11.6 | 4.85<br>13.9 | 7.95<br>18.2 | 6.37<br>18.2 | 7.21<br>18.4 | 6.22<br>18.5 | 4.90<br>16.2 | 4.71<br>14.9 | 2.98<br>12.0 | 2.93<br>10.6 | 60.43<br>172.9 |
| Warkworth: | 3.16<br>10.5 | 4.20<br>9.1 | 3.10<br>9.0 | 5.10<br>13.2 | 8.39<br>15.2 | 7.77<br>17.4 | 6.80<br>16.9 | 4.15<br>14.9 | 4.91<br>15.0 | 4.92<br>15.4 | 3.65<br>12.7 | 3.62<br>11.0 | 59.77<br>160.3 |
| Henderson: | 3.11<br>14.8 | 4.21<br>13.8 | 3.26<br>14.7 | 4.98<br>19.9 | 7.38<br>23.7 | 5.86<br>22.4 | 6.23<br>23.7 | 4.44<br>22.0 | 5.33<br>24.4 | 5.00<br>20.6 | 3.60<br>20.7 | 3.89<br>19.5 | 57.29<br>240.2 |
| Patutahi: | 2.57<br>7.7 | 3.42<br>9.1 | 4.22<br>10.9 | 3.30<br>9.7 | 4.50<br>11.7 | 3.74<br>11.2 | 4.30<br>12.7 | 3.65<br>13.2 | 2.92<br>10.5 | 2.53<br>9.8 | 1.87<br>9.3 | 2.17<br>7.8 | 39.19<br>123.6 |
| Tauranga: | 4.09<br>10.5 | 3.64<br>8.7 | 3.99<br>10.9 | 4.71<br>11.6 | 5.13<br>13.7 | 5.28<br>13.8 | 4.95<br>14.7 | 4.20<br>14.1 | 4.28<br>14.0 | 5.17<br>14.8 | 3.33<br>12.0 | 3.51<br>11.3 | 52.28<br>150.1 |
| Hastings: | 1.44<br>8.3 | 1.60<br>8.3 | 2.10<br>9.4 | 2.28<br>9.7 | 4.09<br>11.4 | 2.38<br>11.9 | 3.80<br>12.4 | 2.91<br>13.8 | 2.21<br>13.6 | 1.30<br>10.5 | 1.94<br>9.1 | 2.14<br>8.6 | 28.19<br>127.0 |
| Nelson: | 3.26<br>8.5 | 2.11<br>6.7 | 2.56<br>8.5 | 3.49<br>9.6 | 3.70<br>10.3 | 2.47<br>10.0 | 3.31<br>10.6 | 2.92<br>10.7 | 3.34<br>11.7 | 4.05<br>11.9 | 2.99<br>11.2 | 3.77<br>9.2 | 37.97<br>118.9 |

the Moerewa Valley near Kawa Kawa where it is impossible to grow citrus trees in the open owing to frosts caused by the drainage of cold air from the high land surrounding into the valley. In other cases, a difference in elevation of a few feet may make all the difference between suitable and unsuitable land for citrus.

D. Climatic Factors:

(1) Wind: Very windy districts should be avoided; hence the west coast, on the whole, is unsuitable, and the citrus districts tend to localise on the east coast. Protection may also be gained from prevailing winds by a judicious choice of site in relation to the local configuration of the land.

(11) Temperature: "The bulk of the oranges which supply the markets of the world are produced in countries which experience a certain degree of frost, such as California, Spain, Florida, Palestine, Australia, Japan and Italy. Oranges grown in moist tropical countries are lacking in tartness, color, shipping and keeping qualities. All of these qualities, so desirable in a marketable orange, become more marked as we approach the line where frequency of frosts makes the culture of the trees unprofitable." (7:1927).

Temperatures below 30 degrees F. are, however, becoming limiting factors to the growing of most types of citrus on a commercial scale. Such a critical temperature is, however, subject to variation within limits according to the influence of other factors chief amongst which are:-

(a). Diseases. Diseased conditions such as bark blotch or other disturbing factors either of a physiological or a fungous nature lower the resistance of a tree to frost.

(b). The general vitality of the tree which is influenced by the manuring and general treatment. Nitrogen, sufficient to give a dark green colour but not to cause sappy growth seems from Tauranga experience (10:1935) to have a definite effect in increasing the resistance to frost injury.

(c). Dormancy. The citrus tree is never completely dormant, but any practices tending to give soft growth late in the autumn should be discouraged; severe pruning, heavy nitrogenous manuring or late cultivation should be avoided where frost damage is likely to occur.

(e) Stocks. Few data are available in New Zealand on the influence of the stock in increasing frost hardiness, but there seems to be some little foundation in Florida for the belief that trees worked on trifoliate orange are more resistant than those worked on sweet orange or citronelle, but no conclusive information is yet available for New Zealand conditions

(f) Variety. Hume (18:1926) arranges the citrus varieties commonly in cultivation in the following order of hardiness:-
(1) Trifoliate orange, (2) Satsuma mandarin, (3) Sour orange, (4) sweet orange, (5) grapefruit, (6) lemon (including citronelle), (7) lime, citron and shaddock.

West, of the Griffeth Research Station, N.S.W. found that under normal conditions lemons would withstand conditions of 28 degrees F., and sweet oranges 26 degrees F. without damage, but any temperature which may be given is subject to the influence of numerous other factors outlined above.

Slow thawing results in a diminished injury after frost, and may have an appreciable practical application in the placing of shelter belts to assist in avoiding frost injury, e.g. a high shelter belt on the eastern side of a grove may shield frosted trees from the early morning sun and avoid serious injury.

In attempting to establish a correlation between the degree of frost and the resultant injury to citrus trees, it is necessary to differentiate between a "ground frost" as recorded at a meteorological station and the temperature of the air surrounding the tree. A much better correlation is likely to exist between minimum air temperatures as recorded in the standard Stevenson screen and degree of injury to citrus trees.

In this respect Kidson states(20:1935): "In accordance with a European convention, a ground frost is considered to have occurred when the temperature recorded by a minimum thermometer, one inch above the ground on an open, grassed surface, has fallen below 30.4 degrees F. Damage, even to tender low-growing plants, is unlikely at higher temperatures". "Many of the ground frosts referred to in the preceding paragraphs are confined to a very shallow layer at the surface and most plants are tall enough to escape their effects. Furthermore, the readings obtained by a grass minimum thermometer depend very much on the precise position in which it is placed. There is an increasing tendency, therefore, to concentrate on the readings of sheltered thermometers at a height of about 4 feet above ground, such as are obtained in the standard Stevenson screen."

However, in past discussions on the damage resulting from a frost it has been usual to consider the minimum on the grass and such have little significance in relation to citrus. A particular instance occurred in the case of a ground frost of 14 degrees at Tauranga in May, 1931, accompanied by a minimum screen temperature of 22.5 degrees F. This frost caused widespread damage to citrus trees in the district, yet a ground frost of 14 degrees at

Gisborne in 1934 caused no more damage than slight yellowing of immature fruit and the dropping of occasional leaves from soft growth; unfortunately no record is available of the minimum temperature recorded in the screen on this occasion. Possibly, also, other factors, such as the conditions at thawing may have entered into the damage occurring in this example, but it serves to illustrate the caution which must be exercised in drawing conclusions based on the degree of ground frost.

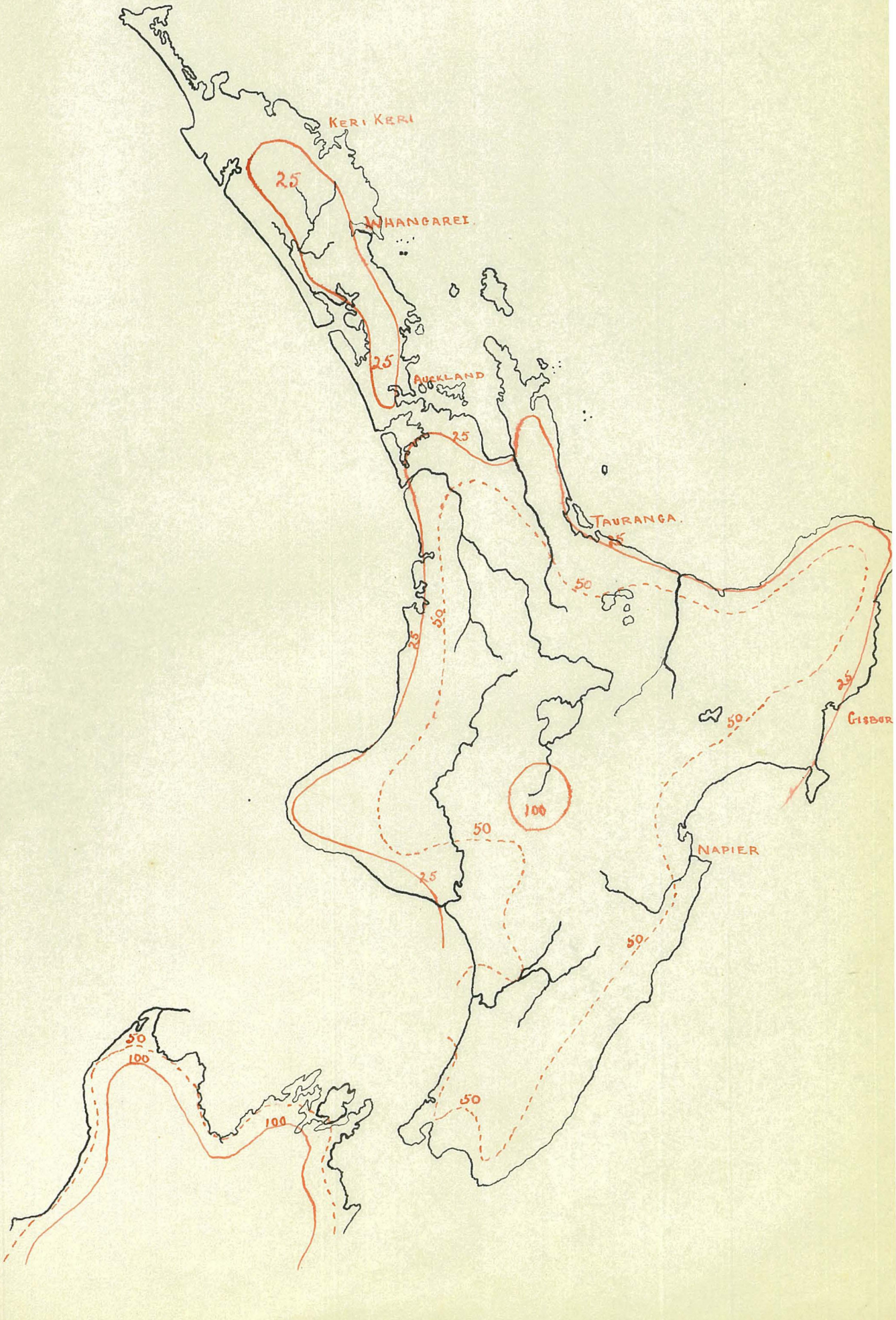
Figure 11 shews, for the North Island the number of days with ground frost per annum, while Figure 111 shews the more significant feature, namely the number of days per annum with minimum shade temperature below 32 degrees F. It will be noted that the principal citrus growing districts fall in the area of 25 ground frosts per annum or less, but this number is fairly frequently exceeded at Tauranga and Gisborne. The North Auckland peninsula and the Auckland district fall in the area of less than 10 days per annum with a minimum shade temperature below 32 degrees F., while a narrow coastal belt along the east coast of the peninsula comes in the area of no days below 32 degrees F. recorded. Tauranga and Gisborne on the other hand fall between the 10 and 25 days per annum frequency lines.

"Frost, however, is a very local phenomenon, and the frequency of occurrence may vary within wide limits over a comparatively small area."(20:1935). This tendency to localisation of frosty areas in the citrus districts is very marked and makes it a matter of extreme difficulty to map the "frost free" areas.+

+ Frost free is used here as a purely relative term in respect of the growth of citrus fruits.

## F I G U R E  11.

Shewing the Number of Days with Ground Frost per annum. (After Kidson). Note that the main citrus areas fall either outside, or just on the line of 25 frosts per annum



## FIGURE 111.

Shewing the number of days with Minimum Shade Temperature below 32°F. (After Kidson).

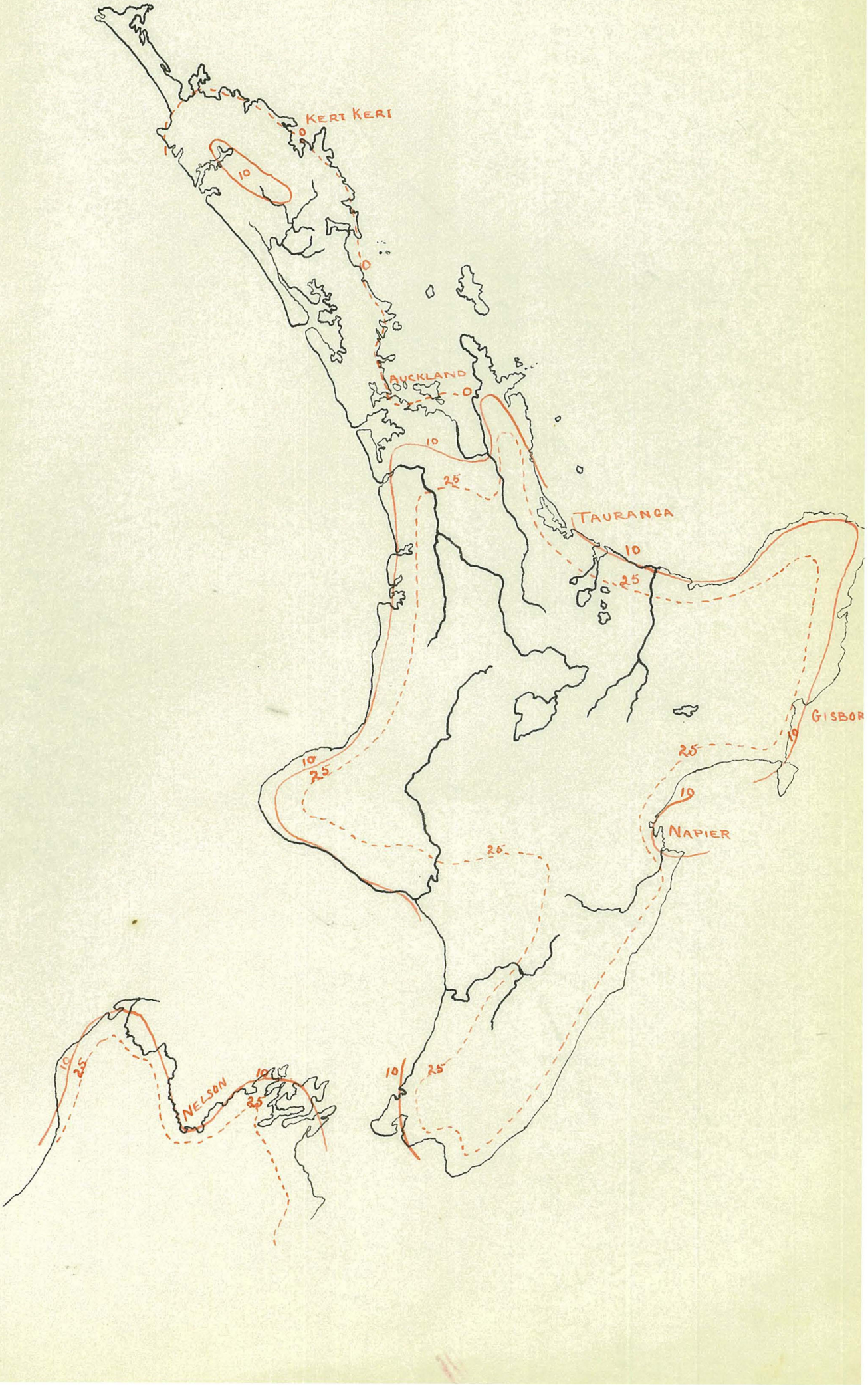


TABLE V.

Mean Number of Frosts in the Screen in the Main Citrus Areas.

| DISTRICT. | JAN. | FEB. | MAR. | APRIL. | MAY. | JUNE | JULY | AUG. | SEPT. | OCT. | NOV. | DEC. | YEAR. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AUCKLAND. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | Nil. |
| TAURANGA | 0.0 | 0.4 | 0.0 | 0.1 | 0.9 | 3.0 | 4.5 | 2.7 | 1.1 | 0.2 | 0.0 | 0.0 | 13.0 |
| GISBORNE | .. | .. | .. | 0.2 | 0.5 | 3.0 | 4.5 | 2.2 | 0.7 | .. | .. | .. | 11.0 |
| HASTINGS | .. | .. | .. | 0.3 | 4.9 | 6.8 | 10.7 | 5.6 | 4.6 | 1.1 | 0.1 | .. | 34.1 |
| NELSON | .. | .. | .. | .. | 0.2 | 3.4 | 4.8 | 2.6 | 0.9 | .. | .. | .. | 12.1 |

# TABLE VI.

Mean Values for Meteorological Observations at Auckland and Tauranga.

## AUCKLAND (160 ft.)

| | Jan | Feb | Mar | April | May | June | July | Aug | Sept | Oct | Nov | Dec | Year. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mean Daily Maximum | 72.6 | 72.9 | 70.9 | 66.9 | 62.1 | 58.6 | 57.0 | 57.8 | 60.1 | 63.2 | 66.0 | 69.3 | 64.8 |
| Mean highest maximum | 78.6 | 78.6 | 76.4 | 72.2 | 67.3 | 64.0 | 62.5 | 62.8 | 65.4 | 68.6 | 72.0 | 75.7 | 79.7 |
| Absolute highest maximum | 81.5 | 85.0 | 79.0 | 77.4 | 71.0 | 67 | 65 | 67 | 70 | 72 | 75.5 | 79 | 85 |
| Mean Daily Minimum | 59.7 | 60.4 | 58.5 | 55.3 | 51.3 | 48.1 | 46.2 | 46.2 | 48.9 | 51.7 | 54.1 | 56.8 | 53.1 |
| Mean Lowest Minimum | 51.8 | 53 | 51.5 | 46.4 | 42.7 | 39.5 | 38.1 | 39.1 | 41.7 | 44.3 | 47.1 | 49.4 | 37.3 |
| Absolute Lowest Minimum | 48 | 48 | 46 | 41 | 38 | 36.5 | 35 | 36.4 | 37.8 | 41 | 41 | 43.5 | 35 |
| Days of frost in screen | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 0.0 |
| Days of ground frost | .. | .. | .. | .. | .. | 0.1 | 0.7 | 0.1 | .. | .. | .. | .. | 1.0 |
| Relative Humidity | 77 | 75 | 78 | 79 | 81 | 80 | 82 | 80 | 80 | 79 | 79 | 77 | 79 |

## TAURANGA (22 yrs).

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mean Daily Maximum | 74.1 | 74.5 | 72.4 | 67.9 | 62.7 | 58.8 | 57.6 | 58.8 | 61.9 | 65.2 | 68.2 | 71.9 | 66.2 |
| Mean highest Maximum | 83.1 | 82.2 | 80.8 | 74.4 | 68.9 | 65.7 | 63.6 | 64.7 | 69.3 | 72.3 | 75.9 | 81.5 | 85.0 |
| Absolute highest maximum | 87.5 | 87.0 | 86.5 | 78.5 | 75.0 | 71.5 | 68.0 | 67.8 | 75.0 | 78.0 | 83.0 | 87.0 | 87.5 |
| Mean Daily Minimum | 53.9 | 54.9 | 51.8 | 48.1 | 44.2 | 40.6 | 39.5 | 40.0 | 42.7 | 46.5 | 49.1 | 51.3 | 46.9 |
| Mean Lowest Minimum | 42.8 | 44.0 | 41.1 | 36.5 | 32.5 | 29.9 | 29.3 | 30.1 | 32.0 | 34.3 | 38.1 | 39.2 | 27.9 |
| Absolute Minimum | 37.1 | 35.0 | 34.5 | 31.0 | 22.5 | 23.8 | 24.5 | 24.2 | 21.0 | 25.0 | 31.0 | 31.5 | 21.0 |
| Frost in screen | .. | 0.4 | 0.0 | 0.1 | 0.9 | 3.0 | 4.5 | 2.7 | 1.1 | 0.2 | .. | .. | 13.0 |
| Ground frost (6yrs) | 0.2 | 0.0 | 0.0 | 2.4 | 9.7 | 14.2 | 16.0 | 14.2 | 7.7 | 4.2 | 1.3 | 1.3 | 71.2 |
| Relative Humidity (4 yrs.) | 71 | 75 | 76 | 79 | 78 | 82 | 84 | 84 | 81 | 79 | 78 | 74 | 79 |

Not only are insufficient data available in the citrus areas, but the variations are extremely rapid and complex, to which must be added the difficulty that citrus trees differ in their susceptability to frost injury, as outlined in a previous paragraph. However, the area shewn in Figure 111 as having less than 10 days per annum may be taken as representing the majority of the areas suitable for citrus growing; it must be emphasised, however, that even within this area there are numerous areas where, owing to local configuration of the land or other conditions frosts are experienced of too great severity for the successful commercial culture of citrus, e.g. Moerewa valley and numerous other areas. (See Figure 11. Area enclosed, more than 25 frosts per annum).

Many of the frosts experienced in this belt are of the "gravity" type, i.e. due to the settling of cool air from higher land surrounding a valley. A level plain or valley bottom will be more subject to frost than a hill slope, and a hollow in a plain still more so. Table V shews the mean number of frosts in the screen in the main citrus areas, while Table V1 shews the mean values for temperature records at Auckland and Tauranga.

Apart from configuration of the land the incidence of frosts is affected by other factors such as the humidity of the atmosphere, the amount of moisture present in the soil and in groves close to shallow tidal estuaries the state of the tide has an influence, frosts tending to be less severe when high tide is between 3-5 a.m.

Whatever method is used in attempting to correlate temperature with the growth of citrus on a commercial scale, it is open to a great many sources of error; the final test must always be the success of trees in actual growth on the area.

(111) Relative Humidity: The average relative humidity of the atmosphere throughout the citrus districts in the Dominion is relatively high and this is probably inimical to the production of fruit of the finest colour, texture (rind) and keeping qualities. Most of the oranges supplying the world's markets come from areas having a low average relative humidity and a maximum of sunshine; conditions usually only realised under irrigated conditions.

(D) Nearness to Market or Transport Facilities:

With improved overseas communication the cost of landing fruit in our markets has been considerably reduced so that the margin of protection afforded by freight differences in favour of the local grower has been considerably reduced and in the case of shipments to South Island ports has in some cases become negligible. The question of proximity to markets therefore becomes increasingly important.

For example take two growers, A. and B.; A situated in close proximity to the market and able to deliver his fruit for two pence a case; B. situated in a more remote district but supplying the market at a cost of 1/2d. Given equal quality fruit, A. stands to receive a nett return of 1/- per case more than B., which on a per acre basis on a full-bearing grove represents approximately £20 per acre per annum. Capitalised, this means that A. could afford to pay £400 per acre more for his land than B., assuming other costs to be equal, and still be on an equal competitive basis. Such differences do actually occur, in supplying some of the main markets in the Dominion. In this respect the Auckland district is particularly favourably situated since it has a large local market and is served by both rail and boat for shipping to southern markets.

Transport, in the early stages of the development of the industry, was principally by rail or boat and in consequence there was a tendency for growers to select orchard sites in close proximity to shipping or rail facilities. With the advent of efficient and speedy road transport this factor has probably ceased to exercise a measurable effect on the location of groves.

(E) Proximity to other growers.

This has probably exerted a measurable influence on the location of groves and localisation is highly desirable, since it renders possible the erection of properly supervised and well equipped central packing and curing depots with the consequent advantages of standardised packing and marketing.

The opportunity afforded of discussing problems with other growers is probably also a factor in increasing efficiency in production and introducing new and improved methods of management.

## CHAPTER 1V. DISTRIBUTION OF CITRUS GROVES AND CITRUS DISTRICTS IN NEW ZEALAND.

A. Present geographical Distribution of groves. B. Citrus Districts described: (1) Whangarei, (11) Auckland. (111) Tauranga. (1V) Te Puke. (V) Gisborne. (V1) Hastings. (V11) Nelson.

### A. PRESENT GEOGRAPHICAL DISTRIBUTION OF GROVES.

By the influence of the factors discussed in Chapter 111, the citrus industry has become localised to a marked extent in certain areas. Table V11 gives a reasonably accurate picture of the distribution of citrus growers, average size of orchard and number of trees in the various districts. The distribution of growers with over 100 trees is shewn graphically in Figure 1V, while Figure 1V a etc. shew the local distribution in the main areas (marked by large circles in Figure 1V).

On the basis of number of trees planted in registered orchards the citrus districts are arranged in the following order; Auckland, Whangarei (includes Keri Keri), Tauranga, Gisborne, Nelson and Hastings with a few growers in other districts.

The extent to which the industry is commercialised in any one district may best be judged by the average size of the groves. On this basis the districts are grouped in descending order as follows: Whangarei district, 114.3; Tauranga, 63.3; Auckland 50.5; Gisborne, 22.9 and Nelson 20.4, the average size of grove for the Dominion being 44.0 trees.

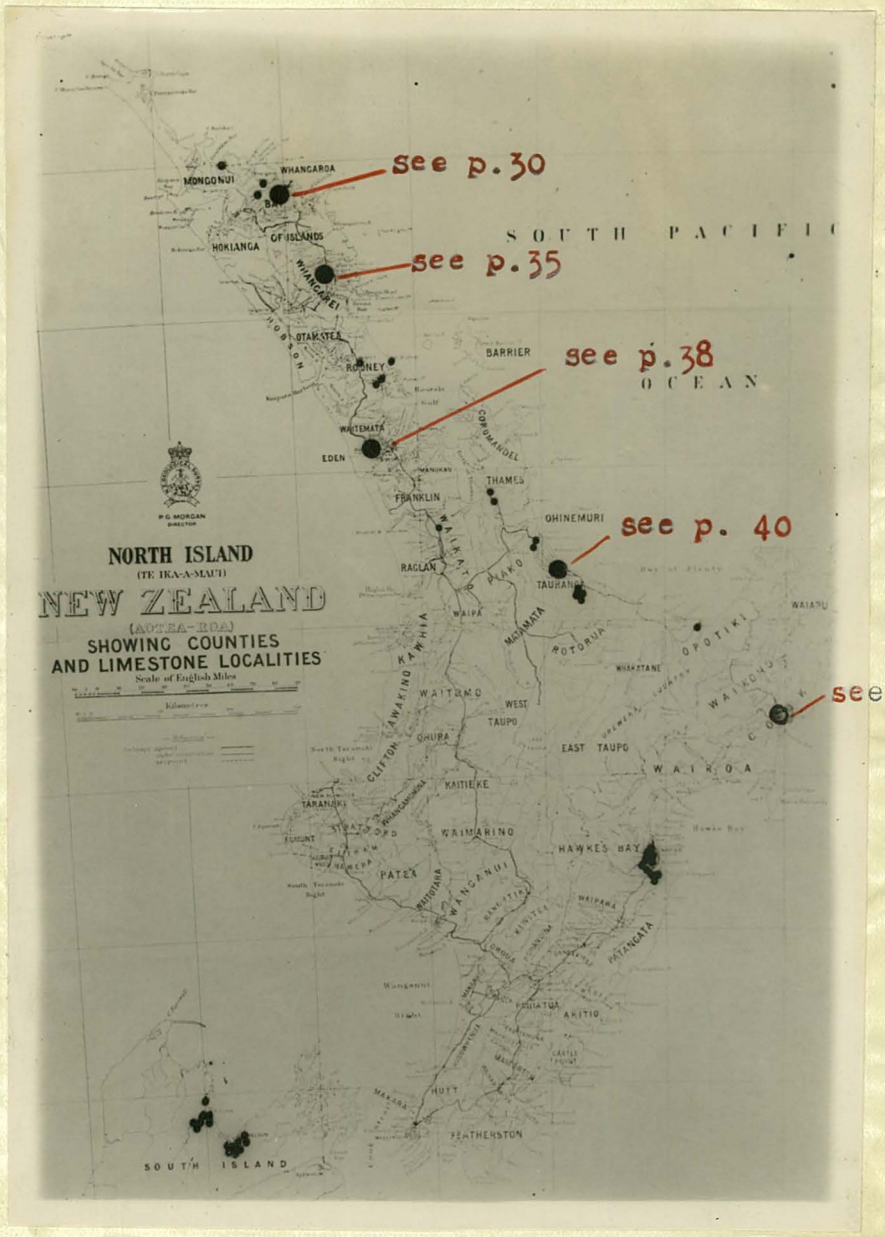



FIGURE lV. Pin Map shewing the distribution of growers in New Zealand with 100 citrus trees or over. Each pin represents a grower - however for the main districts, marked by large pins, see the sectional maps as indicated. Only a very small proportion of the total growers fall outside the limits of relatively localised areas.

TABLE V11.

Shewing the Number of Growers, Number of trees and Average size of grove in the main citrus districts.

| District. | No. Growers | Lemon Trees. | Orange Trees | Total Trees | Average size grove. |
|---|---|---|---|---|---|
| Whangarei | 299 | 15,396 | 18,790 | 34,186 | 114.3 |
| Auckland | 948 | 35,897 | 12,070 | 47,967 | 50.5 |
| Hamilton | 126 | 1,084 | 239 | 1,323 | 10.5 |
| Tauranga | 391 | 21,542 | 3,233 | 24,775 | 63.3 |
| Gisborne | 196 | 2,940 | 1,564 | 4,504 | 22.9 |
| Hastings | 267 | 3,604 | 974 | 4,578 | 17.1 |
| Wellington & Taranaki | 248 | 1,248 | 231 | 1,479 | 5.9 |
| Nelson | 201 | 3,912 | 206 | 4,118 | 20.4 |
| Sth. Island | 122 | 350 | 87 | 437 | 3.5 |
| Totals | 2,798 | 85,973 | 37,399 | 123,372 | 44.0 |

The position of the Whangarei District is, perhaps, slightly misleading, since its high average number of trees per grove is greatly affected by the influence of the Keri Keri Group Settlement Scheme where the average size of grove is in the vicinity of 500 trees. Since this area consists principally of young groves, production is not in proportion to the number of trees planted, but a rapid increase may be anticipated in the future.

## B. THE CITRUS DISTRICTS DESCRIBED.

In order that the later discussion on cultural practices, etc., may be more intelligible a rapid survey of soil conditions, and other factors in the various districts where citrus is principally grown is here given.

(1) Whangarei District.

(a) Keri Keri sub-district.

The citrus plantings at Keri Keri consist entirely of young trees and represent by far the largest block of citrus

of uniform age in the Dominion. The ages of plantings are shewn in Table V111 below.

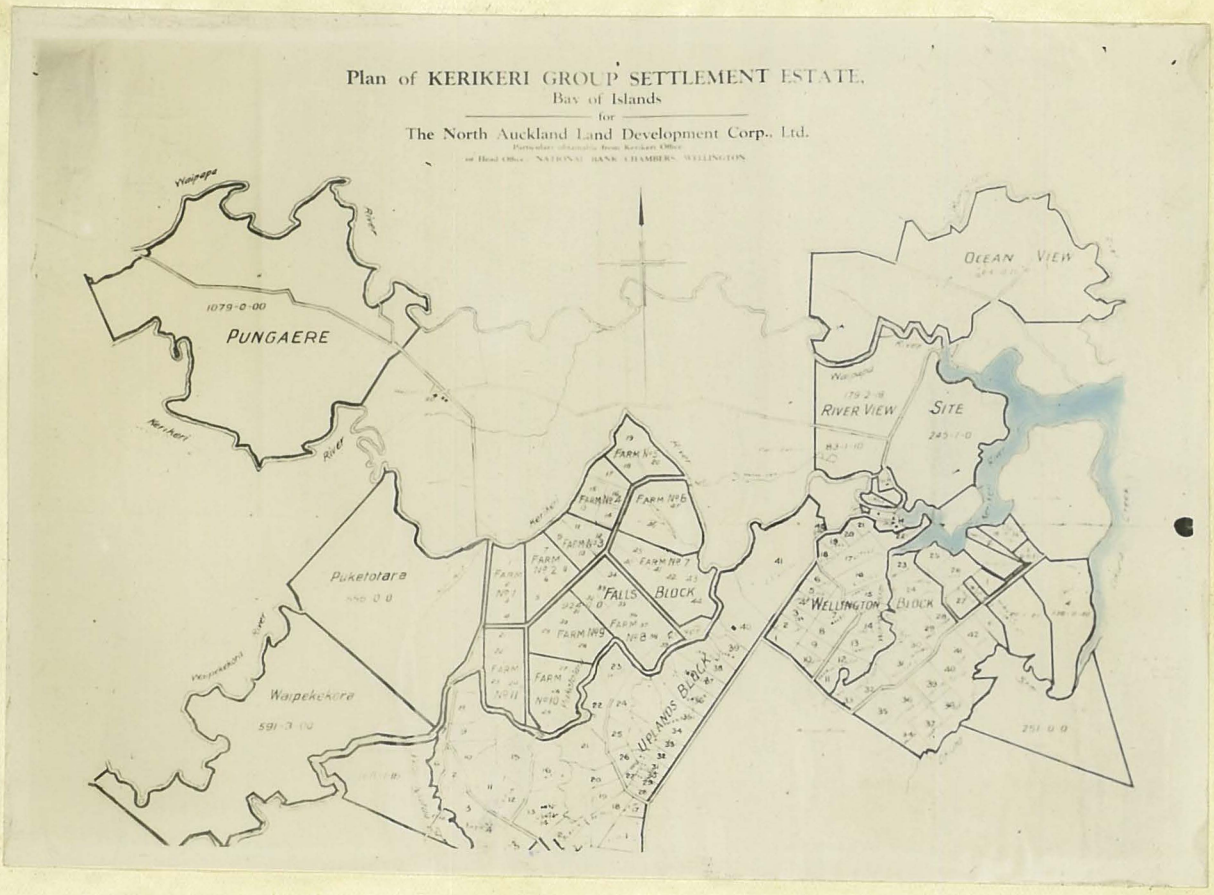
TABLE V111

Shewing the age of present plantings of citrus in the Keri Keri Group Settlement: data kindly supplied by Mr. R.Waters, Honorary Secretary of the Keri Keri Settlers' Association.

| Year of Planting. | Lemons | Oranges | Other Citrus | Total. |
|---|---|---|---|---|
| 1927 | 230 | 264 | | 494 |
| 1928 | 2,327 | 5,492 | 35 | 7,854 |
| 1929 | 2,291 | 4,993 | 226 | 7,510 |
| 1930 | 1,655 | 603 | 133 | 2,391 |
| 1931 | 599 | 296 | | 895 |
| 1932 | 897 | 542 | 273 | 1,712 |
| 1933 | 988 | 188 | 5 | 1,181 |
| 1934 | 1,678 | 853 | 49 | 2,580 |
| Total | 10,665 | 13,171 | 721 | 24,557. |

The plantings are the direct result of the formation of the Alderton Group Settlement Scheme and its administration by The North Auckland Land Development Corporation Ltd. The Corporation commenced operations in October, 1927, purchasing an estate of approx. 8,000 acres of which the Wellington and Uplands Blocks have been subdivided and opened for settlement and the easily plowable areas largely planted in young citrus trees, about fifty-four sections having been planted (See Figures V and 1V a). The area of land held by the Corporation and suitable for citrus has now been mainly sold to settlers or intending settlers, although parts of the River View Block are still suitable for development. Large areas of the original purchase of land are "ironstone" country and probably unsuited to the growing of citrus.

# F I G U R E  V.




Plan of Keri Keri Group Settlement Estate, Bay of Islands. Shews the position of the Blocks discusse in the text. The Uplands and Wellington Blocks have been mainly sub-divided and largely planted.




**FIGURE IV a.** Pin Map shewing the distribution of growers with 100 citrus trees or over in the Keri Keri District. The darker coloured areas represent the volcanic lava flows of the district but are not necessarily all suitable for the planting of citrus, much of it being what is locally known as "ironstone" land. The area of volcanic land round Waimate North shews in the lower left-hand corner.

The Worsp+ Block is, however, probably suitable for planting and represents the major area of suitable citrus land at Keri Keri still awaiting development.

The total area of land, suitable for citrus, at Keri Keri is probably in the vicinity of 4,000 acres made up as follows: Uplands Block, 1200 acres; Wellington Block, 1190 acres; Worsp's Block, 1360 acres; River View, 250 acres. Of this total area probably not more than 2,000 acres is utilisable for actually planting citrus after deducting the area of land in steep slopes, streams, etc. There is, therefore, still considerable room for development in the settlement.

The settlement lies at the head of the Keri Keri inlet on the western side of the Bay of Islands and the majority of the plantings are situated on an elevated tableland, which slopes gently towards the inlet. Near the head of the inlet the tableland has an elevation of 150-200 ft. rising at the top of the Uplands Block to a height of approx. 450 ft. The table-land constitutes part of the Keri Keri Series of lava-flows which cover with an almost continuous sheet an area of over 100 square miles. Bell and Clarke (3:1928) state: "The land underlain by the older lava flows (locally known as "ironstone" land, from the lumps of red ochre and limonite which strew its surface), although formerly covered by mixed bush, seems now almost entirely barren."

Grange (15:1934) has published an interesting paper on the "Ironstone Soils of North Auckland" and excerpts are given below.

+ Not owned by the Corporation.

"The ironstone soils are derived from the older basalts (Miocene or Pliocene) of North Auckland. All the horizons have a clay texture, and the amount of clay increases with the depth.

"The soil has a fine crumb structure, and is consequently easily worked despite its heavy texture. This is in sharp contrast with the gumland soils which cake into a hard mass during summer. The soil drains readily. During a day of heavy rain, water saturates the soil down to the nodular layer and lies on the surface of the virgin soil, drainage being held up by the nodular layer; but when observed on the day following the excess has drained away. The presence of ferric hydrate is no doubt the cause of the good physical condition of these heavy clays.

"The clay soils at Keri Keri settlement which shew a resemblance to the ironstone soils rarely contain a well defined iron nodular band. Small concretions are occasionally visible at 18ins. below the surface. The residue obtained on washing the surface soil contains small iron concretions and a few aluminium concretions."

The clays are lateritic, having a silica alumina ratio of less than 2.0, while the proportion of titanium oxide is outstandingly high. The soils are abnormally low in available plant-foods; there is a high lime requirement and the figures for exchangeable lime are low. Tests also shew the presence of considerable amounts of active aluminium.

In spite of the high clay content of the soil as shewn by the mechanical analysis the soils are free-working and to all appearances light textured; this is probably due in some measure to the low silica/alumina ration of the clay and also as Grange has pointed out to the presence of ferric hydrate in the soil. Owing to its light texture and the

presence of a semi-impervious layer impeding drainage, the soil washes badly with heavy rains and during the late autumn and winter months must be protected by a cover crop.

The response to soluble phosphates appears, on the evidence of growers, to be unsatisfactory unless accompanied by heavy dressings of lime. Without lime is applied, insoluble phosphates appear to give better responses.

The average rainfall is in the vicinity of fifty inches per annum, although no weather records are kept nearer than Russell, a distance of ten miles (See Table IVa). Frost is practically unknown on the upper parts of the area, but light ground frosts occur in the lower levels of the valleys.

The average size of holding approximates to 20-25 acres and most of the settlers have 500 trees, more or less, planted on their sections. Their influence on the figures for the Whangarei District is clearly seen in Table IX in the group 351-600 trees.

Plantings have not been confined to citrus and much passion fruit is grown in the settlement and is processed in a factory controlled by a New Zealand firm known as Pashon Products Ltd. In the early stges of the settlement it was a general policy to interplant the young citrus with passion fruit, but in the light of experience this method of intercropping has been discontinued.

The area is subject to strong winds and many of the groves suffer from undue exposure; shelter trees, however, make rapid growth and with the increasing realisation that citrus will not succeed without ample protection from wind, this defect is being remedied.

Those groves which have been well managed are making excellent growth (Plate 11) and shewing high production for their age. Many costly mistakes have been made, but the settlement seems now on the highroad to profitable production,



PLATE 11. A young lemon grove at Keri Keri. Where well attended the trees have made excellent growth.

while in future plantings the early errors may be avoided and much expense saved.

Roads within the settlement are not "first-class" but are passable in practically all weathers. The main roads are in excellent condition and a good road leads to the rail-head at Okaihau, a distance of 16 miles. A boat service also communicates with Auckland, but no direct service is available to the South Island. Freight charges to the main markets appear to be the biggest factor operating against the success of the settlement.

TABLE 1X

Shewing the number of registered growers of citrus in the Whangarei District, clasified according to size of orchard.

| Group No.. Trees. | No. Growers | Percentage in Group. | No. Lemon Trees. | No. Orange Trees | Total Trees. | Av. No. Group. |
|---|---|---|---|---|---|---|
| 1-20 | 167 | 55.8 | 723 | 457 | 1,180 | 7.0 |
| 21-50 | 38 | 12.8 | 840 | 363 | 1,203 | 31.6 |
| 51-100 | 21 | 7.0 | 957 | 630 | 1,587 | 75.5 |
| 101-200 | 16 | 5.3 | 1,553 | 534 | 2,087 | 130.4 |
| 201-350 | 16 | 5.3 | 2,723 | 1,331 | 4,054 | 253.3 |
| 351-600 | 34 | 11.3 | 5,924 | 10,600 | 16,524 | 486.0 |
| 601-1000 | 5 | 1.6 | 1,836 | 1,801 | 3,637 | 727.4 |
| over 1000 | 2 | 0.7 | 840 | 3,074 | 3,914 | 1857.0 |
| District. | 299 | | 15,396 | 18,790 | 34,186 | 114.3 |

(b) Whangarei sub-District.

Whangarei was once the centre of quite extensive plantings of sweet oranges but of latter years, due to the spread of the town and the influence of over-seas competition, these have practically disappeared or at most are represented by but remants of the former groves. The present plantings at Whangarei are mostly of more recent date.

Table 1X shews the grouping of the citrus orchards according to the number of trees they contain. This table has not been divided into sub-districts and represents the whole of the citrus grown north of an east and west line

drawn through Helensville.

The influence of the Keri Keri Group-Settlement Scheme is clearly visible in the case of the group 351-600 trees, which here contains 48 per cent. of the total trees in the district, as compared with the Dominion Summary (Table 111) in which this group contains only 22 per cent of the total trees.

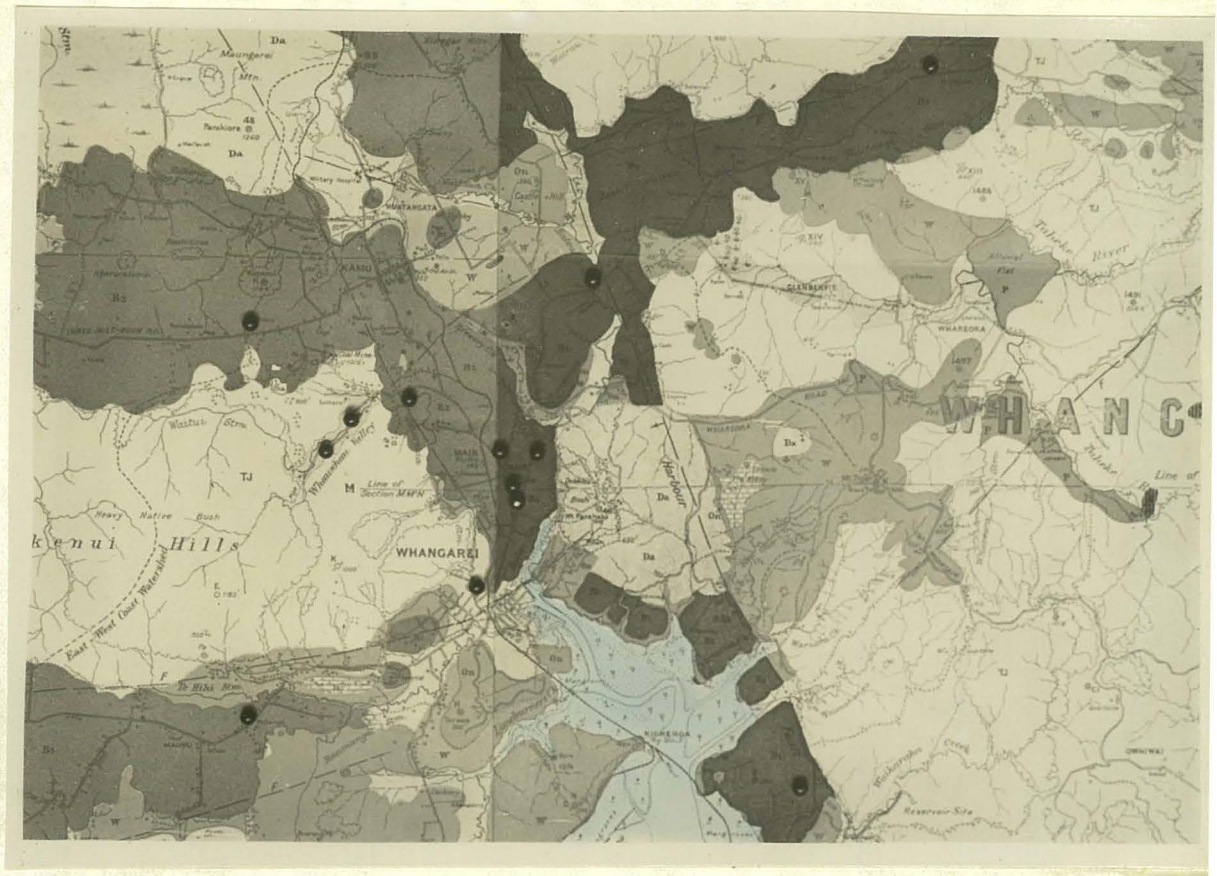
The soils of the Whangarei District are mainly derived from basaltic lava flows of the later Pliocene or Pleistocene and for the most part are well drained and fertile. In some cases the presence of unweathered stone in the soil renders clearing for cultivation an expensive item, costing in some cases up to £30 per acre. The soil is a laterite with a silica/alumina ratio of approximately 1.3-1 (15:1934) and is well supplied with "available plant food."

Most of the citrus plantings are on this volcanic soil (see detail map, Fig.1Vb) but several growers are on alluvial flats in the Whau Valley and at Otaika.

The average rainfall of the district is 60.24 inches per annum (see Table 1Va) well distributed though tending to dry periods during the summer months when precipitation is at its minimum and insolation at its maximum.

No records are available in regard to temperatures, but ground frosts are generally light and rarely cause any damage to citrus.

Communication and transport facilities are good. The district is well roaded, is in direct rail communication with the main North Island markets and is also served by a direct boat service to the South Island as well as a coastal service to Auckland. The local market is also large enough to absorb a considerable part of the output of the orchards in close proximity to the town. In supplying Auckland, however,


WHANGAREI
Hills
Harbour
Waitui Stm
Heavy Native Bush
East - West Coast Watershed
Whangarei Valley
Line of Section M-M'N
Tikipunga
Kiripaka
Reservoir Site
Tributary
Tributary
Tributary

growers are at a distinct disadvantage when compared with those in closer proximity to the market, e.g. Avondale, Henderson, Mangere, Birkdale, etc.

(11) Auckland District.

The Auckland District is, in point of number of growers and total number of trees, the most important of the citrus districts. The district includes over 30 per cent of the registered growers of citrus and nearly 39 per cent of the citrus trees in the Dominion. The number of registered growers classified according to size of orchard is shewn in Table X. As in the other commercial districts a large proportion of the growers have less than 21 trees and the proportion of large holdings is small; in spite of the large number of growers only four have over 600 trees. This is due principally to the fact that with the majority of growers citrus is not a sole source of income.

TABLE X

Shewing the Number of Registered Citrus Growers in the Auckland District, Classified according to Size of Orchard.

| Group No. of trees. | No. of Growers. | % Growers in group | No. Lemon Trees. | No. Orange Trees. | Total Trees. | Av. trees in group. |
|---|---|---|---|---|---|---|
| 1-20 | 527 | 55.5 | 2,853 | 1,300 | 4,153 | 7.8 |
| 21-50 | 173 | 18.2 | 4,537 | 1,399 | 5,936 | 34.3 |
| 51-100 | 117 | 12.3 | 6,511 | 1,919 | 8,430 | 62.0 |
| 101-200 | 79 | 8.3 | 8,425 | 2,866 | 11,291 | 142.9 |
| 201-350 | 35 | 3.7 | 6,674 | 2,531 | 9,205 | 262.9 |
| 351-600 | 13 | 1.3 | 4,675 | 1,098 | 5,773 | 444.0 |
| 601-1000 | 4 | 0.4 | 2,222 | 957 | 3,179 | 794.7 |
| Over 1000 | . | . | .. | .. | .. | .. |
| District total | 948 | | 35,897 | 12,070 | 47,967 | 50.5. |

The district probably displays within a small area, greater differences in soil type and climatic conditions than any of the other citrus districts. The major soil

types represented are:-

(a) Laterites or lateritic clays derived from the basaltic lava-flows of the Auckland Isthmus and Mangere.

(b) The light friable loams of the Avondale Flats; a related type of similar profile is also found in widely scattered parts of the area.

(c) The clay loams and alluvial clay loams of Oratia, Henderson, Birkdale, etc. derived from sedimentary rocks.

The laterites of the Auckland peninsula and Mangere are of a similar type to the volcanic soils of the Whangarei district, but occupy a minor position of importance in the citrus area.

The light friable loams of the Avondale Flats are mature soils with a well developed profile; the upper horizon is dark brown in colour and 1 - 2ins. in depth; the second horizon is slightly lighter in colour and varies in depth from 6-10ins. or more. These two layers contain a high proportion of fine sand and silt, while the proportion of clay decreases with increase in depth. Below the "top-soil" is a layer of brown friable loam with occasional iron concretions, reaching to a depth of 18-30ins. when a horizon of white leached sand is reached. This layer is apparently cemented by some agent, possibly colloidal silica, and hinders the downward flow of rain-water, but appears to offer little resistance to the passage of tree roots. The soil is generally low in "available plant food" but responds readily to treatment and is easily cultivated. Given satisfactory under-drainage, or where the sand horizon is not too impervious, the soil is admirably suited for citrus.

The clay loams and alluvial soils of the area vary widely; some are very retentive of moisture and require artificial drainage, nearly all tend to be difficult to work in wet weather. They are low in "available plant food" and

are acid in reaction. While many high producing groves are situated on this class of soil, it is not an ideal citrus soil but its situation in proximity to a large market has enabled growers to overcome the inherent unsuitability of the soil by attention to drainage and heavy manuring, coupled with good general management.

As can be seen by reference to the detail map of the Auckland area (Fig.1Vc.) there is extreme localisation of growers within sections of the district, this being most marked at Henderson, Avondale Flats, Oratia, Birkdale and to a lesser extent at Kumeu and Huapai. The particular factors operating in this case were probably:-

(a) Freedom from frost. This has probably been one of the major factors in determining the present distribution of groves, and under the prevailing conditions in the district is of paramount importance in the locating of new plantings. Where, in the case of older plantings, it has been found that frosts cause serious loss in production, a number of growers have adopted the practice of heating their groves with crude oil.

(b) The topography of the land has led, necessarily, to the discarding of much of the area as totally unsuitable for citrus plantings.

(c) Transport in the early stages of the development of the industry, was principally by rail and in consequence there was a tendency for otherwise suitable locations, in close proximity to the railway to command a premium.

The rainfall over the area varies considerably, according to the local configuration of the land, but may be taken as averaging from 44-60ins. per annum, well distributed over the year, though with a tendency to dryness during the summer months (See Table 1Va). This is not usually serious but in exceptional seasons may cause severe defoliation of the trees

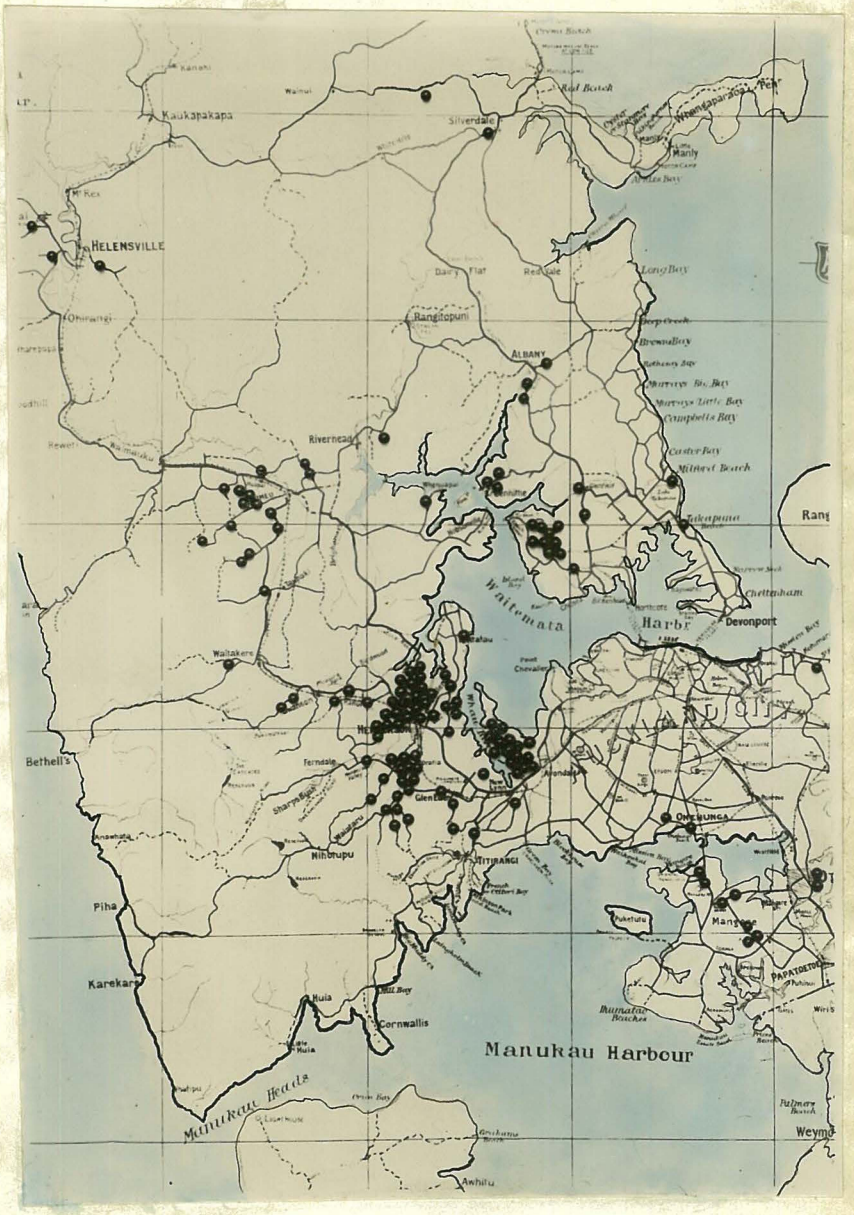



FIGURE 1V c. Pin Map shewing the distribution of growers with 100 citrus trees or over in the Auckland District. Note the localisation of groves in the vicinity of Avondale, Henderson, Oratia, Birkdale and to a less extent Kumeu.

and even a dropping of much of the newly-set fruit. Thunderstorms are not infrequent during the summer months, but tend to be very local and consequently of limited value to orchards. Auckland has an average of 1972 hours of bright sunshine during the year and this figure may be taken as substantially correct for the remainder of the district.

While the records taken at the Auckland meteorological station shew a high mean temperature and a minimum of ground frosts, these conditions cannot be taken as representative of the district as a whole. Certain parts of the citrus-growing areas are subject to "gravity frosts" of varying severity during the winter; on some occasions these have been such as to cause severe damage to citrus trees. The question of location of new plantings therefore becomes a matter of mapping those areas which have been proved free from frosts of sufficient severity to damage citrus and, as has been pointed out in a previous section, this is a matter of considerable complexity, requiring considerable knowledge of local conditions.

Transport facilities are good, the district being served by both rail and road the latter being used to the almost entire exclusion of the former for conveyance of fruit to the Auckland market. Two proprietary packing and curing sheds are situated in Auckland city and receive supplies of fruit by rail, lorry and coastal steamer services, serving a widely scattered area, as well as those in close proximity. They are also fortunate in having at hand a large market which can absorb a big proportion of the fruit processed, so saving freight costs.

(111) Tauranga District.

While in point of number of growers and in total number of trees, Tauranga falls behind the Auckland and

Whangarei districts, the advertising value of unified co-operative marketing of lemons and oranges by the Tauranga Citrus Association has gained for the district a high reputation for citrus production.

Table Xl shews the number of registered citrus growers in the Tauranga district, classified according to the size of orchard.

TABLE Xl.

Shewing the Number of Registered Citrus Growers in the Tauranga District, Classified according to Size of Orchard.

| Group No. of trees. | No. of Growers | % Growers in group | No. Lemon trees | No. Orange trees | Total Trees. | Av. trees in group |
|---|---|---|---|---|---|---|
| 1-20 | 247 | 63.1 | 1,094 | 382 | 1,476 | 5.9 |
| 21-50 | 44 | 11.2 | 1,314 | 190 | 1,504 | 34.1 |
| 51-100 | 39 | 10.0 | 2,465 | 435 | 2,900 | 74.3 |
| 100-200 | 23 | 5.8 | 2,896 | 294 | 3,190 | 138.6 |
| 201-350 | 22 | 5.8 | 4,921 | 673 | 5,594 | 254.2 |
| 351-600 | 9 | 2.3 | 3,290 | 730 | 4,020 | 446.6 |
| 601-1000 | 6 | 1.5 | 4,060 | 329 | 4,391 | 731.8 |
| Over 1000 | 1 | 0.3 | 1,500 | 200 | 1,700 | 1700.0 |
| District total | 391 | | 21,542 | 3,233 | 24,775 | 63.3 |

The total number of trees in the Tauranga district is only slightly in excess of the plantings at Keri Keri while it is only slightly over 50 per cent of the total for the Auckland district.

The groves are largely confined to positions in proximity to the Harbour on soils overlying the "Tauranga Beds". As far as can be ascertained the soil is composed of ash from the Kaharoa volcanic shower and is of a coarse sandy texture with a fair admixture of coarse pumiceous material. The margins of the shower have not been demarcated with any exactitude and it is possible that the shower does not extend down to the extremity of the Otumaetai

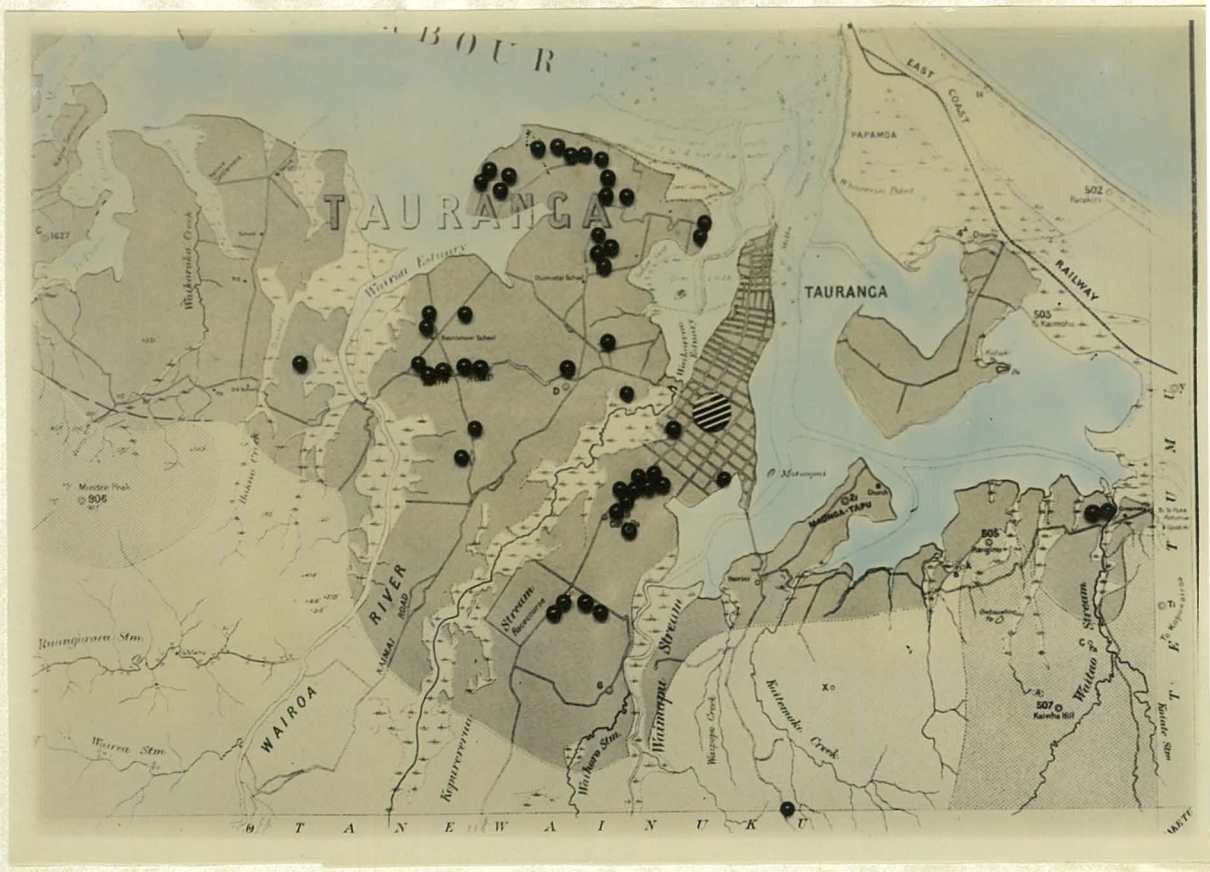



FIGURE 1V d. Pin Map shewing the distribution of growers with 100 citrus trees or over in the Tauranga District. The majority of the groves occur in close proximity to the harbour. The Co-op Curing Shed mark by a banded pin.

Peninsula or that it is becoming very thin; if so this may account for the difference in quality said to exist in the fruit from this part of the district. The origin of the soils is still a matter requiring investigation.

The groves are mostly situated on flat-topped ridges of low elevation (50 - 100 ft.) projecting out into the Tauranga Harbour. The soils are a deep, well-drained sandy loam containing ample humus. In spite of its sandy nature and the admixture of coarse pumiceous material which frequently occurs the soil seems to retain moisture well.

Tables IVa, V and VI shew the mean records of the local meteorological station. The rainfall averages 50 inches per annum, well distributed, while the bright sunshine is, on the average, in excess of that received at the Auckland station.

Frosts are more frequent and more severe than might be anticipated from the proximity to the sea; in 1933 no fewer than 56 ground frosts were recorded by the meteorological observer, the most severe shewing a minimum temperature of 18.2 degrees F. on the grass. The extremity of the Otumoetai peninsula seems to enjoy the greatest freedom from frost but in scattered locations, governed largely by elevation and shelter provided by local configuration, other groves seem also to be relatively free.

There seem to be certain factors operating in the district in respect of frost formation which are not found to any marked extent in the other citrus districts. The Tauranga district is on the seaward edge of a slope which proceeds without serious interruption to the high lands of the plateau round Rotorua. On clear nights the warm air over the Tauranga area rises and is replaed by colder air which flows down from the high land to the southward. The

entry of this cold air causes a southerly draught and lowers temperatures below those which would normally result from radiation alone. Not only so, but the whole air temperature to a considerable height is cooled, so that the normal steep temperature lapse formed under conditions of stagnant air is not realised and a ground frost of 14 degrees F. represents a lower temperature of the air (surrounding the tree) than is normally the case in "gravity frosts". The presence of a southerly draught also renders orchard heating practically ineffectual since the heat generated is carried away almost as rapidly as it is produced, except in certain favoured sheltered locations.

In Fig. Vl the minimum temperatures for each month are shewn graphically over the seven year period 1928 to 1934 for both Auckland and Tauranga. As will be noted, Tauranga is consistently colder than Auckland, while in some cases, e.g. May, 1931, air temperatures in the screen have fallen to surprisingly low levels.

(lV) Te Puke:

Behind Te Puke, on the No.3 road, is a considerable area of soil of similar type to that at Tauranga, but having considerably greater freedom from frost owing to its elevation and also to the excellent frost drainage provided by the deep watercourses cutting through the area. Several established groves on this area are yielding excellent returns, and the area seems capable of greater development.

(V) Gisborne:

In point of number of trees, this is one of the minor citrus districts but appears to have considerable potentialities as far as the growing of sweet oranges is concerned. The number of growers, etc. is shewn in Table Xll.

Figure VI.

## Comparison of Minimum Temperatures at Auckland and Tauranga over the Seven Year Period 1928 - 1934.

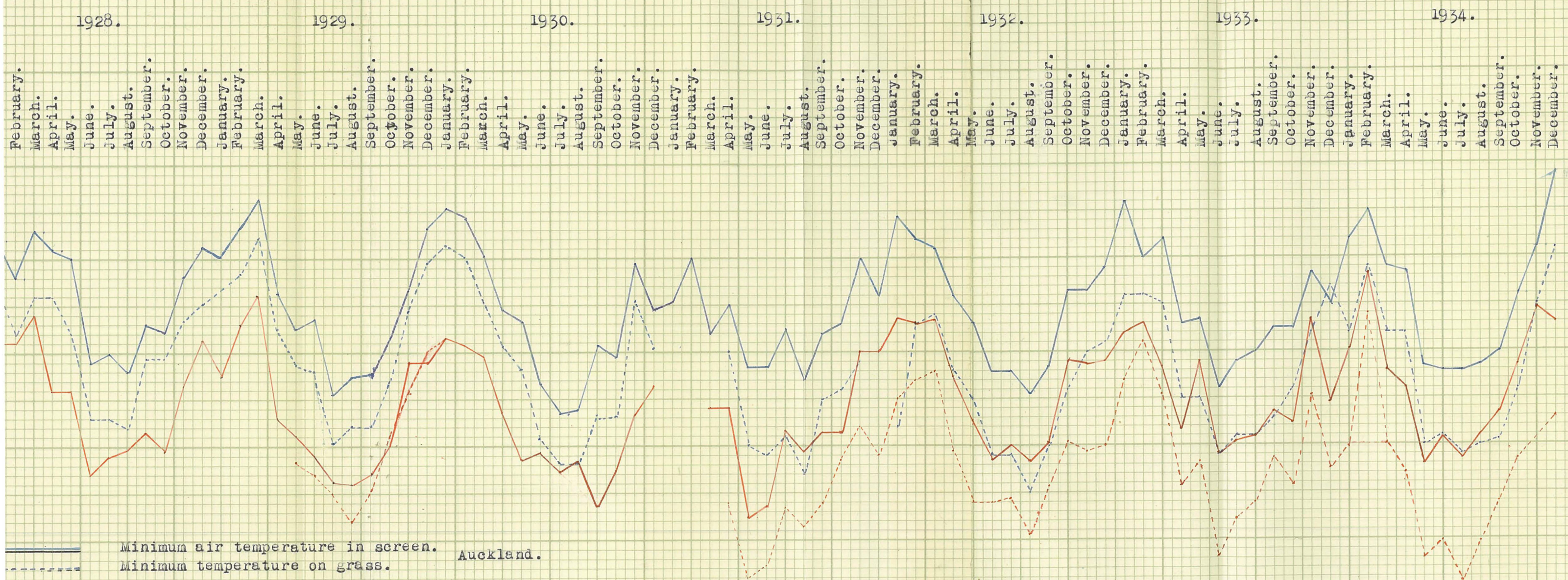


TABLE XII.

Shewing the Number of Registered Citrus Growers in the Gisborne District, Classified According to Size of Orchard.

| Group No. of trees. | No. of Growers | % Growers in group. | No. Lemon trees. | No. Orange trees. | Total Trees. | Av. trees in group. |
|---|---|---|---|---|---|---|
| 1-20 | 154 | 78.5 | 562 | 381 | 943 | 6.1 |
| 21-50 | 24 | 12.2 | 456 | 371 | 827 | 34.4 |
| 51-100 | 7 | 3.6 | 326 | 236 | 552 | 78.8 |
| 101-200 | 7 | 3.6 | 795 | 186 | 981 | 140.1 |
| 201-350 | 3 | 1.5 | 451 | 330 | 781 | 260.3 |
| 351-600 | 1 | 0.5 | 350 | 70 | 420 | 420.0 |
| District total. | 196 | | 2,940 | 1,564 | 4,504 | 22.9 |

The groves are well distributed over the Gisborne Flats, but tend to concentrate in the vicinity of Manutuke, Patutahi, Ormonds and Hexton (See Figure IVe.) The area round Hexton, however, appears to be more subject to frost than the other districts.

The soil is a fertile alluvium of great depth and exceptional fertility.

The mean annual rainfall is 47.5 inches but summer droughts are not uncommon; however, the soil is retentive of moisture and these "dry spells" do not usually seriously affect production.

Frosts are usual on all clear nights during the winter months and in view of their severity (grass min. temperature) do not seem to cause the damage which would be anticipated.

Communication is not good but a boat service connects directly with Wellington and Lyttleton at cheap rates while the local demand is sufficient to consume a large proportion of the crop.

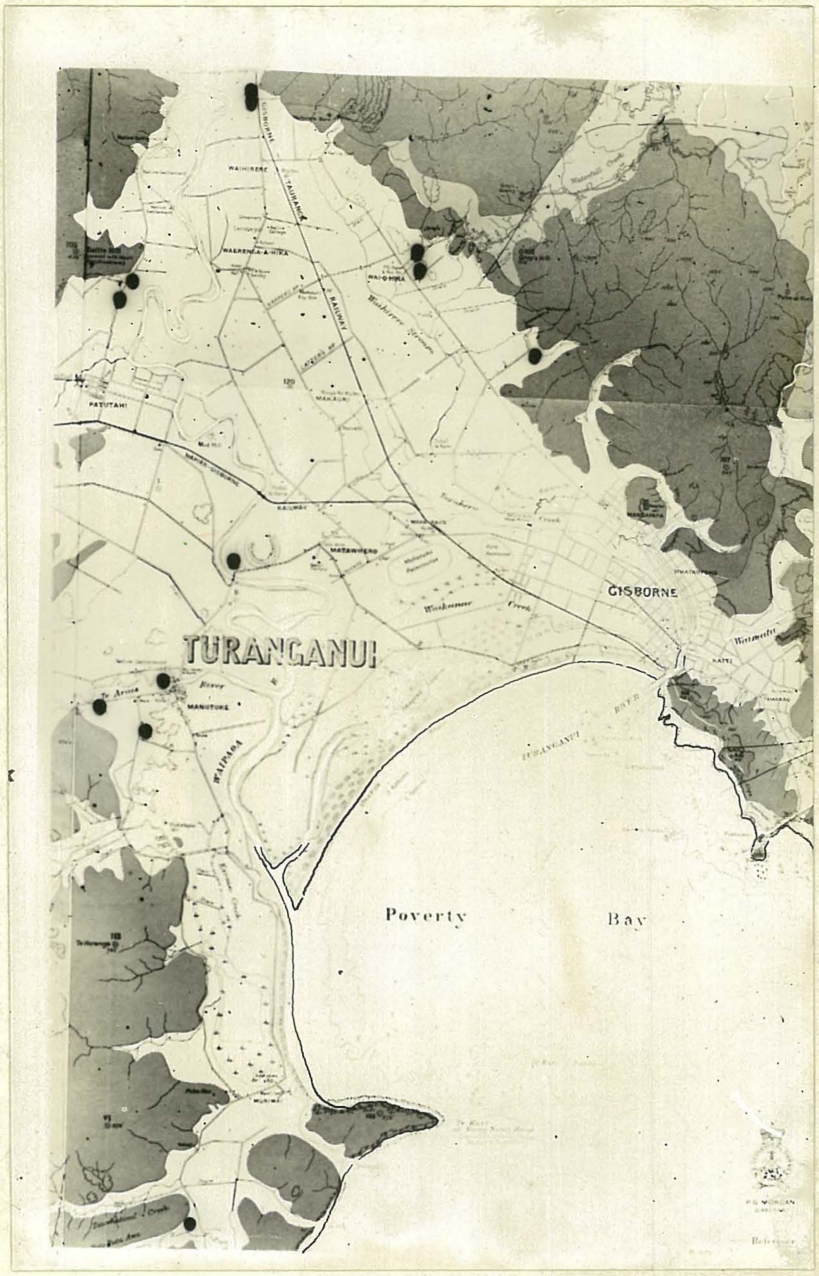



FIGURE IV e. Pin Map shewing the distribution of growers with 100 citrus trees or over in the Gisborne District. The lighter coloured areas represent the Gisborne Flats and the darker parts the hill country.

(V1) Hastings District:

TABLE X111.

Shewing the Number of Registered Citrus Growers in the Hastings District, Classified According to Size of Orchard.

| Group No. of trees | No. of Growers | % Growers in group. | No. Lemon trees | No. Orange trees | Total Trees. | Av. trees in group. |
|---|---|---|---|---|---|---|
| 1-20 | 216 | 80.8 | 1,019 | 240 | 1,259 | 5.8 |
| 21-50 | 30 | 11.2 | 774 | 138 | 912 | 30.4 |
| 51-100 | 10 | 3.7 | 471 | 259 | 730 | 73.0 |
| 101-200 | 10 | 3.7 | 1,279 | 133 | 1,412 | 141.2 |
| 201-350 | 1 | 0.4 | 61 | 204 | 265 | 265.0 |
| District total | 267 | | 3,604 | 974 | 4,578 | 17.1. |

Hastings district suffers from the joint disadvantages of having too severe frosts during the winter months and not sufficient rain during the summer. There are certain locations where citrus appear to escape serious frost damage but the area is very limited and, as a commercial venture the possibilities seem confined to supplying a small local market.

(V11). Nelson:

Nelson was not included in the area surveyed and no first hand information is available. Certain areas, however, seem reasonably free from damaging frosts but the possibilities seem limited to supplying the local market, where a measure of protection due to freight rates is available.

## TABLE XIV.

Shewing the Number of Registered Citrus Growers in the Nelson District, Classified According to Size of Orchard.

| Group No. of trees. | No. of Growers | % Growers in group. | No. Lemon Trees | No. Orange Trees. | Total Trees | Av. trees in group. |
|---|---|---|---|---|---|---|
| 1-20 | 165 | 82.0 | 736 | 90 | 826 | 5.0 |
| 21-50 | 11 | 5.4 | 336 | 28 | 364 | 33.0 |
| 51-100 | 17 | 8.4 | 1,289 | 78 | 1,367 | 80.4 |
| 101-200 | 7 | 3.5 | 1,101 | 10 | 1,111 | 158.7 |
| 201-350 | .. | .. | .. | .. | .. | .. |
| 351-600 | 1 | 0.5 | 450 | | 450 | 450.0 |
| District total 201 | | | 3,912 | 206 | 4,118 | 20.4 |

## CHAPTER V. AREAS AVAILABLE FOR EXPANSION.

The areas which appear most suitable for the expansion of citrus plantings are:-

(a) The remainder of the Keri Keri Block (see p.31)

(b) A considerable area on the later basic lava-flows in the vicinity of Waimate North and Whangarei.

(c) Certain areas in the vicinity of Auckland City, along the foothills of the Waitakere Ranges, near Mangere and on the North Shore, such locations to be chosen with special reference to their freedom from frosts.

(d) Numerous small areas throughout the north where suitable soil occurs in frost free localities, e.g. near Warkworth, Parapara Valley.

(e) Areas close to the seaalong the shores of Tauranga Harbour.

(f) The area behind Te Puke.

(g) Probably the Gisborne area offers possibilities for the growing of sweet oranges and N.Z. Grapefruit.

Areas further south than Gisborne, suitable for the growing of citrus may be considered as being commercially negligible except for a small local supply, though the list of localities given above is not by any means exhaustive.

The question of possible extension of the citrus growing areas becomes in practice largely a survey of the frost-free areas. Such a survey demands the compilation of data over a number of years and the careful checking of observational data with meteorological records. The influence of many factors other than temperature, on the susceptibility of citrus trees to frost injury makes the analysis

of such data slow, and necessitates much careful checking to ensure accuracy. The most that can be expected in the near future, is that such data might give us a fuller appreciation of the factors operating and permit a more accurate judgement of probabilities as to the likelihood of any given area being frost-free.

In any case, the area of land, now known with reasonable certainty to be frost-free is more than sufficient to meet the demands for expansion for many years to come. Such a survey of frost conditions might be necessary were citrus growing being suggested as an alternative to other forms of primary production in the event of a serious limitation of our overseas markets by quotas, but is not considered essential to the ordered development of the industry on its present basis.

## PART 111 PROPOGATION AND VARIETIES:

### CHAPTER V1. NURSERY PRACTICE.

A. General Practices adopted. B. The type of tree Required. C. Suggested methods of improvement:
(1) Culling of Seedling Nursery Stock.
(11) Manuring. (111) Bud Selection (1V) Height of budding. (V) Training of trees after budding. (V1) Root System. (V11) General.

#### A. GENERAL PRACTICES ADOPTED

In every citrus producing country the earliest type of tree planted has usually been seedling and this was also the case in New Zealand where the first trees introduced were sweet orange seedlings. These have proved to be long-lived and productive but the fruit produced while often of excellent quality lacked uniformity; hence seedlings have been displaced by "worked" trees.

"Worked" or budded trees possess many advantages; they bear at an earlier age; the fruit should be of uniform size and quality; a selected variety having desirable qualities may be propagated; and in addition the grower has a choice of stocks, so that better results may be obtained on different soils and greater resistance secured to the inroads of root diseases.

During the course of this survey several of the principal citrus nurseries in the vicinity of Auckland City were visited but the number was necessarily limited and any conclusions drawn here are purely tentative.

The usual practice in the nurseries visited is to sow the seed in well prepared soil in the open as soon as danger from frost is over. The varieties commonly used for "stocks"

are the citronelle or rough lemon, the Island sweet orange and in much smaller numbers the Poncirus trifoliata, the Florida sour orange (Seville), and the Cleopatra mandarin. The first two mentioned stocks, however, probably account for 90 per cent of the citrus trees planted; their relative values will be discussed in a later section.

The seedlings germinate readily and at one year from planting the larger are pulled and transferred to nursery rows. The smaller seedlings are usually left in the seed-bed for a further period of twelve months, when most of them are large enough for planting out. Any that are too small for transferring to nursery rows at the end of two years are discarded by some nurserymen but in other cases all the seedlings are eventually planted out.

Budding is almost universally practiced in "working" the seedling stocks, the T method of shield budding being employed. The seedling stocks are usually budded in the season following setting out in the nursery row; however, some of the larger ones may be budded late in the same season while the smaller, less thrifty seedlings are allowed to remain in the nursery row until they attain sufficient size for budding.

The most satisfactory size for budding is considered to be when the stocks have attained a diameter of $\frac{1}{4}$ to $\frac{3}{8}$ inches at the point of insertion of the bud. Budding may be carried out at any time from October to the end of February but most nurserymen seem to favour autumn budding. The bud is usually inserted at a height of from 3 to 6 inches from the ground depending largely on the size of the stock.

In the spring following budding the top of the stock is removed to force the buds into uniform growth. Staking

of the shoots arising from buds is not usually practiced.

The trees are usually sold at two years from budding but trees which have not attained the requisite size in that time are allowed to remain in the nursery row for an additional period. The majority of trees are sent out as balled, headed trees, two years from bud the average price for first quality trees being £15 a 100. Smaller trees or trees not so well headed can be secured at lower prices.

## B. THE TYPE OF TREE REQUIRED.

Sound health nursery stock is essential to the successful establishment of a profitable commercial orchard. In how far is the system in vogue in this country supplying the orchardist with a desirable type of tree?
For ordinary commercial planting the most satisfactory type of tree should, in the writers opinion, have the following qualifications:-

(a) The trees should be uniform in size, height of branching, type of leader development, etc.

(b) The trees should be vigorous, healthy, well-grown, and large in relation to their age.

(c) The stocks should have been carefully selected for uniformity of development, all undersized or backward specimens having been rejected in the nursery.

(d) The buds or scions should have come from parent trees carefully selected in respect of the productive capacity and trueness to type for the variety, etc.

(e) The bud union should be at least 6 to 8 inches above the soil level to give maximum protection against root disease.

(f) The young tree should have a well developed and evenly balanced head, the lowest branch being not nearer than 15 inches from the ground level.

(g) The root system should be well provided with fibre and all "bench rooted" specimens should have been rejected in the nursery.

(h) The trees should be as low in price as is consistent with the above standards, though this is a minor consideration and should never be allowed to over-rule the other factors outlined above.

The type of tree planted is fundamental to success. The best of the nursery stock sold in this country is definitely good and will bear comparison with that from most other citrus producing countries. There are, however, certain respects in which improvement might be effected; such improvement is greatly retarded by the fact that growers as a whole do not appreciate the importance of planting only the best trees available and grudge the small increase in initial outlay required to buy only the best. Nursery practice has first of all to supply the demand, and it is probably along the lines of grower education that an effort should be made to improve the general type of tree produced.

## C. SUGGESTED METHODS OF IMPROVEMENT.

The main lines along which improvement of nursery stock in New Zealand might be pursued are, in the writer's opinion:-

(1) Much heavier culling of seedling stocks prior to budding in order to secure greater uniformity.

(2) Heavier manuring of seed beds and nursery stock generally in order to obtain satisfactory growth and development.

(3) Greater attention to bud selection, to ensure the propagation only of good type strains within a variety.

(4) Budding should be higher from the ground than is usually practiced in order to reduce the danger of root disease.

(5) More careful training of the trees after budding, to ensure a single stem or "leg" well headed at a height of 15-18 inches.

(6) In some cases more attention should be paid to securing a good fibrous root system by suitable manuring and cultural methods.

(1) Culling of Seedling Nursery Stock

As the result of studies and experiments and the cumulative observations of growers, certain stocks have come to be commonly used. It is generally conceded, however, that the problems connected with rootstocks are poorly understood; moreover, recent work in California and at the East Malling Experiment Station, England, has forcibly drawn attention to the fact that within each species or variety now in use as a rootstock, there occur numerous varieties or strains each possibly having a distinctly different reaction on the fruit or scion variety. Webber says (44:1932.p3) "the size and vigour of the orchard tree is considerably influenced by the character of the seedling used as a stock, and apparently justifies the adoption of some method of stock selection".

The question of variability in citrus rootstocks of the same variety and possible methods of selection so that only the most desirable forms may be planted are fully discussed by Webber (40:41; 42 and 44) and in Technical Communication No.3 of the Imperial Bureau of Fruit Production (19:1932).

It is not possible here to review the mass of evidence which has been accumulated on the subject but an example may prove illuminating.

Batchelor and his co-workers (2:1928) in preliminary work in preparation for fertiliser experiments aimed at uniformity of nursery stock, treatment, and, as far as possible, soil.

"The following measures were followed to produce especially uniform trees:

1. The sweet orange (Citrus sinesis) nursery stock which was transplanted from the seed bed to the nursery in 1914, was thoroughly culled and the undersized trees were discarded. These discards amounted to possibly 15 per cent of the seedlings.

2. After one years growth in the nursery, and at the time the trees were budded in 1915, another selection of the small-sized fruits was made, and these were discarded.

3. When the trees were dug from the nursery for transplanting to the grove in 1917, the small-sized budded trees were culled from the lot, making a third discarding of trees which lacked vigour and size. Thus from the establishment of the nursery until the actual planting of the grove, an endeavour was continuously made to produce a vigorous and unusually uniform lot of trees.

"Plump well-formed buds from mature budwood were used for propagation purposes. Only such twigs were used as shewed blossoms formed or in process of formation on the tips of the current seasons growth at the time the bud wood was cut."

In spite of the care taken to secure uniformity, yield and growth records taken over a twelve year period

prior to the first application of fertiliser treatment revealed the existence of considerable variation. Thus there was a difference of practically 109% between the lowest yielding plot, which produced an annual average of 79 lbs. per tree of oranges for the six year period recorded, and the highest yielding plot which produced 179 lbs. This variation was not considered strange by the authors in comparing areas of soil one-third mile apart. But, in addition they found that, "A comparison of adjacent plots, however, shewed variations in production in some cases of 30 to 40 per cent."

They consider "The two groups of factors which are most persistently operative in causing the variation in production are: first the inherent qualities of the tree due to character and vigour of rootstock and top; second, the variability of the productivity of the soil in one part of the field compared with another. They comment as follows:- "In spite of the variation in growth and production of the trees of this field, it is believed that this planting is singularly uniform in comparison with the average citrus grove. This fact has been brought out in statistical studies of the variability of this and other orchards. In appearance the trees are strikingly similar".

In reference to the above experiment Webber says (44:1932):- "When the budlings had reached the age to be transplanted in to the orchard they represented the appearance of an exceptionally fine block of very uniform nursery trees; and yet, when the selection of trees was made to plant the experiment in question, it was found that the size of the scions, 3 to 4 inches above the bud union, varied from 0.85 cm. to 3 cm. or more in diameter.

"In order to obtain some clue as to what would have

been the result if all sizes of the nursery trees had been used without selection, a comparative trial was planted with 18 large, 18 medium, and 18 small trees of each of three varieties, all on sweet-orange stocks, a total of 162 trees."

"It will be seen from an examination of the data given in Table 1 (omitted) that, during the eleven year period up to 1928 in which the trees were growing in the grove, in general the large trees remained large; the medium trees, medium; and the small trees, small; and also that the size of the yield corresponds to the size of the tree."

Webber examines exhaustively the data from the above and other carefully designed experiments and arrives in every case at the conclusion that variability of the rootstocks within a variety is one of the major causes of variation among trees grown under uniform conditions. In discussing the results of a further experiment he says:- "It does not seem probable that the variation in soil, buds, or bud unions could be responsible for the differences exhibited by these three sections of the same grove. It is difficult to escape the conclusion that they were primarily due to the differences in the size of the nursery stock selected for the planting. Since uniformly good buds were used it seems likely that the most important variable was concerned with size and type of the rootstock seedlings."

The question which immediately presents itself is "In how far are these results applicable under New Zealand conditions?" Webber (41:1920) described the normal nursery practice in California at that time as follows and such a description is substantially true of conditions in New Zealand today:-

"The stocks are grown from seed and the seedlings transplanted from seed-bed to nursery about twelve months after sowing at which time they vary greatly in size, ranging from a few inches to 18 inches or more, this variation being always seen. In ordinary practice all of the seedlings are transplanted or at most only a few of the smaller ones are discarded.

"After another twelve months those large enough are budded, there being considerable variation in the size of the seedlings, the smaller ones being budded later.

"The budded trees then wait another two years and are transplanted to the grove. At this time they still vary greatly in size. Quite commonly only the largest trees in a nursery will be dug and sold, while the rest will be left for a future occasion. The smallest trees from the smallest stocks will finally reach sufficient size and ultimately find their way into the grove."

Such small trees have under Californian conditions been found to be definitely inferior in yield to the larger trees of similar history. There seems no reason to believe that such is not also the case under New Zealand conditions and casual inspection of seedlings of citronelle and sweet-orange in the nurseries visited shewed a certain number of variants as well as wide divergences in size of similar age seedlings.

It appears, therefore that quite apart from the possibility of undesirable variants such as described by Webber (41:1920; 44:1932) the larger sized trees are more desirable and since the elimination of small seedlings and budlings cannot be injurious, even if no permanent improvement is achieved, and in view of the increased yield secured, it seems evident that the safest and best policy

to pursue is to practice a severe nursery selection.

The method of nursery selection recommended by Webber (44:1932) is as follows:-

"Seed Bed Selection - When the seedlings are dug from the seed bed discard the smallest seedlings to the extent of about one-fourth of the whole population, or 25 per cent. Discard at this time all malformed seedlings such as extreme cases of "gooseneck" or "bench root".

"Nursery selection - When the seedlings growing in the nursery have reached the size and age for budding, go over them carefully and cut out all plants differing sufficiently from the standard or normal type of the stock to be recognised as distinct and peculiar in any character. This elimination should be irrespective of size. After this elimination of variants, the small seedlings should be cut out and discarded to the extent of 25 to 30 per cent of the entire remaining population.

"After this elimination has been made the entire remaining population may be budded and safely considered as propagated on good, uniform, highly selected stocks. As the seedlings up to this time previous to budding, have little value, the carrying out of this elimination does not entail very great financial loss.

"Budling Selection - Some buds do not heal well or are defective and do not give vigorous good trees. Such small and inferior budlings should be cut out and discarded before the budlings are dug for orchard planting. With good buds and selected large stocks the elimination at this time will be very slight, probably not over 1 to 5 per cent".

Some method of stock selection such as outlined above could, in the writer's opinion, with advatage be adopted by nurserymen in this country.

(11) Manuring of Nurseries:

In California, Florida and other citrus countries, citrus nursery stock is usually fertilised, the general recommendation being three applications per year of from 500 to 1500 lbs per acre per application of a good mixed fertiliser. Such heavy dressings may not be required under all conditions in this country but there is little doubt in the writer's mind that much heavier applications than are given at present would result in greater uniformity of growth and a lower proportion of small low-grade nursery stock.

(111) Bud Selection:

Just as in stocks so in the scion wood used in propogation there occur numerous strains[+] within a given horicultural variety and it becomes a matter of paramount importance that only true to type, high producing strains should be propagated. There seems little need at this juncture to stress the importance or value of citrus bud selection.

The importance of bud selection would not appear to have been fully recognised until the increasing variability of products from Californian orchards led to the investigation of bud mutation in citrus by Shamel and his co-workers.

[+] Strain is used "to designate a group of individuals of a horticultural variety differing from all other individuals of the variety in one or more recognizable and constant characteristics and capable of perpetuation through vegetative propagation."

"Shamel's method of orchard analysis or experimentation was to number all the trees in a grove and then, during a period of five or six years, follow the yields produced by each tree and the number of good, bad and off-type fruits produced by each tree each year. These data were used together with a study of the branching and foliage characters of the individual trees to determine the number of types present and which were the good and which the poor types. He demonstrated conclusively that the orchards of every variety generally grown are now composed of many types, and that a large number of the trees in many orchards were not yielding sufficiently or giving fruits of sufficiently good quality to pay their expense of upkeep. These he designated "boarder" trees and advocated their removal or top-working with good strains to increase the orchard productivity.

"Mr. Shamel also advocated that all buds used for propagation should be taken only from trees of known high yielding capacity of fruits of good standard types; this to be determined by individual tree records of large numbers of trees on the best groves of the different varieties during several years.

"As an indication of the care that has been taken in making the tree selections, it may be mentioned that in one Washington Navel grove at Highlands, California, individual tree performance records have been kept on 18,000 trees for a period of six years."

As Webber points out in a later section (42:1925):-

"If the bud selection methods initiated by Mr. Shamel accomplished nothing more than to eliminate off-types of small, odd-shaped, and worthless fruits, it would be abund-

antly justified, but aside from that, it gives us the certainty of the maintenance of high productivity. More could scarcely be asked, but it holds out also the possibility of ultimately securing inherently higher yielding strains."

The necessity for carrying out similar work in New Zealand was early recognised by Mr. G. A. Green and others and bud selection has been carried on in this country for the last fifteen years. Marked improvement has been made in the type of citrus nursery stock being propagated in that time, but the lack of sufficient financial support or sympathetic co-operation by orchard owners has frustrated any efforts to place the work on a sound basis.

Tree performance records are absolutely essential if the work is to be carried to its logical conclusion. What dairy farmer in this country would choose a herd sire on the appearance of the dam? He immediately enquires for the performance record of the dam; yet every citrus orchardist in this country is planting trees propagated from trees of unknown performance!

The writer in no way desires to belittle the excellent work which has already been done or the benefits which have accrued from it but rather to point out the unenviable task which has been imposed upon the bud selector and the futility of expecting anyone to judge even approximately the yield of a tree over a period of years. Batchelor and his co-workers (2:1928) who found differences of up to 30 to 40% in adjacent plots (see p. 54) record "In appearance the trees are strikingly similar".

No data are available shewing the proportion of citrus nursery stock sold which has been propagated from selected budwood, but the total proportion would be small and the work is in danger of lapsing if financial aid is not forthcoming. It should be impossible to sell a tree to a commercial citrus orchardist worthy of the name, unless it has been propogated from selected budwood, and education, demonstration and instruction are required to bring home to orchardists the necessity of planting only nursery stock propagated from the most carefully selected material. Individual selection of propagating material by nursery-men is not recommended since, if it is to be efficiently carried out it demands duplication of effort and lacks the stability and confidence which should characterise such a movement.

Other advantages besides increased production, are the increased uniformity of fruit grown on the trees from selected buds so reducing the cost of sorting and packing the crop, while more uniform market grades, made possible by the uniformity of fruits increase the confidence of the consumer in the fruit and induce a larger consumption. This condition is economically valuable, both to the producer and to the consumer; it stabilises the industry as a whole and adds materially to the reputation and value of the crops.

The inauguration of performance record selected buds is urged as a necessary step to the successful production of a type of product which can compete satisfactorily with overseas competition. Our aim should be to have every tree planted propagated from performance record buds.

(IV) Height of Budding:

One of the reasons for using "worked" trees in preference to seedlings is that thereby the resistance of the tree to root diseases is increased; this benefit is largely nullified if budding takes place at too low a level and the writer is of the opinion that greater resistance would be imparted to trees by the general adoption of budding at a height of say 8 to 10 inches.

(V) Training of Trees after Budding:

Many trees sent out from citrus nurseries in this country are badly formed, may branching almostly immediately above the bud union in place of a straight "leg" or trunk of 15 to 18 inches before the commencement of branching. Low branching trees are undesirable as they hinder cultivation, the lower branches frequently bend with the weight of fruit until touching the soil resulting in damaged or diseased fruit while the proximity of the "fork" to the soil level probably makes such trees more susceptible to bark diseases such as "bark blotch."

Much of the difficulty in securing good growth of the budlings would probably disapear if the trees were adequately selected prior to budding ( p. 57 ) and subsequently adequately fertilised. The ranker type of growth which might be expected to result would probably necessitate staking of the young trees in order to ensure a straight "leg" but such should present no difficulties and is the standard practice in other citrus countries.

(VI) Root System:

Poorly rooted trees are usually the result of leaving stocks in the nursery row for too long a period without wrenching or moving the tree. In the spring, prior to sale, the young trees should be well "wrenched" in the nursery row in

order to induce the production of fibrous roots.

(V11) General:

Such improvement in the general quality of nursery stock as has been outlined above can only be secured when citrus orchadists come to a full realisation of the benefits accruing from the planting of only superior quality budlings and are willing to pay the small increase in price which would be necessary to cover the higher cost of producing such trees; hence the first step consists in the education of the growers to appreciate the value of the right type of tree.

One grove was visited where the grower proudly informed the writer that he had secured the trees planted for £4 a 100. "They were miserable runts of trees that the writer is certain would save the grower endless trouble and expense if they died early. No good nurseryman should send out such trees, and no grower, if he knew his business, would accept and plant them."

These specimens cost the grower 9 pence each; the best would have cost him 3/6 each and would have been, at the most conservative estimate, one year earlier in coming into bearing. This in itself would have paid for the extra cost of the better trees, but in addition the grower would have saved interest on capital, rates and working expenses for one year; in addition with the better trees he could have had some guarantee that the trees were propagated from buds, selected from trees true to type for the variety and of apparently good productive capacity so that labour and capital expended on their care and maintenance could in due season be reasonably expected to secure its reward; with the low priced trees he had no such guarantee.

## CHAPTER V11 - CITRUS ROOTSTOCKS.

A. Advantages of "worked" trees. B. The Ideal Citrus Rootstock. C. Varieties of Citrus Rootstocks in New Zealand: (1) Citronelle. (11) Sweet Orange. (111) Trifoliate orange (1V) Sour Orange. (V) Other stock varieties. D. Double working. E. Proportions in which Stocks are in use in New Zealand. F. Summary.

### A. ADVANTAGES OF "WORKED" TREES.

The advantages of using "worked" citrus trees are briefly:-

1. Since most citrus varieties are genetically heterozygous they do not breed true when raised from seed, although this position in the case of citrus is considerably complicated by the phenomenon of polyembryo and the production of apogamic seedlings (really asexual). However, for the purposes of commercial planting it has up to the present been found necessary to asexual methods of propagating in order to ensure uniformity in the offspring. The difficulties of securing uniformity even by this method have proved considerable and have been discussed in the previous section.

2. Budded trees, as a rule, come into bearing at a much earlier age than seedling trees.

3. The method permits of the careful selection and propagation of only the best types within a given variety giving uniformity of size and quality and the reasonable certainty of high productive capacity.

4. The grower has, in addition, a choice of stocks so that better results may be obtained on different

soils.

5. Many citrus varieties on their own roots are subject to attacks of root diseases; certain stocks are markedly resistant to these diseases and have been almost universally adopted wherever these diseases are prevalent.

There are few growers now who doubt the value of "worked" stock; the question awaiting solution is "On what stock shall I order my trees?"

## B. THE IDEAL CITRUS ROOTSTOCK.

Before attempting to answer this much debated question let us review the desirable properties of an ideal citrus rootstock.

(a) It must be compatible with the scion forming a successful union.

(b) For ordinary commercial purposes it must not unduly dwarf or stunt the growth of the scion. American experience on the whole (p.55) has shewn that the larger the tree (of similar strain) the larger the yield. Some nurserymen contend that the smaller size of tree may be compensated for by closer planting in the orchard. No definite information on this point seems to have been collected, but in any case the method seems scarcely justified unless some other advantage is also gained.

(c) The fruit produced on the stion must be of good quality; i.e. the stock must exercise no adverse influence on the quality of fruit produced by the scion

+ Stion - a word introduced by Webber to indicate any plant or tree composed of a stock and scion growing in combination.

(d) The stion should be long lived and fruitful throughout its life.

(e) The stock should be resistat to the attacks of organisms cusing root diseases.

(f) It should be uniform in the type of its progeny. A stock which could be readily propagated by either top or root cuttings, so ensuring the propagation of selected strains would be a decided advantage under some conditions.

(g) It should be redily propagated and budded in the nursery so reducing nursery costs. This advantage should not be permitted to outweigh the fa more important characters outlined above, but is an added desirable characteristic.

Any tendency to judge the value of a rootstock solely on the vegetative growth secured in the early years of growth is to be deprecated; quality of fruit, retention of juice, fruitfulness, longevity and disease resistance are all important factors to be considered.

## C. VARIETIES OF CITRUS-ROOT STOCKS IN USE IN NEW ZEALAND.

The only stocks commonly used in New Zealand are, the citronelle or roughlemon, the Island sweet-orange (Citrus sinensis), the trifoliata (Poncirus trifoliata) and to a small extent the sour orange (C. Aurantium Linn). The ordinary lemon (C. Limonia, Osbeck), the Rangpur lime (C. aurantifolia, Swingle) and the Cleopatra mandarin have been tried experimentally.

(1) The Citronelle or rough lemon is a horticultural variety of the common lemon (C. Limonia, Osbeck). Its origin is doubtful, the seed used in New Zealand for propagating coming largely from Norfolk Island whence it was introduced

in the early days of colonisation and has now gone wild. It is also common in the older settled parts of the North Island of New Zealand where it was introduced at an early date, while it is abundantly naturalised in Florida, South Africa, etc.

There are doubtless a number of strains within the variety, each of which would eventually have its own particular effect on the scion. Some of these strains are commercially recognised as in the Bombay Presidency where two strains, Jamburi and Id are recognised as having distinctly different reactions with the scion.

Experience with the citronelle as a stock overseas has been very varied; its use has been discontinued in Hawaii "because of lack of resistance to gummosis" (23:1934); Henricksen (16:1930). Speaking of groves in Porto Rico says, "It (citronelle) may be planted in any soil that is suitable for citrus growing, and is preferable to other stocks in extremely light sandy and in very impervious soils. Trees which are budded on lemon stock are said to be more likely to produce coarse fruits than are those budded on other stocks. This was not found to be the case, but may be in a more extensive study when more fruit is available. The longevity of trees which are budded on lemon stock is said to be less than that of those budded on the other stocks, but this fact was not established."

H. J. Webber writing of the rootstock trials begun at Riverside Experiment Station, California, in 1927, says (45: 1934) "Rough lemon has given results in the trials so far which entitle it to specia consideration, --"

Camp (5:1931) speaking of Florida conditions places the rough lemon second only to the sour orange which is the standard stock in that country. He comments: "It is not

as resistant to foot rot and similar diseases as sour orange, but is more resistant than most of the other root-stocks."

Webber (42:1925) in his report on the citrus industry of South Africa remarks: "Fortunately, however, the information that has been accumulated clearly indicates at least one safe stock for very general use. This is the so-called rough lemon."

Contrary to the opinion sometimes expressed in this country Provan (25:1933) writing in the Journal of Agriculture for Victoria says that "rough lemon is a useful stock for sweet orange in non-irrigated areas owing to its ability to withstand drought." Under irrigated conditions, however, he noted a gradual deterioration in growth after the 15th. year.

Webber (42:1925) summarises the position as follows: "The rough lemon is easy to grow, develops rapidly, buds easily and in general forms a good union with orange, grapefruit and lemon varieties. It produces, generally a good root development, a good growth of tree, good bearing capacity and good fruit. Probably the greatest weakness of the rough lemon as a stock is in its susceptibility to collar-rot. Fortunately it is by no means so susceptible to this much dreaded disease as the sweet orange though it is by no means as resistant as the Seville orange. The rough lemon does possess quite a high degree of resistance, though it is not entirely immune."

Quinn (26:1933) in a study on the influence of rootstock on the texture and flavour of orange fruits in South Australia found that the acidity in the fruits from Thompson's Navel trees on rough lemon was approximately 16.25% lower than that of fruits from trees on sweet orange. The acidity of

Washington Navel was 12.08% less on rough lemon than on sweet orange. The percentages of sugar found in both cses was slightly greater on sweet orange stocks. As regards juice, fruits of both varieties carried more juice when grown on sweet orange than on rough lemon. Fruits of both varieties became sweet to the palate earlier on rough lemon than on sweet orange; some of the larger fruit on the rough lemon were mawkishly and insipidly sweet and this was also noticed with Valencia on rough lemon.

Hume (18:1926) mentions also the tendency for trees worked on rough lemon to produce in their early years fruit of inferior quality, thick-skinned and deficient in juice, but as he remarks, this is probably due to the vigorous vegetative growth of the young tree and with increase in age the fruit produced are of as fine quality as those from other stocks. Oranges on this stock, he also considers dry out earlier at the stem end and therefore cannot be held so long on the trees as with other stocks.

Under New Zealand conditions the citronelle appears to give excellent results with lemons on all classes of soil in use for citrus; its use for Poorman oranges requires further investigation before it can be given unreserved support since its use may be one of the fators operating in the early drying out of juice in this variety in some orchards; no mature plantings of sweet oranges on this stock are known to the writer but the majority of the plantings at Keri Keri are on this stock and until further evidence is available judgment must be suspended as to its use for sweet oranges in New Zealand.

(11) Sweet Orange (C. sinensis)

The sweet orange appears to be compatible with most scion varieties but in the case of the Satsuma orange Hume

notes that while the trees grow well they do not fruit well. He adds: "The growth of trees on sweet stock is more rapid than on sour or trifoliate orange; and in general it may be said that in rapidity of development it is surpassed only by the rough lemon and pomelo."

A characteristic of the sweet stock is its shallow rooting system; Mills (22:1902) who investigated the root systems of various citrus rootstocks, declares that on all kinds of soils it is the nature of the sweet orange seedling to form a shallow root system, and that it is a surface growing stock which has few or no deeply penetrating roots. Mr. Geo. A. Green, however, considers that the above statement is not true under New Zealand conditions.

Unfortunately the stock is extremely susceptible to footrot and root diseases and on this account its use has been largely discontinued in many countries in favour of more resistant stocks, chiefly sour orange and rough lemon (citronelle). In Technical Communication No.3, Imperial Bureau of Fruit Production (19:1932) it is stated: "Sweet orange would be far more extensively employed as a stock, were it not that its extreme susceptibility to mal di gomma or footrot exceeds that of any other citrus stock and renders it unsafe to use on any but light and dry soils; moreover, since other more resistant stocks will also do well on these soils, the use of sweet stocks with its attendant risks has in many places been discontinued."

Camp (5:1931) writing of Florida says: "It (sweet orange) should never be used as a rootstock where the sour orange will grow satisfatorily, as the danger from footrot is too great." According to Pope (23:1934) it has been discarded in Hawaii owing "to its lack of resistance to gummosis."

Webber (42:1925) writing of South African conditions remarks: "The use of sweet orange, however, is dangerous in all cases, unless the trees are set high on selected, well drained, rather light soil, are irrigated properly, and frequently inspected to detect and check any infection."

Apart from this susceptibility to disease the sweet stock is an excellent one; it forms a good union with the bud; it gives good growth and develops shapely symmetrical trees of good bearing capabilities which apart from disease are long lived.

Webber (45:1934) in summarising the rootstock experiment on lemons at Riverside, California says that taken as a whole, sweet orange stocks stand at the head of the list for yield, followed by rough lemon, and this result is in accordance with the general observation that the old lemon groves to be found locally on sweet orange are the equals or superiors of groves of similar age on other stocks.

In a private communication to Mr. G.A. Green, Mr. A.D. Shamel remarks, "We are gradualy going back quite generally to sweet orange seed obtained from vigorous old trees for root-stock purposes in our commercial citrus work. I suspect that you will do well to stick to your Raratonga orange and Citronelle seed until you are sure that you have anything better. I think that the selection of healthy vigorous, productive, and resistant older parent trees is important in this connection." Such old seedling orange trees are available in New Zealad (Plate 111), and they should be tried out experimentally as parent trees for propogating material.

The writer's observations during visits to groves in the summer of 1934-5 forced him to the conclusion that there



PLATE 111. An Island Orange seedling 86 years of age and still in a flourishing condition at Warkworth. The tree tends to bear in alternate seasons and while not carrying a crop at the time the photograph was taken is this year estimated to bear at least 10 bushels of fruit.

were practically no citrus soils on which sweet stock could be safely planted in New Zealand without adequate under-drainage. Only when efficient artificial drainage is provided can sweet orange stock be relied upon to give a satisfactory length of life for citrus trees under our prevailing conditions. Apart from this one weakness the stock is probably ideally suited for our conditions.

(111) The Trifoliate Orange.(Poncirus trifoliata,Raf.)

The Trifoliate taken as a whole, may be regarded as an erratic stock, in that its effect on the scion can never be accurately foretold. This tendency to variation Webber (24:1925) ascribes to the existence of a number of strains having different reactions on the same scion variety, instancing the similar behaviour of the Paradise apple stocks before the days of clone selection and propogation.

It has probably been used as a stock in China and Japan from very early times; certainly for 800 years at least. It was first tried in America about 1895 and is still extensively used as a stock for the Satsuma orange, while in Sicily it offers promise as a stock for several kinds of blood orange. It has never been widely used in New Zealand as a citrus stock in commercial plantings.

The soils best suited to the trifoliate are those of an alluvial or moisture retaining nature with a neutral or acid reaction. It does not grow well in dry or calcareous regions. It is generally conceded to be resistant to the attacks of organisms causing footrot and gummosis, but recent writings have thrown considerable doubt on this point.

The trifoliate orange is a deciduous dwarf tree forming a good root system with abundant fibre and deeply penetrating roots. When worked with a vigorous scion the roots increase in vigour and Hume and Webber both remark that in no case has the trifoliate stock failed to outgrow the scion worked upon it; in other words the girth of the stock at the point of union invariably becomes greater than that of its scion. In one orchard the writer visited near Auckland this was not the case as far as lemons were concerned; in this case the scion had outgrown the stock in many cases; on all oranges observed, however, the stock was the larger.

It is not a congenial stock for many citrus varieties and its chief claim for recognition in this country lies in the marked improvement in the quality of fruit produced by many varieties of citrus when worked on the stock. The trees produced are usually (but not always) smaller in size than those worked on other stocks, but are more precocious; part of the dwarfing effect usually observed may be due to the early and heavy fruiting usually induced by this stock. The fruit produced are generally of higher colour, thinner skinned, they contain less rag and hold their juice longer on the tree.

Davis (i2:i924) testifies to the striking improvement in quality of any fruit grown on this stock in South Africa.

It appears to the writer that future development in the growing of sweet oranges in New Zealand demands an active experimental enquiry into the possibility of improvement of quality of the product by the use of different stocks or combinations of stocks and without making any definite statement it is felt that the trifoliate stock, combined with a suitable scion variety and grown on suitable soil appears to offer possibilities for the production

of high quality sweet oranges in this country.

In respect of quality of fruit it is interesting to note the conclusions of Quinn (26:1933) who found that on tests with the Mediterranean Sweet variety the acidity of the fruits decreased progressively according to whether the rootstock was trifoliate, sweet orange, pomelo or rough lemon respectively. Sweetness followed the same order. Juice was most abundant in fruits from pomelo stocks followed in turn by those on trifoliate, sweet orange and rough lemon. Practically similar results were recorded for Valencias.

Among the orchards visited during the course of the survey may be mentioned two in the Auckland district and one at Gisborne where trees on trifoliate stock were observed to be making excellent growth and appeared to be giving good production. In one case on Avondale Flats three trees of the variety Lue Gim Gong on trifoliata stock were planted in the spring of 1931; when observed in February, 1935 the trees were as healthy as could be desired, deep green and vigorous in habit being 5 feet six inches in height while other well-grown specimen trees of this variety on trifoliate stock were observed.

In another orchard visited at Henderson another grower had planted in September, 1931, 95 lemon trees on trifoliata stock. These were deflowered for two years after planting and at the time of my visit in February, 1935 the trees averaged 6 to 7 feet in height and were bearing a heavy crop of fruit.

On deep alluvial soil on the Gisborne Flats trifoliata appears to thrive; in one orchard a fine row of Ruby blood on trifoliata stock, seven years from planting and approximately 8 feet in height was observed; Groverley Navel of the same age was markedly stunted the trees being only 30 to 36 inches in height; Golden Nugget and Navelencia had in the same time reached a height of approximately 5 feet.

Three Lue Gim Gong planted on trifoliata, sweet orange and citronelle stocks were respectively 6.7ft., 8ft. and and 8ft. in height. In these cases the dwarfing effect of trifoliata stock does not appear tohave been serious except in the case of the Groverley Navel.

In any case more definite experimental evidence is required before one is in a position to finally pass judgment.

(iv) Sour or Seville Orange (C. Aurantium, Linn).

According to Hume (I8: I926), 75 percent of the world's commercial output of citrus is grown on sour stock, and Coit (7:1927) seems to think that it would be as well if the remaining 25 per cent were also so grown. It is compatible with the majority of citrus varieties grown in most countries.

The sour orange is characterised by abundant and deeply penetrating roots. Hence in Florida (7:I927) it was found to be less affected during periods of protracted droughts than other more surface feeding varieties. The comparative immunity of sour orange to footrot and all those forms of gum disease which have devastated so many orchards in the past, is a factor which has told heavily in its favour when choice of rootstocks has been under consideration. In the early years, trees on this stock are not very free bearing, but the fruit that is produced is of good quality from the start, a characteristic which is not common to the quicker growing sorts such as rough lemon.

Its once conspicuous failure is as a stock for oranges in South Africa where it has proved a complete failure.

It is used almost exclusively as a stock for lemons in Italy. In California in recent years there has been a return to sweet orange as a stock for lemons owing to a falling off in vigour of trees worked on sour stock after they reach the age of ten years, particularly in Ventura County.

It is difficult to say why the stock has not been tried out in this country. It was for some reason not included in the trials of rootstocks at Tauranga and the writer found no trees in orchards which were known to be on sour stock although a number of sour orange trees were observed all apparently in vigorous growth.

It has been included in the Mount Albert Test area and it will be interesting to note its response to New Zealand conditions.

(v) Other Stock Varieties.

(a) Rangpur Lime. (c. aurantifolia, Swingle).

The Rangpur lime was tried as a stock at the Tauranga Experimental Area and proved fairly successful in point of yield as a stock for Lisbon or Genoa lemons. Its use has not extended commercially owing to its susceptibility to frost and also to its liability to uproot in heavy wind due to its shallow rooting system.

(b) Common Lemon (C. Limonia, Osbeck).

While in the early days of the industry the lemon was frequently propagated on its own roots either from cuttings or layers the trees were usually short-lived owing to attacks of footrot. Its use for commercial plantings has therefore been abandoned though some nurserymen (not in commercial areas) still raise considerable numbers of lemon cuttings for sale.

(c) Cleopatra Mandarin (C. nobilis var. deliciosa, Swingle).

Reasoner Bros. of Floria who introduced the Cleopatra mandarin as a stock have adopted it along with sour orange as their standard stocks. They write, "Cleopatra mandarin is a very hardy subject and produces a quality of fruit superior to any other stock we know of. It is a vigorous grower; withstands prolonged droughts; holds fruit even later than sour stock and does so with no drying out of the fruit, even late in the season. Its added advantages of immunity to citrus

scab, footrot and many fungus diseases makes it an ideal root system.

It seems to be compatible with most citrus varieties under Florida conditions and should be worthy of trial here.

(d) Grapefruit or Pomelo. (C. maxima var. uvacarpa, Merril and Lee).

This stock has been tried out in a number of localities but its use has never become extended possibly because its soil adaptations are limited or partly because the grower feels little inclination to become involved, unless driven by necessity, with a stock whose reactions are still a matter of uncertainty.

The use of the local Poorman orange or New Zealand Grapefruit as a stock is probably worthy of trial since it is comparatively easily grown from cutting and is a strong and vigorous grower.

## D. DOUBLE WORKING OF STOCKS.

"Double working" consists in budding or grafting a suitable scion with mutual affinities on to a particular stock; allowing it to grow for one or more seasons and then budding over the double worked tree with a commercial variety of proven affinity with the intermediary. This method has been used in the past on certain apple and pear stocks but outside New Zealand is a new departure as far as citrus is concerned. Only one reference could be found in the literature, in which double working of citrus was mentioned; this was in an article dealing with the use of sour orange as a root-stock for sweet orange and mandarin in Java, published in "Landbouw", 1934. Sweet orange or Japanese citron was tried as the intermediate stock, and sour orange the root-stock, proper.

The suggested benefits to be derived from double working are : -

I. The production of good commercial trees on soils which are unsuitable for stocks for which the tree has a natural affinity.

2. Retaining the improved quality of fruit obtained on trifoliata, while eliminating its dwarfing tendency.

As far as the writer knows the method was first adopted and tried out experimentally by Mr. H. R. Wright, of Auckland. He has had a number of experimental trees in his nursery for some years and these appear sufficiently promising to warrant, in the writer's opinion, experimental trial of the method under standardised conditions where satisfactory comparison can be made with trees propagated by the ordinary methods.

The double worked stock which has been principally tried out by Mr. Wright is trifoliata plus Cleopatra mandarin or alternatively trifoliata plus"Best's Seedless" these double stocks being subsequently re-worked with another commercial variety which ordinarily lacks affinity with trifoliata.

The results to date appear very promising.

## E. PROPORTIONS IN WHICH STOCKS ARE IN USE IN NEW ZEALAND.

While an attempt was made to determine in all cases the stocks on which orchards were worked little success attended the effort since most of the growers visited were unable to supply the information. The young plantings at Keri Keri, while mainly on citronelle stock, were said to vary, some being on sour orange and some on sweet orange but no register was available as to where these trees had been planted. On observation, only, the writer

believes that a larger proportion of young plantings (exclusive of Keri Keri) are worked on citronelle than was formerly the case.

The data collected from such growers as were able to supply information is tabulated in Table XV below. The figures of Keri Keri growers have been excluded from the list; were they included the proportion of trees planted on citronelle would be overwhelmingly great.

T A B L E XV.

Showing the proportions and numbers of trees of the different varieties worked on citronelle, sweet orange and trifoliata stock in the groves where definite information was available (Keri Keri figures were excluded).

| Stock | LEMONS. Bearing | LEMONS. Not Bearing | LEMONS. % | N.Z.GRAPEFRUIT. Bearing | N.Z.GRAPEFRUIT. Not Bearing | N.Z.GRAPEFRUIT. % | TOTAL. | TOTAL. % |
|---|---|---|---|---|---|---|---|---|
| Sweet Orange | I,556 | 474 | 57% | 466 | 239 | 86% | 2I8 | 6I% |
| Citronelle | 500 | 860 | 39% | 50 | 57 | I4% | I05 | 29% |
| Trifoliata | 50 | 95 | 4% | .. | .. | .. | 34 | 9% |

While the total number of trees included in the table is relatively small it serves to indicate that of the older lemon plantings 75% are on sweet orange stock but of the newer plantings only 30% are on sweet stock the remainder being planted chiefly on citronelle. Plantings of New Zealand Grapefruit are preponderantly on sweet orange stock, while the total numbers of sweet oranges is so small as to lend little significance to the figures.

## T A B L E  XVI.

Summary of the Distribution, Soil Adaptability, Disease Resistance, Etc. of the Rootstocks chiefly used in New Zealand.

| Stock | Distribution. | Soil Adaptability. | Effect on Scion. | Disease resistance. | Recommended in N.Z. for the Varieties |
|---|---|---|---|---|---|
| Citronelle or rough lemon. | Practically universal. | Especially suitable for sandy soils, but adaptable over a wide range. | Fruits in the early years are liable to be of inferior quality; later it produces as fine fruit as any other stock. Trees on it have tendency, corrected later, to tall upright growth in centre. Evidence contradictory as to influence on taste and shape of fruit. Said to withstand drought well. Marked recuperative powers after period of neglect. | Fairly resistant to brown rot and footrot gummosis; much more so than sweet Orange stock. | All commercial lemons. Judgment suspended in case of N.Z. Grapefruit and sweet oranges until further experimental data available. |
| Sweet Orange. | Universal but not generally used owing to susceptibility to foot rot & gum diseases. | Light dry soils owing to susceptibility to footrot. Root system shallow. | Rapidly produces a shapely tree, being superior in this respect to sour orange & trifoliate, though not to citronelle and grapefruit. | Susceptible to footrot and brown rot gummosis, etc. on poorly drained soils. | All varieties, on soil that has been efficiently under-drained. |
| Trifoliata. | Japan, China parts U.S.A. | Alluvial or moisture retaining soils with natural or acid reaction. Roots deeply penetrating with abundant fibre. | Stock usually outgrows the scion in circumference. Often somewhat dwarfing, though this is possibly due to slight incompatability and environmental conditions or to different Strains within the species. Trees precocious and bear fruit of exceptional quality. | Usually considered resistant to footrot and gum diseases but resistance has been questioned by recent reports. | May have possibilities for sweet oranges but experimentation necessary. |
| Sour orange | Throughout citrus growing regions, except South Africa. | Wet or heavy soils but covers wide range. | Not free bearing in early years but fruit of good quality from the start. Later bear freely. Dwarfing effect on light land in South Australia. | Resistant to footrot and gum diseases. | Not at present in use nor has it been included in any trials prior to Mt. Albert test. |

## CHAPTER VIII. A SUMMARY OF ROOTSTOCK TRIALS COMPLETED OR IN PROGRESS IN NEW ZEALAND.

A. The Tauranga Trial. (I) Layout etc. (II) Critical Examination of Results.
B. Mt. Albert Citrus Test Area.
(I) Introductory. (II)Criticism of Layout adopted. (III) Disposal of other Selected Citrus Stock.

### A. THE TAURANGA ROOTSTOCK AND VARIETY TRIAL.

(I) Layout etc.

In 1919 a trial area was established by the Horticulture Division of the Department of Agriculture to test the suitability of certain varieties of citrus fruit for commercial growing in New Zealand. In 1923 the area was disposed of to Mr. J. H. Davidson, the past manager, who undertook to continue the records for a certain period.

The area consisted of approximately seven acres, comprising 493 lemon trees and 145 trees of various sweet oranges grapefruit and limes. The area was planted in August 1918, with the exception of the stock-testing block, three rows of Genoa lemons, and about half of the sweet oranges which were completed in the following spring.

Four trees at the end of each row of lemons were worked on Trifoliata and have now been removed. The crops indicated in the following table are the average of the four trees on each kind of stock, the count being based at the rate of 150 lemons per case for the seasons ending March 31st.

## T A B L E XVI.

Shewing the Yields of Five Varieties of Lemons on Various Rootstock at the Taurange Trial Area for the Years ending March, 31st. 1925, 1927, and 1928.

Yield in cases, on following stocks.

| Variety. | Year. | Sweet Orange. | Lemon. | Trifoliata. | Rangpur Lime. | Citronelle. |
|---|---|---|---|---|---|---|
| Eureka. | 1925 | 1.75 | 1.0 | 0.75 | 1.5 | 2.5 |
| | 1927 | 4. 0 | 3.0 | 0.06 | 2.05 | 4.05 |
| | 1928 | 2.0 Av.2.6 | 1.06 | 0.03 | 1.05 | 2.05 |
| | Average | 2.6 | 1.7 | 0.3 | 1.5 | 2.9 |
| Lisbon | 1925 | 1.66 | 1.0 | 2.0 | 1.5 | 0.25 |
| | 1927 | 5.0 | ,, | 2.01 | 4.02 | 2.05 |
| | 1928 | 2.05 | ,, | 1.05 | 2.02 | 1.05 |
| | Average | 2.9 | .. | 1.7 | 2.5 | 1.1 |
| Villa Franca | 1925 | .. | 0.5 | 0.4 | 1.5 | 2.0 |
| | 1927 | .. | .. | 1.05 | 3.02 | 4.0 |
| | 1928 | .. | .. | 1.01 | 2.03 | 2.0 |
| | Average | .. | .. | 0.8 | 2.2 | 2.7 |
| Genoa | 1925 | 1.0 (young) | 2.5 | 1.0 | 1.66 | 2.25 |
| | 1927 | .. | .. | 1.05 | 2.06 | 4.0 |
| | 1928 | .. | .. | 1.0 | 1.02 | 2.02 |
| | Average | .. | .. | 1.0 | 1.6 | 2.7 |
| Missina | 1925 | .. | 0.2 | 0.2 | 1.6 | .. |
| | 1927 | .. | .. | 1.0 | 3.0 | 3.0 |
| | 1928 | .. | .. | 0.07 | 1.07 | 2.02 |
| | Average | .. | .. | 0.4 | 1.9 | .. |

In respect of the yields quoted in the above table Everett (1 3 :1928) says "it should be borne in mind that throughout the Tauranga district there have been light crops of almost all citrus fruits for the past three years. The 1927-28 seasons crop was one of the lightest ever experienced in the Bay of Plenty, being in most cases almost a complete failure".

Where no yields are given for a variety on a particular stock it is because no records are available and does not indicate that no crop was harvested. Wherever records are available for the three years these have been averaged; where the yield for one or more years is not available the average is omitted.

No published data are available in regard to the type of stock planted or the treatment in the nursery

prior to planting. Davidson (II: 1926), however, gives the following note in regard to the Lisbon variety: "This block of trees is the poorest in the area. They were a nasty lot when they came from the nursery, the rootstocks being old and stunted. The following season after planting the poorest of them were lifted and destroyed. In spite of the fact that they receive the same manurial treatment as the other sorts they do not respond as they ought to. Many of the trees have not yet borne any fruit, and the average picking for the block last season was approximately one quarter case of fruit per tree".

A summary of the observations from the trial area of lemons is given by Everett (13: 1928). "The results obtained so far from the different lemon variety and rootstock tests indicate that the three most suitable lemon trees to grow for commercial purposes - in the locality of Tauranga, at least- are Lisbon on Rangpur lime or sweet orange, Genoa on rough lemon, and Eureka on rough lemon stocks. While the yields recorded above show that the crop for the past two seasons has been lighter on the Genoa than on either the Lisbon or Eureka, it must be borne in mind that the appearance of the Genoa fruit is better than that of either of the other two varieties".

On the basis of average yield over the seasons given in Table XVI the recommendations would be, Eureka on citronelle and Lisbon on sweet orange equal with an average of 2.9 bushels per tree, followed closely by Villa Franca and Genoa on citronelle with an average yield of 2.7 bushels per tree. It is doubtful whether such differences in yield are significant.

The continued recommendation of Rangpur lime as a stock seems hard to understand in the face of the following

comment by Davidson (II: 1926), "Lisbon on Rangpur lime. Trees are vigorous and healthy. Six trees continue to bear rough fruit, and if no improvement shows they will be re-worked. Several of the trees were severely blown about: two of them were entirely blown out of the ground, the root-system being so damaged that they had to be removed. The rooting-system of the lime is not so deep as that of the lemon or orange, which is rather a disadvantage". Add to that that the production is lower than on sweet stock and there appears little reason for its recommendation.

(II) Critical Examination of Results.

It is usually considered axiomatic in any experiment that as far as possible all variables other than the ones being studied shall be minimised in the experiment or due allowance must be made for their effect. In an experiment of the type under consideration the chief variables which should be minimised or excluded are :-

1. Variation in soil fertility, drainage etc.
2. Variations in treatment of the various plots.
3. Variation in other environmental factors such as wind, frost, etc. not so easily controlled.
4. Variations within the scion variety itself; budsshould be carefully selected and preferably be taken only from one tree to avoid variation.
5. Variations within the stock variety used; stocks should be carefully selected and rogued for variants or observed differences in stions may be due to the use of different strains within the stock variety.
6. Variations in the size of budlings at time of planting. Webber (44: L932) has shewn by carefully planned experiments that "There is thus apparently an advantage possessed by the seedlings and budlings that are large while growing in the

nursery which is carried over when they are transplanted into the orchard and persists for a considerable period, at least long enough to give a larger crop of fruit during the first eight years". This may be explained as an example of Blackman's "compound interest law" of plant growth.

Taking every precaution to ensure uniformity in a grove prior to commencing fertiliser experiments Batchelor and his coworkers (2: L928) found differences of up to 40% in yield between adjacent plots and up to 109% between plots more widely spaced.

What significance therefore can be attached to the rootstock trials at Tauranga ? In the light of knowledge in respect of rootstock variation, the necessity for bud selection, influence of size of budling at planting, etc., all of which has accumulated since the experiment was commenced it appears to the writer that the results obtained are of little real significance. Probably on the evidence it is safe to condemn trifoliata as a stock for lemons under Tauranga conditions but in the other cases it is not possible to be sure that the observed differences are significant.

In effect the Tauranga trial becomes little more than an expensive observational trial the results of which should in general be accepted with considerable caution.

## B. MT. ALBERT CITRUS TEST AREA.

### (I) Introduction.

After many vexatious delays a test area was finally established by the Citrus Committee of the Auckland District Council of the Institute of Horticulture and the first trees were planted on the I4th. August, I933, with the approval of the Department of Scientific and Industrial Research.

Various locations were viewed in the endeavour to find a suitable site for the area; it was desired that it should be reasonably central and that it should be representative of one or more of the types of soil commonly used for growing citrus in the district. Finally an area was chosen in close proximity to the Mount Albert Grammar School on the northern slopes of Mount Albert.

The area obtained contains approximately two acres of volcanic soil of a lateritic type (no analysis available). Previously it was subdivided by a stone wall running lengthwise across the area; the subdivision above the wall was more or less continuously cropped, the material grown being fed over the wall to stock on the lower area. Continual working of the upper section resulted in soil being piled up on the upper side of the wall.

On taking over the area the wall was removed and the area ploughed and levelled. A series of trees of selected scion variety on selected stock varieties were then planted on the area and have since received cultivation and attention with the aid of monies granted for the purpose by the Department of Scientific and Industrial Research and by the Unemployment Board. The layout is shewn in Fig. VII. The trees at the time of the writer's visit were suffering somewhat from dry weather but otherwise appeared to have established satisfactorily.

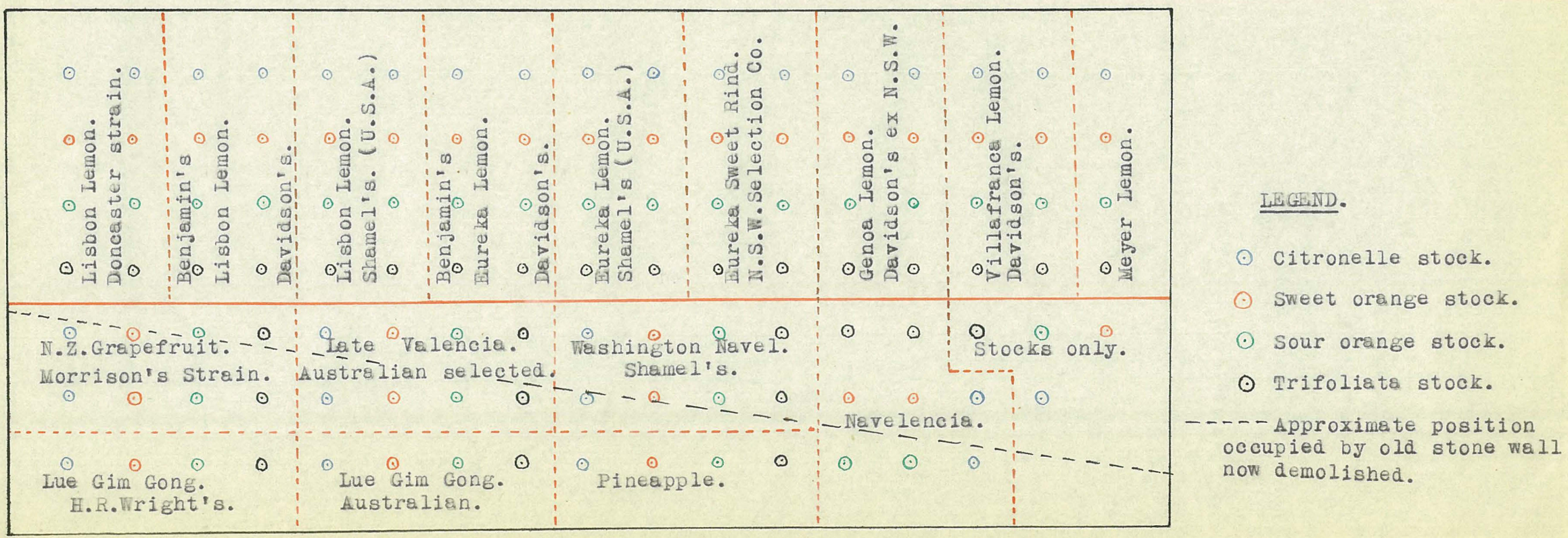
(II) Criticism of the Layout Adopted and its effect on the Conclusions which can be drawn from the Test Area.

The volcanic soil type which comprises the Test Area is unfortunately not representative of the types on which most of the citrus is grown in the Auckland district (see page 37) and the application of any conclusions which may be drawn is therefore limited.

Secondly, the previous history of the area makes

# F I G U R E  V11.

Shewing the Layout Adopted for the Mt.Albert Citrus Test Area.



the designing of a suitable layout to obviate possible differences in soil fertility a matter of extreme difficulty. The present layout appears faulty in that it makes no attempt to eliminate the effect of a number of variables. Take for instance the row of lemons on citronelle stock (Fig. VII) should this row prove superior throughout the trial the observed superiority may be due to :-

I. The superiority of citronelle stock for lemons on this type of soil

or 2. It may be due to the fact that being an outside row the trees have a greater area available for rooting.

or 3. The soil at the top of the slope may be better than that lower down.

or 4. The superiority might be due to better shelter from the prevailing winds owing to proximity to the shelter belt; to greater freedom from frost or other causes.

The layout adopted appears to give little or no check on the effect of the above factors and any conclusions which may be drawn from the area must always be subject to the above limitations.

The layout could at little trouble have been considerably improved by :-

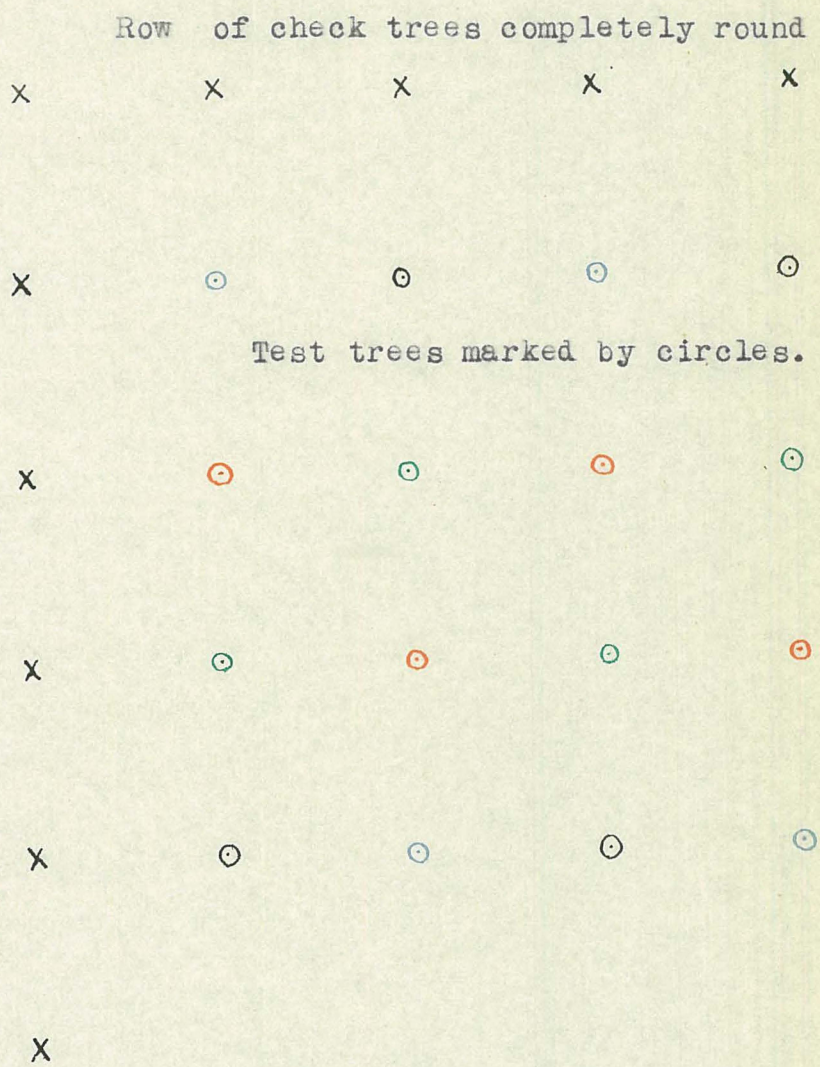
(a) Placing a row of check trees completely round the experimental block to obviate variables 2 and 4 above.

(b) By reversing the order of alternate rows in the lemon block i.e. the corner block of Lisbons arranged as shewn in Fig. VIII.

Such a layout as suggested is still open to considerable criticism but appears to be a big advance over the one actually followed in planting the area.

## F I G U R E  V111.

Shewing suggested improvement which might have been made in the original layout of the Mt.Albert Citrus Test Area, for the first block of Lisbon Lemons.



The value of the area in its present form seems limited to providing a rallying point for field days, as an adjunct to the agricultural section of the Mt. Albert Grammar School, possibly as a source of budwood of known strain and as an interesting observational rootstock trial which may suggest possible lines for future investigation.

(III) Disposal of Other Selected Citrus Stock.

Approximately 1000 trees were propagated for the Auckland Citrus Committee by Mr. E. A. Herd, Hillsborough Road, Onehunga, from selected budwood, both of local strains and of selected imported strains. These were worked on four rootstock types and as the number was in excess of the requirements of the Committee for planting the Mount Albert area it was felt that they would be of the greatest value if distributed as widely as possible so that their growth under different soil conditions might be observed.

This was done and a register has been compiled by the Committee shewing the tree numbers and other details of trees sold so that it is available for future reference.

This appears to be a valuable movement since it ensures the trees being planted on a wide variety of soil types and under different climatic conditions and if annual or biennial visits can be made to the trees and records kept of their progress it should afford valuable information.

## CHAPTER IX. VARIETIES OF CITRUS IN NEW ZEALAND.

A. Lemons. (I) Lisbon. (II) Eureka. (III) Genoa (IV) Villa franca. (V) Meyer.
B. Grapefruit. (I) N.Z.Grapefruit.
C. Sweet oranges. (I) Washington Navel. (II) Lue Gim Gong. (IV) Jaffa. (v) St. Michael. (VI) Ruby Blood.
D. Mandarins. (I) Satsuma. (II) Temple Orange.
E. Proportions in which varieties are already planted.
F. Recommendations to Intending Planters and Summary of Varieties.

Everett (I4:I933) enumerates 20 varieties of oranges, I2 varieties of lemons and a number of miscellaneous citrus varieties as having been introduced into New Zealand; this is probably a conservative estimate. As Webber (42: I925) remarks in regard to South Africa "A mistake that is commonly made in the early development of a fruit industry and by those who have not become specialists therein, is to plant a few trees of a large number of varieties rather than a large number each of a few varieties. The glowing terms in which each variety is described in the nursery catalogue and the lack of knowledge of which is best leads him to choose many. The markets demand a fruit of known type and quality. They demand a few good standard types and accept other types grudgingly".

### A. LEMONS *

The principal varieties of lemons which have been commercially planted in New Zealand are the Lisbon, Eureka, Villa Franca and Genoa. Other varieties which have been introduced but never widely planted are the rough lemon or citronelle (used as a stock), Meyer, Messina, Crisp's Ideal, Ponderosa or Wonder lemon and Sicily.

* See Appendix II for descriptions of individual varieties in more specific terms. The description given in the text is only of a general character.

(I) Lisbon.

The Lisbon type was one of the first varieties of lemon to be introduced into the country and probably constitutes over half of the bearing lemon trees planted. Since the institution of bud selection work, however, it has come to be recognized that the variety is really a heterogenous population consisting of a number of strains, some superior to others. The main strains which have been separated are :-

(a). the original long-thorned type introduced at least sixty years ago.

(b). the short-thorned or Sydney type; present sources of budwood chiefly Benjamin's, other strains originally imported from Sydney and C.H.Scott at Henderson. Probably identical with type (c).

(c). Ferdinand Finger's or Doncaster strain of short-thorned Lisbon; recently introduced by the Auckland Citrus Committee direct from R. J. Serpel, Doncaster, Victoria.

Buds of A. D. Shamel's best selected strain have also been imported from California by the Committee and have been planted out in the Test area at Mount Albert.

The short-thorned or Sydney type is the better of the two New Zealand strains and may,under trial, prove to be identical with the Doncaster strain.

The variety is a strong vigorous grower, prolific, moderately thorny, and well furnished with foliage (see Plate IV). It is well furnished with fruiting laterals and bears its crop evenly over the tree. The fruit is very uniform in size, ripens evenly, and keeps well; the tree has a tendency to bear its heaviest crop in the spring when lemon prices are at a minimum while the thorns are a distinct disadvantage in picking.



PLATE IV. A fine young Lisbon lemon tree on citronelle stock at Keri Keri; 4yrs. from planting. Under good management conditions trees at Keri Keri have made phenomenal growth. These trees were inter-cropped with passions and do not appear to have suffered any setback.



PLATE VI. A young three year old Washington Navel on citronelle stock at Keri Keri. Not all the trees have fared as well as this one, but this shews what can be done under good conditions.

Selected strains may be safely recommended for commercial planting.

(II) Eureka.

As in the case of the Lisbon several strains of Eureka are found in New Zealand plantings the two chief strains being : -

(a). The original strain imported from California about 1888. This type "sports" freely and often gives thick skinned and irregular fruit of low commercial value. If any grower is dissatisfied with the Eureka variety it is usually because his plantings are of this type.

(b). The "Sweet Rind"; a type of Eureka introduced at a later date from Sydney. It has proved to be of better quality and appearance, thinner skinned and better textured.

(c). A. D. Shamel's best selected strain has also been imported by the Citrus Committee and is under trial at the Mount Albert Test Area.

The variety forms a somewhat smaller tree that the Lisbon and is practically thorn-free. The fruit is of uniform shape and keeps well being the standard variety grown in California. The tree has a tendency, not easily corrected, to grow the fruit at the extremities of the branches where it is more subject to wind-rub and it is generally poorly furnished with foliage. The variety is very prolific coming into bearing at an early age and bearing a better summer crop than Lisbon. It is one of the best commercial varieties in this country.

(III) Genoa. This variety was originally introduced from Sydney for trial at the Tauranga Horticultural Station and under conditions there has proved one of the most profitable varieties. The tree is thornless, semi-dwarf in habit and the fruit keeps excellently. The fruit is unusually uniform

in type, of good form, type and appearance with a thin rind. It is not as vigorous a grower as the two preceding varieties but as it becomes better known it will probably prove popular. Chief source of budwood, Davidson's, Tauranga.

(IV). Villa franca.

This is a variety which is being planted to a certain extent in the Tauranga district. It yielded moderately well in the Tauranga trials and Davidson remarks in regard to it (II:1926): "It has the same advantage as the Eureka variety, of being a vigorous grower and an early bearer. The general habit of the tree is stocky and rigid. The branches are much shorter-jointed and less drooping than those of the Eureka, and the tree is therefore better suited for exposed situations. & The fruit produced on young trees is decidedly of poor quality. The nipple does not grow out, which makes the fruit too round and rough looking. It is also a heavier summer-bearing variety than the Lisbon or Eureka, and this is decidedly in its favour".

It is doubtful whether it possesses any characteristics which warrant its planting in place of one of the three preceeding varieties. Chief source of bud-wood Davidson and Benjamin Tauranga.

(V) Meyer Lemon.

Though this variety is not recommended for commercial planting a note in regard to it is added here owing to the wide publicity it has received since its introduction a few years ago. It is a hardy dwarf variety of extremely precocious nature when worked on trifoliate stock. The fruit tends to be smaller than the ordinary lemon and somewhat resembles the Tahiti lime in shape; the skin is of extremely smooth texture and turns a deep golden yellow colour which makes it very attractive for window dressing. While analysis does not show it to be markedly lower than other varieties in acid content it lacks the pronounced flavour of the other varieties.

& Now that the trees are older the writer understands the quality has improved and is now up to standard.

## B. GRAPEFRUIT.

Most of the leading varieties of American grapefruit have been introduced into this country and given fairly extended trial. None of the varieties which the author has seen fruiting can be considered as commercially satisfactory. Two growers at Keri Keri reported that their trees bore fruit of good quality but unfortunately they were out of season at the time of my visiting the district. An improvement in quality is observed when worked on trifoliata stock but the trees are unduly dwarfed. The only grapefruit which has proved satisfactory under our conditions is the Poorman orange or New Zealand Grapefruit.

(I) <u>New Zealand Grapefruit:</u> Poorman Orange.

This variety was introduced by Sir George Grey at Kawau its place of origin not having been traced. There are two strains recognized :-

(a). A habitually seedy type, coarse and rough-skinned.

(b) Morrison's strain which is a superior type, practically seedless, think-skinned and smooth textured.

The tree is a strong, vigorous grower, densely foliaged and a prolific cropper (see plate V). The fruit is medium sized, a bright yellow colour, juicy and practically seedless. The flesh is tangerine coloured, while the flavour is pleasantly sub-acid. It forms an excellent breakfast fruit and is rapidly increasing in popularity.

It is the only grapefruit which can be recommended for planting in this country.

Season; as grapefruit, late July till December. In some localities or possibly on some stocks the fruit tends to dry out and cannot be held on the tree later than September; for marmalade the fruit may be picked as early as May.



PLATE V. A young 3yr. old N.Z. Grapefruit tree on citronelle stock bearing over 60 fruit all over 3½ins. in diameter. This is one of the pedigree trees raised for the Auckland Citrus Committee and later sold to growers in widely scattered districts for testing purposes.

## C. SWEET ORANGES &

The main varieties of sweet orange which have been introduced into New Zealand are Washington Navel, Valencia Late, Lue Gim Gong, Jaffa, St. Michael, Ruby Blood, Pineapple Golden Nugget, Groverley Navel, Thompson's Improved, Hamlin, Navelencia, Parson Brown, Parramatta and Joppa. In addition two local varieties, Best's seedless and Dacre's have been planted to a limited extent. The difficulty which confronts the intending planter is to decide on which variety to plant :

In order of numbers the varieties most widely planted at the present time are probably Washington Navel, Valencia Late, St. Michael and Lue Gim Gong.

(I) Washington Navel.

The Washington Navel is one of the most widely planted of the citrus varieties and under suitable conditions produces fruit of almost ideal characteristics. Coit (7:1927) says "the natural qualities and character of this orange, have made it the greatest commercial orange in the world. These thornless trees combine heavy amd regular yields with a high colour of the fruit, a silkiness of texture, and a general finish which is almost perfect". Its very perfection seem to render it more susceptible to adverse conditions than other varieties; it reaches its highest pitch of perfection in the dry air, bright sum, and cool nights usually characteristic of irrigated areas. Coit (7:1927) states that in the coastal region of California the skin tends to be somewhat thicker with a rough surface and paler colour. It remains to be demonstrated that these are not the conditions operating in New Zealand or whether the climatic influence can be compensated for by a choice of stock.

The variety has been planted in large numbers at

& See Appendix II for more detailed description of each variety.

The variety has been planted in large numbers at Keri Keri and these are now coming into bearing (see Plate VI); the result is still problematical, though some of the fruit produced has been of excellent quality.

The tree grows well under New Zealand conditions, though it is semi-dwarf in habit, but fruiting appears to be somewhat irregular and while the flavour usually leaves little to be desired the fruit is frequently somewhat irregular and variable in shape and size. This may be due to poor strain and it will be interesting to follow the production from the improved strains recently imported.

Under New Zealand conditions the fruit is early mid-season, ripening from August to early October.

Californian experience (3I:I929) has shewn selected strains of the Washington type to be superior to any of the numerous other selections such as Thompson's, Groverley, Golden Nugget, Buckeye, etc. This may not prove to be so under our conditions but is an indication of the caution necessary in introducing new strains.

(II) Valencia.

Like the Washington Navel the Valencia succeeds best under irrigated conditions. During recent years it has rivalled the former in importance on the world's markets owing to its lateness of season. It has recently been planted in large numbers at Keri Keri (see Plate VII) and while the trees are still young the quality of fruit being produced did not impress the writer. The skin was coarse textured and poorly coloured while the flavour was rather insipid; the fruit were of good commercial size and may improve in quality as the trees increase in size. It should be borne in mind that the bulk of the plantings at Keri Keri are on citronelle stock which is generally considered to produce a poor quality of fruit during its early years of bearing. The tree un-



PLATE Vll. (left) A six year old Valencia orange tree on citronelle stock at Keri Keri. Trees of this age are now coming into bearing, but up to date the fruit has not been of the highest quality.

PLATE Vlll. (right) A 3yr. old Lue Gim Gong on sweet orange stock at Warkworth. The Lue Gim Gong is very similar to the Valencia but somewhat later in season.



doubtedly grows and crops well.

Season November to January. The best selected strains have been imported from California and Australia and planted in the Mt. Albert Test Area.

(III) Lue Gim Gong.

This variety was introduced to the horticultual world in 1912 by the Glen Saint Mary Nursery Company of Florida. A. D. Shamel in a private communication states :

"My observations here and in Florida have convinced me that Valencia Late and Lue are one and the same variety and that Lue, formerly called Lue Gim Gong, is a selected strain of the Valencia variety originating from a bud variation. I am of the opinion that the fruits of the Lue strain may hang on the trees in good condition a little later, perhaps, than those of the parent variety, in some instances at least. There is no tendency hereor in Florida to substitute the Lue for the Valencia variety commercially ". Dated 23/5/34.

Much the same remarks apply to Lue under New Zealand conditions as given for Valencia. In the writer's opinion apart from the fact of its very late season it appears to have little to commend it for commercial planting (see Plate VIII).

Season: owing to the fact that fruit will hang on the tree for such a long period it is difficult to define the season; they could probably be marketed any time from November till May but fruit with normal juice content can frequently be picked at any season of the year.

(IV) Jaffa.

This variety is the one mainly grown for the production of the Palestine crop and has been planted here on a small commercial scale. The fruit is seedy, of medium size, juicy, of good flavour and fine texture. This variety worked on trifoliate stock has produced some of the finest quality fruit the writer has seen grown in this country.

If this same quality can be produced in quantity there is no hesitation in saying that it could command the New Zealand market as a mid-season orange.

Season: on sweet orange stock, August, September but may be held as late as November on trifoliata stock. Requires experimentation on different stocks but shows considerable promise.

(V) St. Michael.

One commercial planting of about I20 trees was visited during the survey (see Plates IX & X). Some of the trees in this orchard are now 40 years old and in some seasons have yielded up to I5 bushels of saleable fruit per tree. This grower over the last 9 years period has averaged approximately I0/4 per case, gross, which can be considered quite a payable return.

The fruit is of medium size, well coloured, juicy and of good flavour. The skin is slightly thicker than desirable and could be smoother in texture; the trees are prolific in bearing and fruit at an early age.

Season: late September to November; has been shipped as late as Christmas.

(VI) Ruby Blood.

This variety has not been widely planted in New Zealand but some excellent young trees (9 years) were seen at Gisborne. Hume (I8: I926) says "it has no superior and few equals in quality". The trees at Gisborne were bearing a heavy crop of uniform fruit and the variety is probably worthy trial.

Season: August to September.

Other varieties which appear worthy of trial are Pineapple and Hamlin both largely planted in Florida for the mid-season and early markets respectively.



PLATE 1X. (left) St.Michael sweet oranges in a North Auckland orchard. These have proved a consistently profitable variety but are not recommended for future plantings.

PLATE X. (right). A 9yr. old St.Michael orange tree bearing a heavy crop, estimated at 5 bushel cases.



The trial of various sweet oranges on a variety of rootstocks is a matter that should receive immediate attention if any attempt is to be made to give reliable information to intending planters since the time lag from planting citrus to production is so great. The question of stock influence on quality should be thoroughly tried out at the same time. Such an investigation is fundamental to the placing of the sweet orange industry on a sound basis. This matter is further discussed in a later chapter.

## D. MANDARIN VARIETIES.

While at least 17 varieties of mandarin have been introduced none of them has been cultivated on a commercial scale. In respect of mandarin varieties Hume passes the following comments: " the mandarin orange is essentially a fancy fruit and as such commands a fancy price in its season, but it would be useless to attempt to place it on the same plane with the sweet orange as a staple fruit. All the members of the group require careful cultivation and fertilization to secure the best quality. The object of every grower should be, not so much to increase the output, as to produce a fruit of high quality, else there is no room for the fruit on the market. A good mandarin orange is an excellent fruit; a poor one is worthless".

The varieties which appear to warrant experimentation in this country are the Satsuma orange or Onshiu mandarin of Japan and the Temple orange, a Florida production.

(I) Satsuma or Onshiu.

This variety appears to succeed only on trifoliate stock. It is a dwarf grower, but bears profusely. The fruit is variable in size, possibly owing to the large number of strains of which Tanaka has described no less than 600. Some of the better of these strains such as the Wase might

with advantage be introduced into this country for testing purposes. Season: May to July.

(II) Temple Orange.

This variety is probably a hybrid between a sweet orange and some variety of the mandarin group. It has been introduced by H. R. Wright and produces a fine quality fruit of characteristic, rich, vinous flavour. Season: August to November.

## E. PROPORTION IN WHICH VARIETIES ARE ALREADY PLANTED.

While no comprehensive data are available, such orchards as could supply accurate information have been analysed in Table XIX. These figures have been analysed only when a grower was able to supply definite information concerning his whole grove, hence the total number of trees considered is small and cannot necessarily be considered as being truly representative of the plantings in New Zealand as a whole. However, it serves as an indication of the probable proportions in which the varieties are already planted (1934).

### T A B L E XIX.

Shewing proportions in which the main Citrus Varieties were planted in groves where definite information was available.

### L E M O N S.

| Variety: | No. Trees: | Percentage of total Lemon Trees: |
|---|---|---|
| Lisbon | 3,219 | 56.4 |
| Eureka | 2,021 | 35.4 |
| Villa franca | 129 | 2.3 |
| Genoa | 153 | 2.7 |
| Other | 180 | 3.2 |
| Total Lemons | 5,702 | 100.0 |

## G R A P E F R U I T.

| | | Percentage of total Grapefruit Trees: |
|---|---|---|
| New Zealand Grapefruit | 3,274 | 88.0 |
| Other Grapefruit (Including Omi Kin Kan) | 460 | I2.0 |
| Total Grapefruit | 3,734 | I00.0 |

## S W E E T O R A N G E S.

| | | Percentage of total Sweet Orange Trees: |
|---|---|---|
| Washington Navel | I,343 | 38.5 |
| Valencia | 993 | 28.5 |
| Jaffa | 94 | 2.7 |
| St. Michael | I75 | 5.0 |
| Ruby Blood | I9 | 0.5 |
| Navelencia | 65 | I.8 |
| Lue Gim Gong | 4I4 | II.7 |
| Other Varieties | 397 | II.3 |
| Total Sweet Oranges | 3,500 | I00.0 |

## F. RECOMMENDATIONS TO INTENDING PLANTERS.

We have now in the Dominion practically every citrus variety of any repute: having them the question still presents itself, "Which varieties shall I plant "?, and in regard to sweet oranges we are still unable to answer the question.

Several growers have been producing sweet oranges in a small way commercially for a number of years with some degree of success; large plantings have been made in recent years at Keri Keri butthese are only coming into bearing; a number of varieties were included in the Tauranga trials but the results were inconclusive and chiefly served to show that none of the stionic combinations included in the

trial succeeded under Tauranga conditions (not that sweet oranges cannot be grown in Tauranga); a number of sweet orange varieties on different stocks have been included in the Mount Albert Citrus Test Area, but this experiment is subject to certain limitations set out elsewhere; in short, after a considerable number of years we are still not in a position to give any reliable information to intending planters.

Webber (see page 67) has stressed the necessity for a few good types if a uniform quality of fruit, calculated to give consumer confidence, is to be produced and we in this country would do well to heed the warning. Shamel has shewn the folly of multiplication of strains under Californian conditions and the necessity for keeping individua tree records so that only the high production strains may be propagated; strain not variety is the botanical feature that is of prime importance and comprehensive experimentation is required before we can answer the question that must be asked by every intending planter, of sweet oranges.

The recommendations which it is considered can be safely made at the present time are shewn in tabular form in Table XX.

# PART IV. FACTORS AFEECTING THE LOCATION AND ECONOMIC ESTABLISHMENT OF CITRUS ORCHARDS.

## CHAPTER X. FACTORS AFFECTING THE LOCATION OF CITRUS GROVES.

Under the heading of present distribution (p.I3) the factors affecting localisation of citrus areas in New Zealand has been fairly fully discussed. It may be advisable at this juncture, however, to review several of these factors and their relative importance in the selection of a site for future plantings.

Citrus fruits have a great advantage because they are not perishable to the same extent as stone fruits, such as peaches and plums, and after being removed from the trees may be, with ordinary care, kept for a considerable period. Their keeping quality has an important bearing on their transportation for, with proper care, they may be shipped to any of the worlds great markets.

The question of location therefore becomes principally one of relative costs of transport and marketing. The points to be chiefly considered are :-

I. Soil.

(a) Continuity of tract.
(b) Quality and kind of soil.
(c) Drainage outlet.
(d) Freedom from hard pan.
(e) Freedom from stones.

2. Climatic Factors.

(a) Rainfall.
(b) Prevailing winds.
(c) Incidence of frosts.

3. Topography of the Land.

4. Nearness to Market, and transport facilities.

5. Proximity to other growers.

To make the best progress citrus growing probably

should be intensive specialisation on small areas devoted exclusively to citrus and subsidiary operations. Farms should be close together so that growers can have the utmost opportunity to learn from one another's experience: it is pre-eminently a business requiring co-operation in various operations, such as, for instance, spraying, packing and marketing, and if people are far apart co-operation becomes difficult. Also if it is only a secondary source of income with a farmer, he is almost certain to get only secondary results.

Such conditions can only be achieved when tracts of suitable land of considerable area are available. Unfortunately under New Zealand conditions such is not usually the case and it is only in isolated districts such as Keri Keri, Tauranga, Te Puke and Gisborne, and to a more limited extent at Auckland, that such conditions exist.

The quality of soil suitable for citrus culture has been discussed in the previous section (page 14), the chief feature required being good drainage. Certain types of otherwise suitable soil are, however, rendered expensive in establishing an orchard if they are to be rendered suitable for citrus owing to the presence of hard pan, or on some volcanic soils to the presence of large amounts of unweathered rock fragments which render preparation for planting expensive.

Since irrigation is not at present practised in citrus groves in New Zealand, a well distributed rainfall of over 50" per annum is necessary in order to sustain good growing conditions throughout the year. This is rarely a limiting factor, however, under New Zealand conditions.

Exposure to the prevailing winds is a factor that cannot be overlooked and has lent in the past to the localisation of plantings in the East Coast districts where the

winds are of lower intensity. Were it not for this factor there are areas along the West Coast which are otherwise suitable for the growth of citrus, but the difficulty of providing adequate shelter renders them unsuitable (e.g. Waiuku, Kawhia, New Plymouth, etc.)

The susceptibility of citrus trees to injury from frost, and the necessity for a mean average temperature of over 55°F. and the absence of damaging minimum temperature decrees that they must be grown principally in the coastal regions of the Auckland provincial area. There are certain favoured locations further South where these conditions are fulfilled, but the areas lack continuity and are not therefore suitable for wide commercial plantings. Owing to the localisation of gravity frosts which occur throughout much of the area, it would be of great assistance to intending planters were a systematic survey of frost-free areas carried out throughout the citrus belts. This, however, presents numerous difficulties and would be expensive in both time and labour. It is doubtful whether under the circumstances, any intensive survey of this kind is warranted.

Care should be taken, however, that in areas liable to frosts the grove is situated on an area elevated in respect of the local surroundings, so affording free drainage for the cold air. Certain plants such as Bouga invillaea Solanum Wenlandii, Tree Tomatoes, Poinsettia or Jacaranda are excellent indicators of the severity of frosts in the locality. If these show no signs of having been killed back, it is fairly certain that a lemon orchard in the immediate vicinity would not be injured, except perhaps in occasional and exceptional yeafs.

Since land purchased for planting citrus is frequently costly, it is advisable to ensure that as large a proportion of it as possible is suitable for planting,

otherwise the initial cost may become excessive. Local configuration of the land may also give shelter from prevailing winds and has a marked influence on the incidence of frosts.

The above factors having been satisfied and other things being equal, it is best to locate the grove in proximity to either rail or shipping facilities. Transportation by road is expensive and a distance of ten or fifteen miles from a shipping point must not be overlooked in the preliminary reckoning of expenditure and returns. If the grove can be conveniently situated near both rail and shipping, so much the better. Competition sometimes has an influence on freight rates and services. Proximity to a large market so that the lower grade fruit may be sold at minimum marketing charges is an added advantage.

# CHAPTER XI. FACTORS AFEECTING ECONOMIC ESTABLISHMENT OF CITRUS GROVES.

A. Introductory.
B. Initial Preparation of Land.
C. Provision of Shelter. (i) General
(II) Kinds of Shelter trees in use.
(III) Location of belts and planting.
D. Ordering Trees.
E. Drainage.
F. Distance of spacing trees.
G. Planting.
H. General.

## A. INTRODUCTORY.

The planting of the trees is the actual starting of the grove and any reasonable amount of time and care taken in the operation is well spent. All the details should be carefully attended to and the work preferably supervised by the owner himself. The work should be planned well in advance and the following factors should receive attention, -

1. Early preparation of the area by ploughing and sub-soiling the whole area at least twelve months prior to date of planting.

2. After ploughing, plant permanent shelter round the boundary of the area.

3. Plant quick growing temporary shelter inside the permanent belt.

4. Order the trees at least twelve months prior to planting.

5. Plant a cover-crop in the Autumn preceding planting and plough in in early August. If the soil needs liming, a heavy dressing should be made at the time of sowing the cover-crop.

6. At this stage drains should be laid unless the area is already exceptionally well drained naturally or a resistant type of root crop is being planted.

7. Having decided on the spacing to be used, lay out the area by an approved method.

8. Plant the trees in August; in colder districts September may be preferable while in warmer districts some growers prefer May.

9. At the conclusion of planting make a map of the area and record details of every tree in the orchard record book.

10. If necessary, water any of the trees which show signs of wilting during the Summer.

11. Keep the surface soil stirred throughout the Summer to destroy weeds.

12. Keep the trunk and stock of the young tree free of any water sprouts which may commence to grow.

13. Plant a cover-crop in the Autumn with at least 3 cwt. of fertiliser.

14. Apply approximately 2 lbs. per tree of a good mixed fertiliser over a small radius around each tree and work into the soil.

## B. INITIAL PREPARATION OF LAND.

In many cases preparation of the land is inadequate and is commenced too late to allow of sufficient time being given to permit of the fallowing of the land. The land should be ploughed early and preferably sub-soiled at the same time care being taken not to bring the subsoil to the surface. Sub-soiling is advised particularly in heavy soils or soils having a hard pan. Particularly in the case of Keri Keri it is felt that sub-soiling may reduce the tendency to washing of the soil since it would provide a larger volume of soil which would have to reach saturation point before washing commenced. In the Tauranga area it is probably not essential. The land may be left lying fallow for the Summer with an occasional stirring to destroy annual weeds.

In the Autumn sow a cover-crop, preferably leguminous, e.g. Blue Lupins, with at least 3 cwt. of fertiliser, and if the soil requires liming, a dressing of at least two tons per acre of lime should be given. This crop can then be ploughed in in the late Winter prior to the planting of the trees. The soil should be thoroughly worked down and levelled to remove soil inequalities prior to planting.

## C. PROVISION OF SHELTER FOR ORCHARDS.

(I) General.

Many young orchards have been noted where the permanent shelter has been planted at the same time as the young citrus trees, no provision being made for temporary shelter. In many such cases, the young trees are stunted and lacking in vigour and occasionally have been blown over on an angle by the prevailing wind. Until such time as adequate shelter is provided, these trees cannot be expected to make satisfactory growth or reach profitable production.

The detrimental effect of wind on orchards not adequately protected by wind breaks has been investigated by Blanchard (4:L934). He found that a protected orchard will gain two years' growth out of five over the unprotected one. In yield expressed as field boxes the protected trees (oranges and lemons) produced 286 field boxes per acre of 80 trees, while the unprotected trees produced 43.6 per acre of 90 trees. Expressed as number of fruits per tree the protected trees averaged 288 fruits, the unprotected trees 55 fruits. All protected trees exhibited a greater vigour and general thriftiness than the unprotected. No data are available in this respect for New Zealand orchards, but observation would suggest that results in New Zealand are similar to those described by Blanchard for Californian conditions.

Any time spent therefore in securing shelter prior to the planting of the orchard is time well spent. If shelter is not available, it is better to plant quick growing temporary shelter and wait at least twelve months before planting the trees in the orchard. If the trees have already been purchased, it would be preferable to plant them in nursery rows for twelve months rather than set them out in an exposed location.

II. Kinds of Shelter Trees in use in New Zealand.

In Table XXI an analysis of 35 citrus orchards visited during the survey is given indicating the type of tree

used to provide shelter. It will be noted that in most cases more than one variety of shelter tree has been planted, and while the data presented cover only a small number of orchards, these may be considered as being representative of the better protected groves. The totals given in the table are probably not an accurate representation of the proportions in which the various species are planted in citrus orchards in New Zealand, but they serve as a good indication.

The most widely grown permanent shelter belt is Pinus radiata, and provided that this is topped when it reaches a height of approximately 30 feet it forms a very satisfactory wind break which grows rapidly, transplants readily and, if protected from stock, keeps its limbs well down to the ground. It succeeds well in any of the citrus districts.

The various species of Eucalypts (see Plate XI)have been generally proven unsatisfactory as they have a tendency to grow into bare stems providing little shelter for the first 20 feet in height. This has been satisfactorily remedied in some cases by the planting of a lower growing hedge such as Hakea saligna on the inside of the Eucalypts. Except for rough areas on the borders of the grove, they are not, however, recommended for general planting.

Cupressus Lawsoniana where it succeeds forms an ideal hedge, its chief disadvantage being its slowness of growth. This can be overcome to a certain extent by cultivation and manuring during the early years of growth, and the final result compensates for the time and labour involved.

One of the most satisfactory shelter belts is that provided by areas of native bush (See Plate XII). Several orchards were noticed where this had been conserved so as to provide excellent shelter on one or more sides of the orchard.

# T A B L E XXI.

## Analysis of Type of Shelter Provided in 35 Citrus Orchards visited during Survey.

| Grove No. | Barberry. | Eucalypts spp. | Oxylobium. | Hakea saligna. | Pinus radiata. (Syn. insignis). | Bambusa vulgaris. | Cupressus macrocarpa. | Redwood. | Acmena floribunda. | Albizzia lopantha. | Black Wattle. | Cupressus Lawsoniana. | Variegated holly Evonymus japonica | Eleagnus. | Lombardy Poplar. | Native Bush. | General conditions of shelter. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| I | xx | xx | | | | | | | | | | | | | | | Good |
| 2 | xx | | | | xx | | | x | | | x | | | | | | |
| 3 | | | | | xx | | | | | | | | | | | | Good |
| 4 | | | | | | | | | | | | xx | | | | | Ex. |
| 5 | | | | | | | | | | | | xx | | | | | Good |
| 6 | | | | | | | | | | | x | xx | | | | | Good |
| 7 | | | | | | | | | | | | xx | | | | | Good |
| I3 | xx | | | | | | x | | | | | | | | | | Good |
| I4 | | | | | | | | | xx | | | | xx | | | | Ex. |
| I5 | | | | | | | | | | | x | | | x | | | Good |
| I6 | | | | | | xx | | | | | | | | | | | Good |
| I7 | | | | | xx | | xx | | | | | | | x | x | | Good |
| I8 | | | | | xx | | | | | | | | | | | | Good |
| I9 | | | | | xx | | x | | | | | | | x | | | Good |
| 20 | | | | | xx | | | | | | | | | | | | Good |
| 2I | | x | | | x | | x | | | | | | | | | | Good |
| 22 | | | | | | | x | | | x | | | | | xx | | Good |
| 24 | | | | | xx | | | | | x | | | | | | | Good |
| 25 | | | | | xx | | | | | | | | | | | | Good |
| 26 | | | | | xx | | | | | | | | | | | | Good |
| 27 | | | xx | | xx | | | | | xx | | | | | | | Good |
| 30 | | | | | xx | | | | | | | | | | | | Fair |
| 3I | | | | | | | | | | x | | | | | | | Poor |
| 33 | | | | x | | | | | | x | | x | | | | | Poor |
| 35 | | | | | xx | | | | | | | | | | | | Good |
| 36 | | x | | xx | | | | | | xx | | | | | | | Inadeq to N.E |
| 37 | | x | | xx | xx | | | | | x | | x | | | | | Good |
| 38 | | x | | xx | xx | | | | | x | | | | | | | Inadeq to S.E |
| 39 | | | | x | | | | | | | | | | | | | Poor |
| 45 | | | | | xx | | | | | xx | | | | | | | Good |
| 48 | | x | | xx | | xx | | xx | xx | xx | x | xx | | | | | Good |
| 49 | | x | | xx | xx | | | | | x | | | | | | | Fair |
| 50 | | xx | | | | | | | | x | | xx | | | | xx | Ex. |
| 5I | | | | | | | | | | | | | | | | xx | Good |
| 57 | | | | | | | xx | | | | | | | | | xx | Good |
| | 3 | 8 | I | 6 | I7 | 2 | 6 | 2 | 2 | I2 | 4 | 8 | I | 3 | 2 | 2 | I |

X Shelter poor.

XX Shelter provided, adequate.



PLATE XI. Eucalypts in use for shelter round a young grove of N.Z. Grapefruit at Whangarei.



PLATE XII. Native bush (totara) giving excellent shelter to a young citrus grove. Wherever in use, native bush provided some of the most satisfactory shelter seen.

Other species which have been planted and appear to be reasonably satisfactory are Acmena floribunda, Bamboo (Bambusa vulgaris), Californian Redwood (Sequoia sempervirens) and Lombardy Poplar (Populus fastigiata). Acmena floribunda and Bamboo appear to be worthy of wider trial.

Cupressus macrocarpa, while forming a good shelter, is not recommended owing to its spreading habit and the fact that on certain soil types it appears to be comparatively short-lived; any attempt at trimming makes it unduly expensive of maintenance. C. Benthamii is recommended, in preference.

In addition to these larger shelter trees, a number of other smaller growing varieties have been used for cross shelter, Barberry and Hakea saligna being the most popular for this purpose. Temporary shelter is best provided by Albizzia lopantha. (See Plate XIII).

III. Location of Belts and Planting.

Whatever permanent shelter species is selected, good strong plants should be chosen and planted round the boundary of the orchard site subsequent to the initial ploughing. Twenty-two feet inside the permanent belt a temporary shelter of Albizzia lopantha should be sown at the same time. The first row of citrus trees will then be planted at 20 feet from the temporary shelter. This will mean that the first row of citrus will be 42 feet from the permanent wind break, and while this distance may seem excessive while the trees are young, Webber (43: 1930) has shown that a wind break of Eucalyptus globulus planted 30 feet from citrus trees reduced the growth in the first three years by 31.25% and suggests that this very considerable loss is likely to become even greater as the trees grow older. It is probably therefore wise to leave at least the suggested distance and to place a trench or ditch close to the wind break and sufficiently deep to cut all surface feeding roots.



PLATE XIII. Albizzia lopantha used as a temporary shelter round a young sweet orange grove at Keri Keri. Albizzia forms one of the most satisfactory quick-growing shelter plants available.

In the planting of shelter belts it is important to avoid gaps which may cause funnelling of the wind; these gaps may arise either through the presence of gateways, through hollows in the land which render sheltering difficult or to a poor take of trees at planting time; proper measures should be taken to remedy any of these defects.

Where frosts are likely to occur it is sometimes necessary to allow a small gap in the wind break at the lowest point of the orchard so that the cold air may drain away. Unless this is done a pocket of cold air may collect at the lowest point and cause considerable damage. Creating conditions so that thawing will take place more slowly after a frost, i.e. by planting a high hedge on the Eastward side may have possibilities in minimising frost damage in certain districts. The result of planting a wind break to stop the Southerly drift of cold air in the Tauranga district appears to give somewhat variable results and more data are required before it can be recommended.

## D. ORDERING TREES.

Having decided on the variety of citrus to plant and the number of trees required for the area, these should be ordered from a reputable nursery-man at least twelve months prior to being required. Nothing is gained by leaving the purchase until near the time of planting; "first come first served" is true in purchasing nursery trees, and he who comes first will be best served since the supply of nursery stock is frequently inadequate to meet the demand.

The precautions that should be taken in securing selected stock and the type of tree required have already been mentioned (page 50). If possible visit the nursery, see the conditions under which the trees are grown, make a thorough inspection, choose the trees and become personally

acquainted with the nurseryman. The directions for shipment should be plain and explicit, the method of shipment given, the time when shipment is to be made and the address written legibly.

## E. DRAINAGE.

In no case where sufficient tile or fascine drains were in operation was the incidence of foot-rot or bark-disease at all severe. Under the rough classification adopted these orchards were all classed as "Good". If sweet orange stock is to be planted it therefore appears very advisable that prior to planting the area should be adequately drained either by tiles or by means of Tea tree fascines placed every 60 feet and discharging into an open drain along the boundary of the orchard. If an impervious layer of clay or hard pan exists in the soil, care must be taken that this is not allowed to re-form over the drains. It is preferable to fill in above the tiles with gravel or cinders while surface soil should be used to complete the filling of the drain, the sub-soil removed being scattered over the surface of the grove.

## F. DISTANCE OF SPACING IN THE ORCHARD.

The survey revealed that citrus trees in the orchards visited were planted at distances varying from I5 X I5 ft. to 30 x 30 ft. usually on the square system. By far the largest proportion of trees were planted 20 x 20 ft. on the square system. In the case of lemons, however, a considerable proportion are planted 22 x 22 ft. on the square. These figures are shown analysed in Table XXII below.

## T A B L E XXII.

Shewing the Spacings adopted in Planting of 44 Orchards visited; also the Ratio of Bearing to Not-Bearing Trees in each class.

- - - - - - - - - - - - - - - - - -

### L E M O N T R E E S.

| | A. Bearing. | B. Not-Bearing. | Ratio A to B.: | Percentage Total No.: |
|---|---|---|---|---|
| 20' Triangular | 350 | 60 | 5.8:I | 2.7 |
| I5' x I5' on square | 200 | 6 | 33.I | I.3 |
| I8' x I5' " | .. | .. | .. | .. |
| I8' x I8' " | 50 | .. | .. | 0.3 |
| 20' x 20' " | 5,50I | I,285 | 4.2:I | 44.3 |
| 22' x 22' " | 555 | ### 5,247 | 0.I:I | 37.8 |
| 22' x 24' " | .. | 648 | .. | 4.2 |
| 24' x 24' " | I93 | 2,04I | 0.2:I | 8.0 |
| 30' x 30' " | .. | 200 | .. | I.3 |
| | 6,849 | 8,487 | 0.8:I | 99.9 |

### N. Z. G R A P E F R U I T T R E E S.

| | C. Bearing. | D. Not-Bearing | Ratio C to D. | Percentage Total No.: |
|---|---|---|---|---|
| 20' Triangular | 30 | .. | .. | 0.9 |
| I5' x I5' on square | .. | .. | .. | .. |
| I8' x I5' " " | 200 | .. | .. | 5.7 |
| I8' x I8' " | .. | 400 | .. | II.4 |
| 20' x 20' " | I,756 | 689 | 2.4:I | 69.6 |
| 22' x 22' " | 240 | 90 | 2.6:I | 9.4 |
| 22' x 24' " | .. | .. | .. | .. |
| 24' x 24' " | 22 | 85 | 0.26:I | 3.0 |
| 30' x 30' " | .. | .. | .. | .. |
| | 2,248 | I,264 | I.8: I | I00.0 |

### This figure is unduly large owing to the Keri Keri Group plantings falling into this group. Were Keri Keri data excluded, this number would be 900 and the corresponding ratio 0.6:I.

An analysis of the data showed that there was a general tendency to increase the distance of planting in the case of of lemons, but this was not so apparent in the case of N.Z. Grapefruit. While the data presented are not extensive they are probably fairly representative of the conditions existing in the larger commercial plantings to-day.

Many lemon orchards planted at 20' x 20' on the square have, on reaching maturity, proved to be so close as to render cultivation by means of horses practically impossible, while spraying and picking has been found to be very difficult. Since the average price of land in New Zealand is relatively low while labour costs tend to be high, the close spacing of trees even though it may lead to higher per acre production does not seem warranted. The data available are not sufficiently extensive to make any analysis on this point.

Some growers in the Tauranga area were not in favour of wider spacing than 20' x 20' since they considered that it rendered the trees more liable to frost injury, and such is probably the case, but if the location has been wisely chosen such a factor should not have to be taken into consideration, the principal feature being to determine the spacing at which maximum production per acre can be achieved with a minimum of labour.

## G. PLANTING.

Detailed information under this heading is given in such standard text books as "Hume" (I8: I926). Care should be exercised that the trees are set in the soil at the same level as they were in the nursery. Too deep planting may be a factor in the incidence of collar-rot and bark-blotch. In the warmer districts August is probably the most satisfactory month for planting, though some Growers prefer May, but in the colder districts September is perhaps preferable. One to two lbs. of a slow acting fertiliser should be well incorporated with the soil at the time of planting. Plate XIV shows a young tree well established.



PLATE XIV. A young tree well established.

N.Z. Grapefruit on citronelle stock, one year from planting. Note the healthy, vigorous growth characteristic of trees worked on citronelle stock.

## H. GENERAL.

After the trees have been planted the grove should be mapped and the name of each tree, the variety of stock and its position should be shown, together with the date of planting. This map should be an integral part of the Orchard Record book (see page 168 )

During the early period in the growth of a grove is an excellent opportunity for building up the soil by the inclusion of large amounts of organic material. This can be achieved at least expense by the use of cover-crops and an effort should be made to incorporate by this means as much humus as possible in the soil. Leguminous crops are to be preferred for this purpose but if for any reason they do not succeed in the district they should be replaced by others which do, such as oats, mustard or trefoil. When not growing a cover-crop, during the summer the soil in the orchard should be kept frequently surface stirred to prevent the growth of weeds, which are the main cause of loss of moisture.

Some growers seem to be under the impression that citrus trees do not require fertilising until they commence to come into bearing. This idea is entirely fallacious and if quick returns are desired from an orchard it must be adequately fed from the time of planting. In groves so treated and well sheltered the survey revealed lemon plantings which at three years of age gave an average production of one case per tree, while in the same district where fertiliser had been stinted many trees of five and six years of age were still not productive.

Frequently planters make the mistake of attempting to develop too large an area. In consequence their working capital is restricted and the grove suffers from neglect during the early years. It would be far wiser where capital is limited to develop a section of the area first and when

this is producing payable crops to proceed with the development of the remainder of the area, section by section. Many would-be citrus orchardists are doomed to disappointment through adopting the former policy.

Inter-cropping of the young grove is not recommended. The policy was largely adopted in the early development of the Keri Keri Group Settlement Scheme. (See Plates XV and XVI) but few of the growers having had the experience of inter-cropping with passion fruit would adopt the system in future plantings. Probably were the vines sufficiently fertilised there would be little restriction on the growth of citrus, but the difficulty of satisfactory cultivation does not justify the increased returns secured. Should the inter-crop prove a paying one there is always the tendency to allow it to remain for a longer period than originally intended to the subsequent detriment of the main crop, viz. the citrus.



PLATE XV. A young citrus grove at Keri Keri interplanted with passion fruit. The two small rows between the citrus and the passion fruit are pea-nuts.

Photographed February, 1930.



PLATE XVI. A second view across the same plantation at Keri Keri. Interplanting has been practically discontinued owing to the difficulty of intercultivating and the tendency to leave in the temporary crop to the detriment of

# PART V. FACTORS AFFECTING ECONOMICAL PRODUCTION.

## CHAPTER XII. Introductory.

A. The Sample taken.
B. Analysis data.

There are many variable factors affecting production in so complex an industry as the production of citrus fruits. This survey makes no attempt to analyse them all and in many cases the analysis made may be open to criticism on technical grounds. The data were collected from districts widely separated geographically and include a variety of soil and climatic types while the sample in many cases is too small for the results to be highly significant. However, it is hoped that the analysis made may be helpful in shewing the trends within the industry and suggesting lines for further investigation.

### A. THE SAMPLE TAKEN.

The method of sampling has not been entirely random. In the first place many of the growers kept no records of their orcharding operations. In other cases the records were simply of net cash receipts and expenses. And in the second place an even smaller number attempted to analyse such records as they do keep with a view to either increasing production or to decreasing costs. The question of a satisfactory system of recording is discussed at a later point.

In a number of cases the position was also complicated by the fact that the growing of citrus fruits was only a side line and the allocation of costs to each department of the farm had not been attempted, nor was any data available on which such a sub-division of costs might be made. While many of these farms furnished useful data in regard to physical production, they have had to be deleted from the section dealing with costs and returns.

In a number of cases the groves visited were evidently neglected and these records have been deleted from the analysis given below. It was also found that the smaller orchardists rarely kept accurate records either of production or the expenses incurred and it was found futile to attempt to collect useful information from the average small grower.

In order to economise in time therefore no growers of under IOO trees were visited in the later stages of the investigation and those visited in the earlier part of the survey have been deleted from the analysis. The average size of grower visited during the survey and whose data has been used in the compilation of tables is shown in Table XXIII.

## T A B L E XXIII. x

Classification by Size of Groves visited During the Survey, the Data from which are used in the Analysis of Factors affecting Yields, etc.

| Group: No. of Trees. | No. of Growers in Group. | Number of trees. | | | | |
|---|---|---|---|---|---|---|
| | | Lemon | N.Z. Grapefruit | Sweet Oranges | Other Varieties | Total. |
| IOI - 200 | 2 | 247 | 51 | I2 | | 3IO |
| 20I - 350 | II | I,589 | 882 | 3I5 | 58 | 2,844 |
| 35I - 600 | I7 | 4,858 | I,432 | I,858 | 92 | 8,240 |
| 60I -IOOO | 9 | 5,3I8 | 746 | 854 | 58 | 6,976 |
| Over IOOO | 3 | 3,5I6 | 275 | 400 | 200 | 4,39I |
| TOTALS. | 42 | I5,528 | 3,386 | 3,439 | 408 | 22,76I |

It will be evident from this table that the sample is not truly representative of the citrus growers of the Dominion but rather of the better class orchardist in the larger groups.

## B. ANALYSIS OF THE DATA.

In the analysis of any production data there are always two distinct phases involved. The first of these is the relation between changes in any variable on the one hand and physical production on the other. This relationship is subject to the law of diminishing returns and the factors which result in the

x Full details of growers data used in this and other analyses is given in Appendix III.

greatest yield per acre or per tree may be called the "most productive pfactice".

The second phase of the analysis is concerned with the effect which changes in any variable have on the profitableness of the enterprise. The practice which results in the greatest net returns on the investment may be called the "most profitable practice".

As these are two such totally different concepts they require separate consideration and in the following discussion the most productive practice will be considered first and then some of the more salient factors affecting the most profitable production will be considered.

A disturbing factor in the analysis of the data has been the association of variables, e.g. heavy fertilising was frequently associated with green manuring and clean Summer cultivation. Co-efficients of association have not been determined for the variables considered, but it is probable that the association of what are generally considered to be the better orchard practices has sometimes masked the effect of one variable or affected the significance of the analysis given.

## CHAPTER XIII. INFLUENCE OF AGE ON PRODUCTION.

It became apparent at an early stage in the survey that the age of the trees was one of the major factors causing differences in production per tree. The position is summarised in Table XXIV which shows the age of trees and the average production for various groupings for the year I934. This data is also shown graphically, Fig. IX.

### T A B L E XXIV.

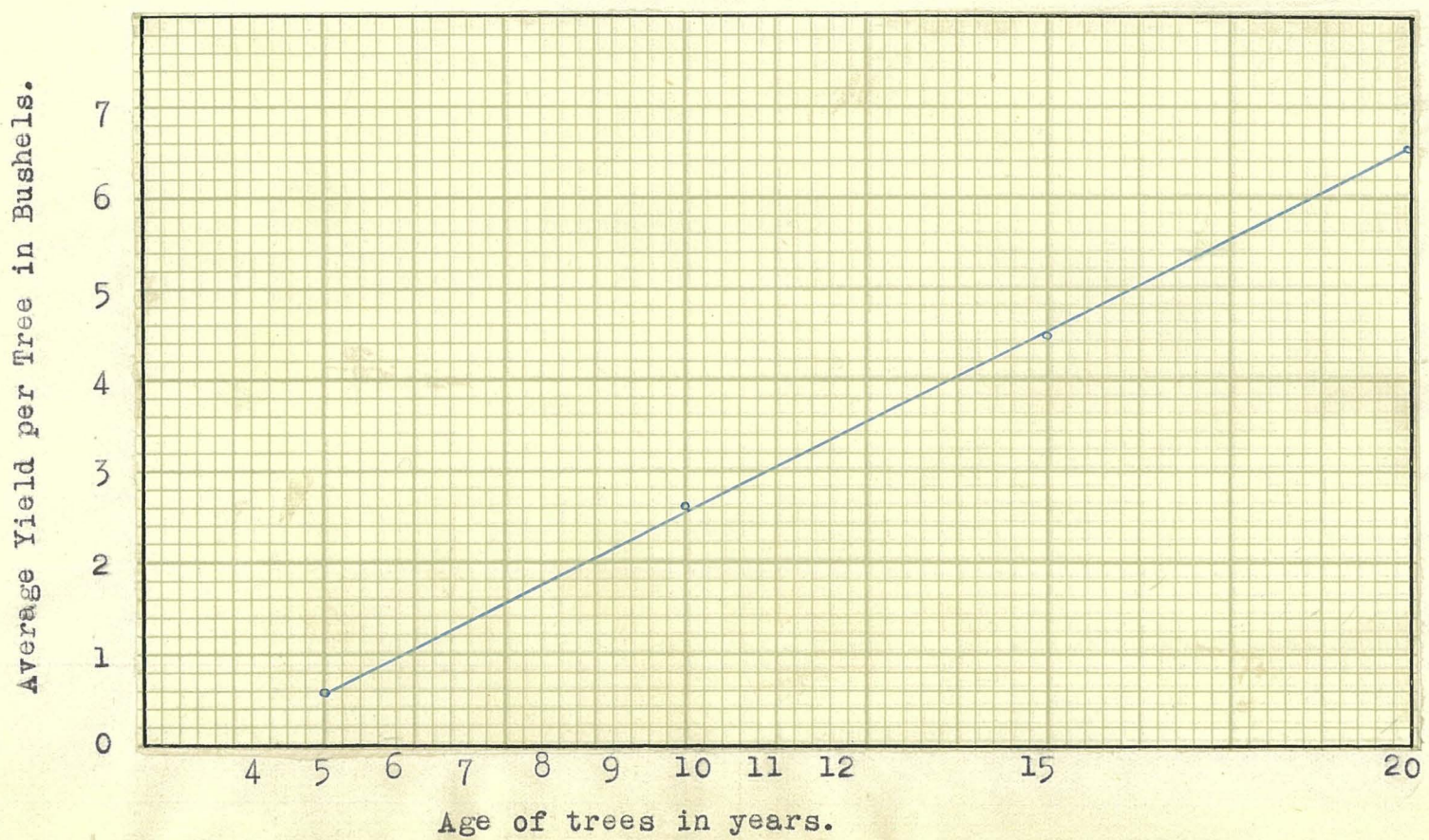
Age of Trees and Production of Lemons.

| Age Group: | Median: | No. Trees: | Prodn. Bushel C/s. | Average Prodn. Per Tree: | Range of Averages Within Group: | Correction Factor: |
|---|---|---|---|---|---|---|
| 3-7 | 5 | 3,333 | 2,045 | 0.6I | 0-I.0 | xI0.54 |
| 8-I2 | I0 | I,I54 | 3,006 | 2.605 | I.6-3.6 | x 2.49 |
| I3-I7 | I5 | 3,46I | I5,302 | 4.42 | 2.2-6.0 | x I.46 |
| I8-23 | 20 | I,266 | 8,I98 | 6.474 | 4.6-7.5 | x I.60 |

Such figures being only for one season must be accepted with caution but they indicate that there is a progressive increase in average production per tree up to the age of 20 years. It is probable that were older groves available for analysis the increase would continue past this stage but the number of examples is too smallto warrant safe conclusions. Possibly this apparently regular increase is due to the method of grove selection; certain it is that many groves have been abandoned in the past as unprofitable before reaching the age of 20 years. However, the data indicate that well-located groves may be expected to continue to yield satisfactorily at least to 20 years of age if given reasonable care.

## F I G U R E  IX.

Shewing the Relationship Found Between Age and Yield of Lemon Trees, 1934.



Such average yields as given in the table above should serve at least as a useful corrective to the somwhat optimistic calculations contained in some Company prospectuses. The variation in individual groups is not great although in one or two outstandingly well managed groves the orchards concerned are giving very high production in comparison with the remainder of the groves in their respective groups. Had the selection of orchards contained those somewhat neglected or poorly managed, the averages shown would probably have been considerably reduced and the figures given must be taken as being indicative of production in better than average groves.

In order that the effect of the other variables affecting production might be more apparent, a correction was applied to all groves of under 20 years of age so that their yields might be comparable with those of mature groves. Taking the mature yield as averaging 6.4 bushel cases per tree, that of I5 year old trees at 4.4 bushel cases per tree, of I0 year old trees 2.6 bushel cases per tree and of 5 year old trees as 0.6 bushel cases per tree, the yields of the orchards included in Table XXIV were increased in this ratio to their potential yield at maturity. The validity of such a correction is open to question but without applying some such correction the effect of the other variables was largely masked and any conclusions that could be drawn were liable to be due mainly to the different ages of groves in various groups; therefore in subsequent analysis of production factors the yields quoted are "corrected" to potential yield at maturity (20 years).

A similar relationship between the age of trees and yields was found by Vaile (37: I924) in his survey of orchard practices in Southern California. His data is shown summarised in Table XXV.

T A B L E XXV.

Relative Yields of Orchards by Ages when the 35-year Old Groves are Considered Full Bearing (After Vaile).

- - - - - - - - - - - - - - - - -

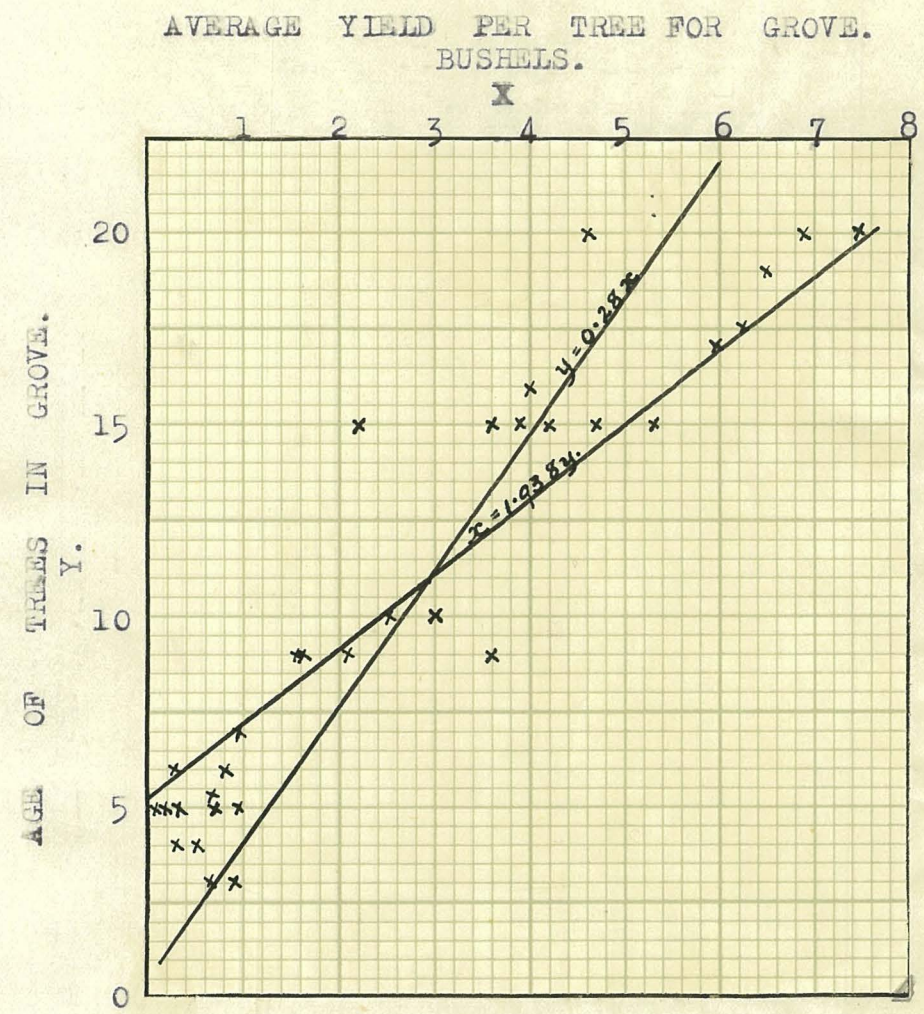
| Age: | Relative Yield: |
|---|---|
| 35 | I00 |
| 30 | 97 |
| 25 | 94 |
| 20 | 92 |
| I5 | 89 |
| I0 | 60 |

It will be noted that under Californian conditions trees apparently reach maturity at an earlier age than is the case under New Zealand conditions; in consequence the increase after the age of I5 years is less rapid than is indicated in Table XXIV.

Since the chapter dealing with the influence of age on production was written, coefficients of correlation and regression have been determined for the data shewn graphically in Fig. IX and in Table XXIV and in detail in Appendix III.

Age and yield shew a positive correlation of 0.737 ±0.072 which applying the usual convention of 6 X $E_r$ is highly significant. Coefficients of regression were also determined and shewed that one bushel variation in yield (±) was accompanied by ± 1.938yrs. variation in age, while one years variation (±) in age was accompanied by ± 0.28 bushels variation in yield.

A "scatter diagram" is given below shewing also the regression lines derived for x on y and y on x.




Scatter diagram shewing the average yield per tree (bushels) of 31 groves visited, plotted against age of trees and the regression lines derived from statistical analysis of the data.

# CHAPTER XIV. INFLUENCE OF PRUNING ON PRODUCTION.

A. Analysis of Data collected.
B. Pruning Orange Trees (I) Overseas Experience (II) Recommendations for New Zealand conditions.
C. Lemon Trees. (I) Overseas experience. (a) Experimental) (b) Relation to Physiological Activity. (II) Recommendations for New Zealand conditions.

Of the many factors affecting production of citrus fruits none is of more interest to growers than pruning, and there is probably none concerning which there is so generally a lack of understanding. There is no commonly recognized orchard operation concerning which there is less agreement. Such a condition has arisen partly owing to the fact that no experiments have been conducted in this country to conclusively settle the matter and secondly owing to the fact that in many cases growers had had past experience with deciduous fruit trees and consider that citrus trees should be treated in a similar manner; other growers having read or heard of the results of experiments conducted overseas have formed the opinion that citrus trees require little, if any, pruning in order to secure maximum production: in consequence there is a wide variety of pruning practices adopted throughout the citrus belt.

## A. ANALYSIS OF DATA COLLECTED.

An attempt was made during the survey to estimate the severity of the pruning in various lemon orchards visited and these were grouped into five gruups according to the method adopted.

N = No pruning.

S = Crossing branches removed and occasionally slightly lifted off ground.

L = As above but trees slightly opened centre and some pruning of fruit spurs at picking

M = Moderately severe pruning: more open centre, limbs lifted off ground and trees slightly reduced in height.

P = Pruned on lines of a spur bearing apple-tree; centre well opened and trees limited in height.

- - - - - - - - - - - - -

It is rather interesting to note that the severity of pruning tends to vary according to the district, being less severe in Tauranga and Keri Keri and generally more severe in the Auckland district. The main contributing factor appears to have been the influence exerted by individual growers here and there who through observation and experience have developed rather definite systems. Through long use of the dominating personality of their originator, certain of these have become established as standard orchard practice. The lighter pruning practice in Tauranga may, however, be a reflex of the somewhat colder conditions experienced.

T A B L E XXVI.

Pruning practices adopted in the Various Districts and Average Relation Correlated Yield of the Groves within each Group.

- - - - - - - - - - - - - - - - - -

L E M O N S.

No. of Growers in each group according to district.

| Severity of Pruning | Keri Keri .. | Whangarei .. | Auckland .. | Tauranga: | Total: | Actual Yield | Relative Weighted Average Yield xx per tree: "corrected" for age Yield | |
|---|---|---|---|---|---|---|---|---|
| x N | 4 | | | 2 | 6 | I00 | I00 | I00 |
| S | I | | | 3 | 4 | 95 | I06 | II6 |
| L | 6 | 2 | 2 | 7 | I7 | I20 | I2I | |
| M | | | 5 | | 5 | 6I | 79 | 99 |
| P | | | 6 | | 6 | I59 | II7 | |
| | II | 2 | I3 | I2 | 38 | | | |

x Keri Keri figures excluded.

xx See Footnote on page 119-120

After correcting production to estimated yield at maturity the average relative production of the various groups was estimated from the data collected and is shown in Table XXVI. This would appear to indicate that the highest production is secured by light pruning. Such figures must, however, be accepted with considerable caution owing to the fact that there is a district grouping and the observed difference in average yield may be due partly to differences in average yield from district to district. The highest actual production recorded in an individual grove was on one of the most severely pruned orchards visited. However, it would appear that light pruning at least is superior to no pruning at all and would suggest that heavy pruning is not conducive to as high production as light pruning.

The low figures given for the "moderately severe" group are unaccountably low. These groves are all situated in the Auckland district on a similar soil type, but do not appear to differ materially in other cultural practices from numbers of other groves in the locality on the same soil type. It is difficult therefore to suggest any reason for the remarkably low yields indicated. That this is not due to the influence of the correction factor is shown by the fact that taking the actual production these groves have an average of only 2.4 bushels per tree.

The practices observed range from practically no pruning whatsoever to pruning on essentially the same lines as practised for a spur-bearing apple tree with all grades of inter-mediate severity. Several old mature groves were visited where the trees had attained a height of I5/20 feet and picking had become a matter of extreme difficulty. In other cases the height of the trees had been severely limited to 8/Io feet. No doubt these latter growers restricted production per tree to a certain extent, but owing to lower picking charges they con-

sidered their net profit per acre to be higher.

The question is one urgently requiring experimentation and it is pleasing to note that the Department of Agriculture have instituted a small scale experiment at Tauranga. The results will be watched with considerable interest.

## B. PRUNING ORANGE TREES.

### (I) Overseas Experience.

A. D. Shamel of the United States Department of Agriculture carried out trials of orange pruning over a five-year period. The method adopted was to leave a check tree unpruned and follow this on the next tree with a certain type of pruning and on the next with another and so on, some eight types of pruning being used. When one set of trees was pruned a second set was pruned in the same order and so on, each type of pruning thus occurring on a number of trees but scattered in the grove so that local soil influences would be equalised. In these experiments during the five-year period the unpruned trees gave the largest yields and apparently the yields were in general heavy or light in accordance with the degree of pruning. These results have been duplicated at the Riverside Experimental Station.

Coit (7:1927), however, advocates severe pruning but gives no data in support of his contention. Hume (I8: I926) on the other hand does not favour heavy pruning of orange or grapefruit trees. He says -

> "In the early years of the young tree's life, sufficient attention should be given to make a well balanced shapely head. Sometimes it may be wise to take out a branch here or to cut one back here and there, but orange and grapefruit trees have a way of balancing themselves, and it is a mistake to remove branches, seemingly out of proportion, when the next flush of growth will do the work of making a symmetrical head much better than the pruner could have accomplished it. Under normal growth conditions, citrus trees will develop shapely beautiful heads. It is extremely doubtful whether attemps at what might be called formal pruning of commercial citrus trees are ever satisfactory. While they will stand much abuse in the form of pruning, it is uncertain whether these various practices have every brought satisfactory results when compared with trees grown in the normal way".

(II)Recommendations for New Zealand Conditions.

Insufficient data are available to analyse yields in comparison with pruning methods under New Zealand conditions, but on observation it is suggested that the pruning of these varieties should be restricted to the removal of sprouts on the trunks and the removal of interfering or crossed branches that develop in the head, and little of this is necessary. When trees reach bearing age the only pruning required is the cutting out of dead wood and diseased or decayed limbs and the gradual removal of the lower branches that bend downwards and touch the ground.

## C. PRUNING LEMONS.

(I) Overseas Experience.

Few records can be found of experiments carried out overseas with the definite object of testing the efficacy of pruning as a means of increasing quality or production from lemon trees.

Coit (7:I927) says -

> "Young lemon trees should be cut back severely from the beginning. They should be curbed in their riotious growth and forced to increase in size slowly and by the addition of the more or less crooked, much branched fruiting type of wood".

On the other hand, Hume (I8:I926) remarks, -

> "The best plan in handling lemon trees is to develop a well placed primary branch system and then let the trees grow and develop in a normal way. Branches so placed as to scar or bruise the fruit, and particularly those carrying many thorns, may be removed".

(a) Experiments overseason.

Shamel and Pomeroy (32:I933) describe an experiment carried out in order to obtain some definite data as a basis for the development of lemon tree pruning practice. Alternate trees in a mature block of Eureka lemons were carefully pruned in May, I929. Although all trees were not pruned to the same extent, on the whole the pruning could be termed "rather severe" The condition of the trees before pruning was dense with long sucker-like branches. Compared with unpruned trees on the

same plot, the loss of yield from pruning in the first year was 65.7%, the second year 22.6% and third year I5%. On a basis of 80 trees per acre the total loss per acre for the first season was 4,600 lbs. for the second season 4,304 lbs. for the third season 2,680 lbs. or a total of II,584 lbs. There was no appreciable difference in size and quality of the fruit from pruned and unpruned trees. Whether the pruning will ultimately benefit the trees sufficiently to enable them to make up the deficit is still to be proved. The authors consider that it is obvious fromthis experiment that the pruning of lemons on a severe basis should not be undertaken without a very careful consideration of all relative conditions, including market prices.

(b) Relation of Pruning to Physiological Activity.

Recommendations for the pruning of citrus trees in California are given careful consideration by R. W. Hodgson in a Bulletin of the University of California Agriculture Experiment Station (I7:I923). He states it is a general axiom of plant physiology that those factors, climatic and otherwise, which favour vegetative growth are in the main antagonistic to fruit production. Therefore severe Winter pruning of the type which favours a vegetative response is usually followed by decreased fruit production.

On the other hand, it is equally true that those conditious which in general act as a check to vegetative growth increase the tendency to fruit production; certain types of Summer pruning tending to check vegetative growth or severe attacks of bark disease, appear to favour fruit production.

Where no outside influence intervene, the seasonal fluctuations in equilibrium between these two opposing sets of factors is reflected in the amount of crop harvested.

Climatic environment in the form of light

intensity and duration, temperature and humidity, up to a certain degree of intensity appear to encourage vegetative growth; beyond that point they appear to become more conducive to fruitfulness.

Nutritional factors are also of prime importance. Recent work at Cambridge has demonstrated the importance of leafage on pastures if maximum production is to be obtained and Kraus and Kraybill (2I:I9I8) are helpful in making clear the importance and practical considerations with respect to nutritive balances existing in plants.

Assuming that water is present at all times in sufficient amounts these investigators have discovered strong evidence that the fruit-bearing propensity is most intimately associated with the ratio existing in the plant between the amount of carbohydrates manufactured and the nitrogenous compounds taken up by the roots. On this basis they have been able to establish four general classes into whichmay be grouped the tendency of plants towards vegetation and reproduction with respect to carbon-nitrogen ratio.

The optimum fruitfulness:

The optimum condition of fruitfulness of value to the orchardist is that in which the nitrogen needs of the plants are satisfied and in which a sufficient surplus of carbohydrates is manufactured to occasion the storage of reserve supplies.

Vegetative Growth:

It has been shown that where the nitrogen supply is ample but the synthesis of carbohydrate materials sufficient only to take care of growth needs without providing for the accumulation of surplus for storage, vegetative growth occurs, accompanied by the production of little or no fruit.

Nitrogen Starvation.

Where the nitrogen supply is deficient, even though carbohydrate surplusses exist, vegetation and reproduction are

both lessened and a condition of disease exists, the characteristic symptoms of which are small yellowish or grey foliage, slender, short and brittle shoots or twigs, and frequently an abundance of under-sized buds or flowers of which a very few mature.

Carbohydrate Starvation:

Eventhough the nitrogen supply is ample, if the supply of carbohydrates is deficient, vegetative tendencies are repressed and unfruitfulness results. Plants in this condition are generally of weak, anaemic growth with pale yellowish foliage and frequently are characterised by total failure to produce flowers or fruit.

A consideration of these principles clearly indicates the dangers which accompany severe pruning of healthy, vigorously growing trees, since such treatment occasions carbohydrate starvation. These principles also serve to make clear the cycles through which the tree normally passes from the time of planting until decadence occurs. In a fertile soil the young tree finds the nitrogen supply ample. Carbohydrate synthesis being small, however, on account of relatively small leaf area, the result is that the first few years of its life are spent in vegetative growth. As carbohydrate manufacture increases with an ever-expanding leaf surface, the point is reached ultimately where a surplus accumulates and optimum fruitfulness occurs. As the tree continues to develop, if the nitrogen supply in the soil is not maintained through fertilisation, this element eventually becomes deficient and decadance from nitrogen starvation occurs. If the nitrogen supply is maintained, however, while conditions exist which occasion either a diminution in leaf area or a decrease in photosynthetic efficiency, carbohydrate starvation occurs and unfruitfulness and decline result.

It can thus readily be seen why it is that pruning during the early years prolongs the period of vegetative growth and delays the time when the tree comes into bearing. It is also apparent why heavy pruning of trees in good fruit-bearing condition tends to repress fruitfulness and induces vegetation. The reason also becomes evident why old and deteriorating trees may sometimes be brought back into bearing by means of pruning treatment which is of a character designed either to reduce the carbon-nitrogen ratio to the point where fruitfulness results or to eliminate tissues of decreased photosynthetic efficiency and to substitute therefore new and more efficient carbohydrate manufacturing leaf surface. These considerations also serve to explain the well-known response of certain types of decadent trees to nitrogen fertilisation.

But perhaps the most important lesson to be drawn from these principles is their application to orchard practice in such a manner as to maintain that ratio between nitrogen intake and carbohydrate assimilation under which optimum fruitfulness occurs. The maintenance of this nutritional balance at all times should be the aim of the grower, and cultural practices used should be analysed in the light of their relation to this balance.

The position in regard to pruning overseas is therefore in much the same position as in our own country and experimentation is urgently necessary in order to give growers a lead on this all important point.

(II) Recommendations for N. Z. Conditions - Lemons.

From observations made during the survey in the better managed citrus groves it becomes fairly apparent that a certain amount of pruning is essential to maximum production under New Zealand conditions and indications are that such pruning should be limited in extent. In the early years

of growth the object should be to encourage a strong framework and the development of a strong and vigorous tree with a large bearing area which will fruit at as early an age as is consistent with the health of the tree. (See Plate XVII).

Experience seems to indicate that the accomplishment of these objects is secured by a minimum of pruning. The leaders should be carefully selected and evenly spaced but severe shortening back by Winter pruning is not generally recommended. The centre should be kept moderately open to facilitate picking and spraying and all branches which cross or rub should be entirely removed. Branches sweeping low to the ground should not be removed unless they are in the way of cultivation or are actually touching the ground since these may constitute a considerable proportion of the early bearing surface of the young tree. Further pruning as the tree matures will consist essentially in maintaining a slightly open centre to the tree and in removing fruiting spurs as these gradually decline in fruitfulness. No particular season appears to be most desirable and much of the pruning may be done while picking.

One of the principle points which the survey disclosed was the necessity for periodical replacement of the fruiting wood by its judicious removal during picking after it had passed the stage of usefulness.

The question of whether trees should be "headed" to a uniform height of approximately 10 feet in order to facilitate picking is a matter open to argument. There is little doubt that this practice reduces the total production of fruit per tree unless the trees are widely spaced and have ample room to spread laterally, but against this must be placed the advantage of less costly picking of the fruit and the fact that on tall unpruned trees much of the fruit tends to be damaged by wind rub and hence is of low grade.



PLATE XVII. One of the pedigree Lisbon lemon trees distributed by the Auckland Citrus Committee photographed exactly three years after planting. This tree has been pruned moderately severely to secure a sound framework and even spacing of the leaders. At 4yrs of age (Aug. 1935) over 2 bushel cases of lemons were picked in two spring pickings from this tree. Citronelle stock.

With high prices for lemons, the extra production and higher picking costs might warrant the taller trees, but under conditions of low prices the position becomes more problematical and will depend largely on labour costs for picking. A restriction on the ultimate height of mature trees appears desirable.

Particular care should be taken in removing the limbs to lower the height of citrus trees or in shortening back leaders; wherever possible, the limbs should be removed to a lateral so that the flow of sap may be diverted. Unless this is done, shortening back usually results in the development of a mass of water shoots or suckers which in turn have to be thinned and shortened back.

Experimental work, is, however, required in order to place instructional work on a sound basis. At the present time the instructor is in the position of having only opinions to offer to the grower requiring advice; to be of best service these opinions should be backed by sound experimental fact.

# CHAPTER XV. CULTIVATION IN RELATION TO PRODUCTION.

A. Analysis of Data Collected.
B. Basic Principles; (I) General Discussion (II) A Possible Alternative to Cultivation.

As in the case of pruning, the methods of cultivation adopted are rarely based on an exact appreciation of the factors involved or the reasons why operations should be performed.

Coit (7: 1927) gives the reasons for tilling as "(I) improves the physical condition of the soil by loosening it and extending the rooting area; (2) aids in saving moisture by enlarging the water holding capacity and by checking surface evaporation; (3) augments chemical action by making inert plant food available, and (4) admits air to the soil. This last function of tillage is very important because plant roots must have air in order to grow".

## A. ANALYSIS OF DATA COLLECTED.

The general practice among the growers visited during the survey was to cultivate the land early in the Spring and to keep the surface cultivated throughout the Summer and Autumn months. Over the Winter period a cover-crop was frequently grown or the soil was permitted to produce a volunteer weed growth which was turned under at the Spring cultivation.

Table XXVII shows the methods of cultivation generally in vogue in the orchards visited. While ploughing and subsequent cultivation with disc and harrows or spring-tooth cultivators is still the most popular method of cultivation, in some of the lighter soils the plough has been displaced by the disc, while a new departure has been the introduction of the rotary hoe (Howard) as a means of cultivation. In one case a commercial planting was observed where in place

of cultivation the grove had been sown down with a permanent pasture sward which was kept closely mown throughout the season, the only cultivation being a circle around each tree reaching to the spread of the limbs.

T A B L E XXVII.

Methods of Cultivation in Vogue in Lemon Orchards in the various districts and average relative yields of the different methods. No. of groves in each group according to district.

| | Keri Keri" | Auckland | Tauranga | Other districts | Total | Weighted relative average Production per tree: Actual Yield | "Corrected" for age |
|---|---|---|---|---|---|---|---|
| Plough and cultivate | 9 | 6 | 3 | 3 | 21 | 100 | 100 |
| Discs and cultivate | 1 | 2 | 5 | 1 | 8 | 111 | 107 |
| Rotary Hoe | 1 | 5 | 3 | | 9 | 138 | 128 |
| No cultivation | - | - | 1 | 1 | 2 | | |

" Not included in production analysis.

An analysis of the average yield of groves under these systems of cultivation showed that production per tree whether based on actual or "corrected" yields was highest in the group cultivated by means of the rotary hoe, while the difference between discs or ploughing was probably not significant. It is doubtful whether these differences between groups may be taken as being due entirely to the method of cultivation practised; it may be due to an association of good management practices in the former group and the fact that these growers are, on the whole, the more progressive of the orchardists visited.

The average depth of cultivation ranged from 3" to 6" but in some light soils where cultivation was carried out by means of discs there is little doubt that the cultivation would in some cases be deeper than mentioned. Most of the groves were kept clean of weed growth during the Summer



PLATE XVIIIa. A tractor operated "Howard" Rotary Hoe working in a Hastings orchard. The Type in use in most citrus orchards is a smaller self-contained unit, though the principal of operation is the same in both cases.

period, but 30% could only be classified as "fair" in this respect.

## B. BASIC PRINCIPLES.

### (I) General Discussion.

The whole question of cultivation and its effect on the soil has come under review during recent years and many of the considerations which were held to justify certain operations in the past are now open to discussion.

To take the points in favour of tilling quoted by Coi (7:I927) above, the following points may be mentioned. Since cultivation is usually carried out to approximately the same depth each year it is somewhat difficult to appreciate how such tilling could extend the rooting area since any roots which may penetrate the cultivated zone are destroyed in subsequent cultivations so that while a layer of loose well aerated soil may be formed on the surface of the grove, it is open to considerable doubt as to whether this is of any appreciable advantage to the trees; while the question of admitting air to the soil and to the roots which is considered so essential is open to doubt since the roots are rigorously excluded from the aerated zone.

There is little doubt that surface cultivation will increase the moisture content of a soil during the summer months, but the emphasis has now been shifted from the old idea of breaking the capillary rise of water to the destruction of weed growth.

Crowther (8: I934) remarks "The ability of some crops to yield well in drought years lead to fantastic views on the extent of the capillary rise of water in relatively dry soils. It is now being recognized that in dry soils plant roots have to go down to the water for it does not rise up to them".

Cultivation therefore may be as shallow as is consistent with the destruction of weed growth on the surface or as may be required to thoroughly incorporate the organic matter being turned under from a cover-crop or volunteer weed growth.

Observations by Webber (43: I930) have shown that weeds may have an excessive depressing effect on the growth of young citrus trees. He found that when young trees of uniform size were planted out on an area, parts of which were infested with Morning Glory (Convovulus arvensis), those free from the weed were after three years growth 26% to 27% larger than those on the weed infested areas. In all other respects the areas were similarly treated and the fact that after three years tree growth may be depressed to this extent gives one a more concrete view of the damage actually caused by severe weed competition. These observations have been confirmed during the survey, particularly in respect of Convovulus arvensis and various twitch grasses (Agropyron repens, Paspalum digitaria, and Poa pratensis).

Continuous deep stirring of the soil during the hot Summer weather gradually destroys a soil that nature has built up for many years and is wholly destructive in its action. Cultivation and soil building are antagonistic factors. Continuous cultivation through dry periods seems tobe a necessary evil to conserve the available moisture, but when there is sufficient moisture it would seem that cultivation should cease for rather extended periods while cover-crops are being grown to assist in keeping up the soil fertility. It is doubtful whether with continuous deep stirring during the Summer months it is possible to maintain the fertility of the soil owing to the rapid destruction of soil organic matter which takes place under these conditions.

Crowther (38:I934) says "The exposure of bare soil, either by deliberate fallows or by normal cultivations, inevitably accelerates oxidation of soil organic matter. The remedy for too rapid mobilisation and loss of nitrogen is to leave the land under a grass cover for a period".

Coit's suggestion of augmenting chemical action by making inert plant food available is therefore only too true and the danger is that excessive cultivation may render impossible the maintenance of a high uniform level of soil fertility. It would seem advisable therefore that after an initial ploughing or cultivation in the Spring to incorporate organic matter, subsequent cultivation should be as shallow as is consistent with the destruction of weed growth over the Summer months. In this respect the rotary hoe is ideal since the depth of cultivation is readily controlled by the operator. As soon as the Autumn rains commence, the land should be laid down to a suitable cover-crop or permitted to produce a volunteer weed growth; the latter practice is, however, subject to the disadvantage that cultivation during the Summer period requires to be more frequent in order to destroy the large numbers of young weed seedlings which germinate, and the former practice is much to be preferred. The area surrounding the spread of the tree should at all times be kept free of weed growth, although it may be lightly cultivated or mulched with straw or other material, care being taken to keep the mulch at least I2 inches away from the trunk.

(II) A Possible Alternative to Cultivation.

The alternative system of no cultivation and the sowing down of the orchard to a permanent sward of clover or pasture grasses appears, on certain soil types subject to "heavy washing", to be worthy of experimentation.

The method is being tried out on one commercial citrus planting at Tauranga, and while the trees are still young (I4 years) the method appears to be giving satisfactory

results.

In another instance a grower planted three St. Michael orange trees on his lawn in I896 as well as a number of trees under orchard conditions. The three trees under "grass" conditions (Plate XVIII) are now 39 years of age and are bearing heavy crops, an average of I5 bushels per tree being picked for the I933 season. These trees are remarkably healthy in appearance and have always been very free of disease, being superior in these respects to those growing under orchard conditions.

Such a method has the following advantages (I) it reduces washing of the surface soil to a negligible amount; (2) it permits the tree roots to penetrate and feed in the surface layer of the soil as well as in the subsoil; (3) it conserves the humus supply in the soil; (4) at least in light soils it probably permits better aeration of the root system than would clean cultivation since the tree roots are given entry into the surface layer of the soil which is usually of a more granular texture than the subsoil and (5) it probably permits of better utilisation of artificial fertilisers. The disadvantages of the system would appear to be the competition taking place between the grass sward and the tree roots for moisture during the dry season of the year. This can, however, be reduced to a minimum by keeping the sward closely cut with a mower throughout the year, the clippings being permitted to lie on the sward. The area covering the spread of the trees should be kept lightly cultivated by hand. The method, at any rate, seems worthy of experimental trial.

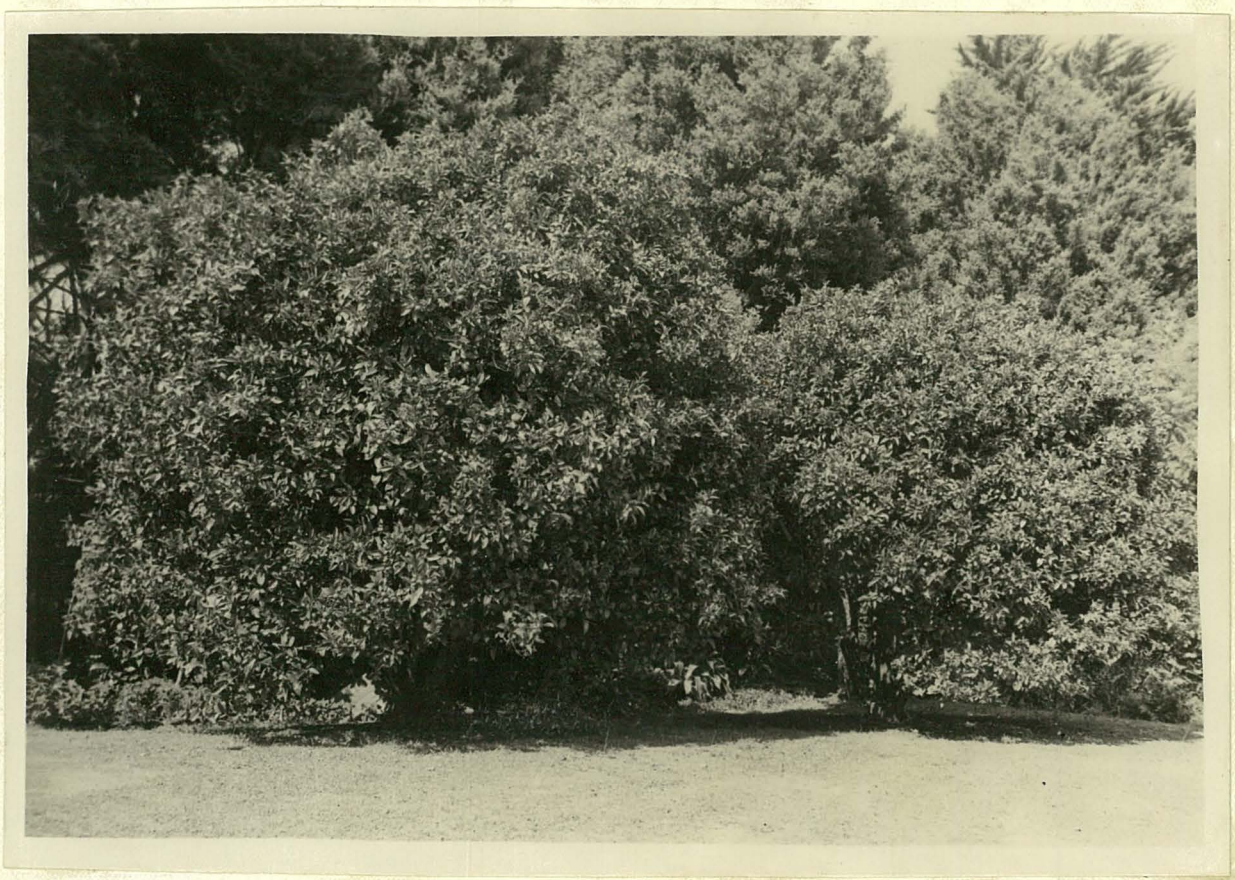


PLATE XVIII. Two St.Michael sweet orange trees planted in 1896 on a growers lawn. Photograph taken May, 1935. These trees are bearing a crop estimated at over 15 bushels per tree for the present season and are in better condition than trees of similar age and variety planted under orchard conditions. It is suggested that this method of culture may be worthy of experimental trial for citrus under some conditions.

CHAPTER XVI. GREEN MANURING.

A. Data Collected.
B. Discussion of Basic Principles.
C. Overseas Experience.

## A. DATA COLLECTED.

Of the orchards visited, approximately one-third (34%) consistently grew cover-crops during the Winter period, their average "corrected" production per tree being 7.4 bushels while that of the remainder was 5.7. While it is not safe to conclude from these figures that the difference shewn is due entirely to the fact of green manuring, it can be stated that green manuring is definitely associated with the most productive orchard practices. In many of the older groves the trees had become so large that cover-crops had become practically impossible. Blue Lupins were the principal crop grown, but oats, barley or Lotus hispidus were being grown successfully in several cases.

## B. DISCUSSION OF BASIC PRINCIPLES.

Since under New Zealand conditions it is not possible to secure adequate supplies of bulky organic fertilisers it becomes imperative to replace the humus destroyed by cultivation by the turning-in of adequate quantities of vegetable matter in the form of green manure.

The general reasons given for the growing of cover-crops (I) their influence in ameliorating soil conditions (2) increasing the humus in the soil (3) surface washing is prevented and (4) in the case of leguminous crops nitrogen is added.

While the value of cover-crops has been repeatedly demonstrated overseas, the reason for their effectiveness is still somewhat obscure since even after prolonged application they have little effect in materially increasing the proportion of humus in the soil. This is shown in Table XXVIII

showing an analysis made of plots at Rothamsted, on the Rubidoux trial plots in California and at Florida Experiment Station.

T A B L E XXVIII.

Effect of Applying Organic Matter on the Organic Carbon content of the Soil.

| Location: | Total Tons Manure: | Over No. of Years: | % Organic Carbon in the Top Soil: |
|---|---|---|---|
| Rothamsted | 700 | 50 | 2.23 |
| " | 0 | 50 | I.I6 |
| Rubidoux | 345 | 23 | I.39 |
| " | 0 | 23 | .52 |
| Florida Citrus Experiment Station | 7 Cover-crops | 7 | .753 |
| " | 0 | 7 | .486 |

It is apparent that the effect of cover-crops must be accounted for in some other way than by the accumulation of organic matter in the soil. When organic matter is added to the soil, it is repeatedly acted upon by the soil bacteria and decomposed into simpler substances. Some of these are washed out of the soil, while others serve as sources of plant food and it is interesting to note that the final dark-coloured portion known as humus possesses a fairly constant ratio of total nitrogen to organic carbon of I - I0 to I-I2. Any disturbances of this carbon-nitrogen ratio is the signal for increased bacterial activity until such timeas the ratio is returned to "normal". When organic materials relatively low in nitrogen are mixed with the soil, the carbon is lost more rapidly than the nitrogen and decomposition proceeds until finally the "normal" ratio is reached. When enough carbon has been lost as carbon dioxide gas to bring the carbon-nitrogen ratio of carbon to a certain point, which varies somewhat with conditions, the organic matter remaining

in the soil is apparently very stable. Owing to this relationship or ratio between nitrogen and organic-carbon, the organic matter in the soil under ordinary conditions cannot be increased or even maintained unless the nitrogen is also increased or maintained. Hence under the usual system of applying bulky organic material low in nitrogen content the increase in humus obtained is relatively small. It would appear that this is possibly the reason why leguminous crops are preferable to other types for cover-crop purposes and have a greater effect in building up the humus supply of the soil.

C. OVERSEAS EXPERIENCE.

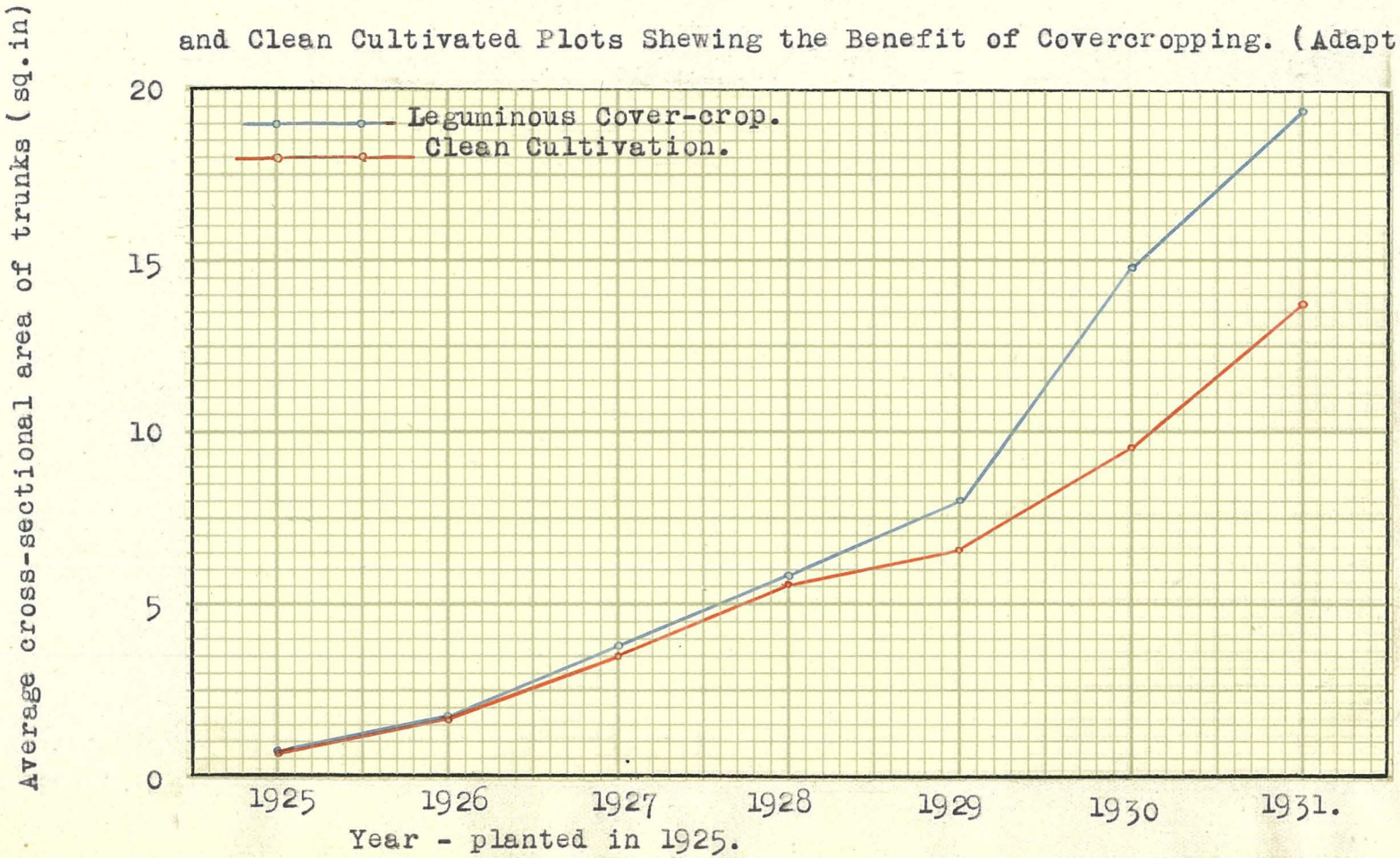
It has been found by overseas experience that legumes fix nitrogen from the air to a marked extent only if available nitrogen is not present in the soil; the richer the soil the less is fixed. The legume crop may therefore not be an important factor in adding nitrogen to the soil in well fertilised groves and this may have a distinct bearing upon the choice of cover-crops.

Whatever may be the fundamental interpretation of the beneficial effects of cover-crops the fact remains that carefully controlled experiments conducted in overseas countries have fairly conclusively demonstrated that they are a valuable aid to maximum citrus production.

In this respect it is interesting to note the results of an experiment carried out by Stokes (33: I932) and his co-workers at the Florida Experiment Station. A number of plots were laid out with uniform size citrus trees and the plots received uniform treatment except in respect of the type of cover-crop grown. At the end of seven years it was found that the trees on cover-crop plots were superior in size and yield to those on clean culture plots. The difference between the clean culture plots and the plot cover cropped with a legume (Crotalaria striata) are shown graph-

# F I G U R E  X.

Graphical Presentation of Average Cross-sectional Areas (sq.ins) of Tree Trunks on Cover-cropped and Clean Cultivated Plots Shewing the Benefit of Covercropping. (Adapted from Stokes 33:1932).



ically in FigureX, while the difference in yield was even more marked.

In this respect Stokes remarks "The top growth of the trees was uniform and normal on all the plots for the first three years of the experiment. After that time the general condition and appearance of the trees on all the cover-crops were better than that on clean culture plots. At the end of the seventh year many of the trees on the clean culture plots were in a very unthrifty condition".

H. J. Webber (42:1925), speaking of the Rubidoux trial plots remarks that "the plots receiving stable manure and also a leguminous cover-crop during the Winter have given regularly the best trees and the best crops", while Surr (34:1931) speaking of the fertiliser experiments at the Riverside Station says "An outstanding feature of the trials is the effect of the lack of organic matter upon the condition of the trees in the comparatively short time since the experiments were started. In some cases the poor condition of the trees was apparent on clean cultivated plots which had only been about three years without organic matter. The tree condition as a whole was even worse where nitrogen was applied without a cover-crop or other source of organic matter than on crops receiving neither fertiliser or cover-crop".

The general recommendation for Californian conditions is that at least half of the nitrogen should be supplied in the form of bulky organic materials and that, while these cannot satisfactorily be entirely replaced by cover-crops, the amount of other organic material required is considerably reduced when cover-crops are grown.

An analysis made by W. P. Kelley indicates that on the Rubidoux plots of the Citrus Experiment Station a Winter green manure crop and about ten tons of manure per acre annually have just kept the organic content of the soil equal to that of virgin soil. The plots so treated have produced more fruit than plots which have received thirteen tons of

manure without the Winter cover-crop.

Particularly during the early stages of establishment of the young citrus grove, it appears very desirable to use every effort to incorporate as much organic matter as possible into the soil. It is probably best to employ a rotation of varieties for cover-crop purposes since such rotation tends to avoid some of the cumulative injury from aphis, mildew and other diseases because of the different habits and susceptibility of the several crops. With mature groves it frequently becomes a matter of considerable difficulty to secure a successful growth of cover-crops among the trees, but the practice should be continued as long as is practicable.

## CHAPTER XVII. FERTILISING AND ITS EFFECT ON YIELDS.

A. Analysis on Data Collected; (I) Nitrogenous Fertilising (II) Phosphatic Fertilising (III) Potassic Fertilising.
B. The Tauranga Experiment.
C. Overseas experience.
D. General Discussion; (I) Rooting habit of citrus in relation to Fertilising (II) Downward Movement of Fertiliser in the Soil.
E. Suggested Fertiliser Programme.
F. Liming.

The successful orchardists of the citrus industry have fully realised the importance of adequate fertilising in order to secure high yields, but as was pointed out at an earlier stage some of the younger plantings are not receiving sufficient fertiliser to secure early production.

The recent trials completed for a five-year period at Tauranga have entirely vindicated the opinion that heavy complete fertilising is necessary to secure high yields and these results have been confirmed during the survey.

### A. ANALYSIS OF DATA COLLECTED.

(I) Nitrogenous Fertilising.

In Table XXIX the amount of nitrogen applied per tree in lemon groves visited during the survey is shown in relation to the production per tree.

T A B L E XXIX.

Shewing Amount of Nitrogen applied per Tree in Lemon Groves visited in the various districts its Relation to Production.

No. of Growers in group, classed according to Districts.

| Nitrogen applied per Tree - in lbs. | Keri Keri | Auckland | Tauranga | Other | Total | Relative Average Production per Tree: Actual Yield. | "Corrected" for age. |
|---|---|---|---|---|---|---|---|
| Under 0.50 lbs. & | 5 | - | 2 | 2 | 9 | I00 | I00 |
| 0.50 - I.49 lbs. | 4 | 7 | 3 | 2 | I6 | 475 | I69 |
| I,50 - 2.5 lbs. | | 4 | 3 | | 7 | 600 | I9I |

& Not included in analysis of yield.

It will be noted that fertilising with nitrogen tends to be heaviest in the Auckland district and that the production per tree is in proportion to the amount of nitrogen applied as fertiliser. It was felt that possibly the above groupings merely segregated the orchards into groups according to their respective ages since in general the rate of fertilising tends to be in proportion to the age of the trees. The rate of application of fertiliser was therefore multiplied by the age correction factor given on page 83 and the groves were subsequently re-grouped with the results shown in Table XXX

T A B L E XXX.

Shewing Relative Average Production per Tree (Lemons) when the amount of Nitrogen applied has been "Corrected" by the "Age Factor".

| Nitrogen applied per "Mature Tree" - lbs.: | No. of Growers in Group. | Relative Average Production per Tree: Actual: | "Corrected". for age |
|---|---|---|---|
| Under 2.0 lbs. | 9 | I00 | I00 |
| 2.0 lbs. and over | 8 | I07 | 124 |

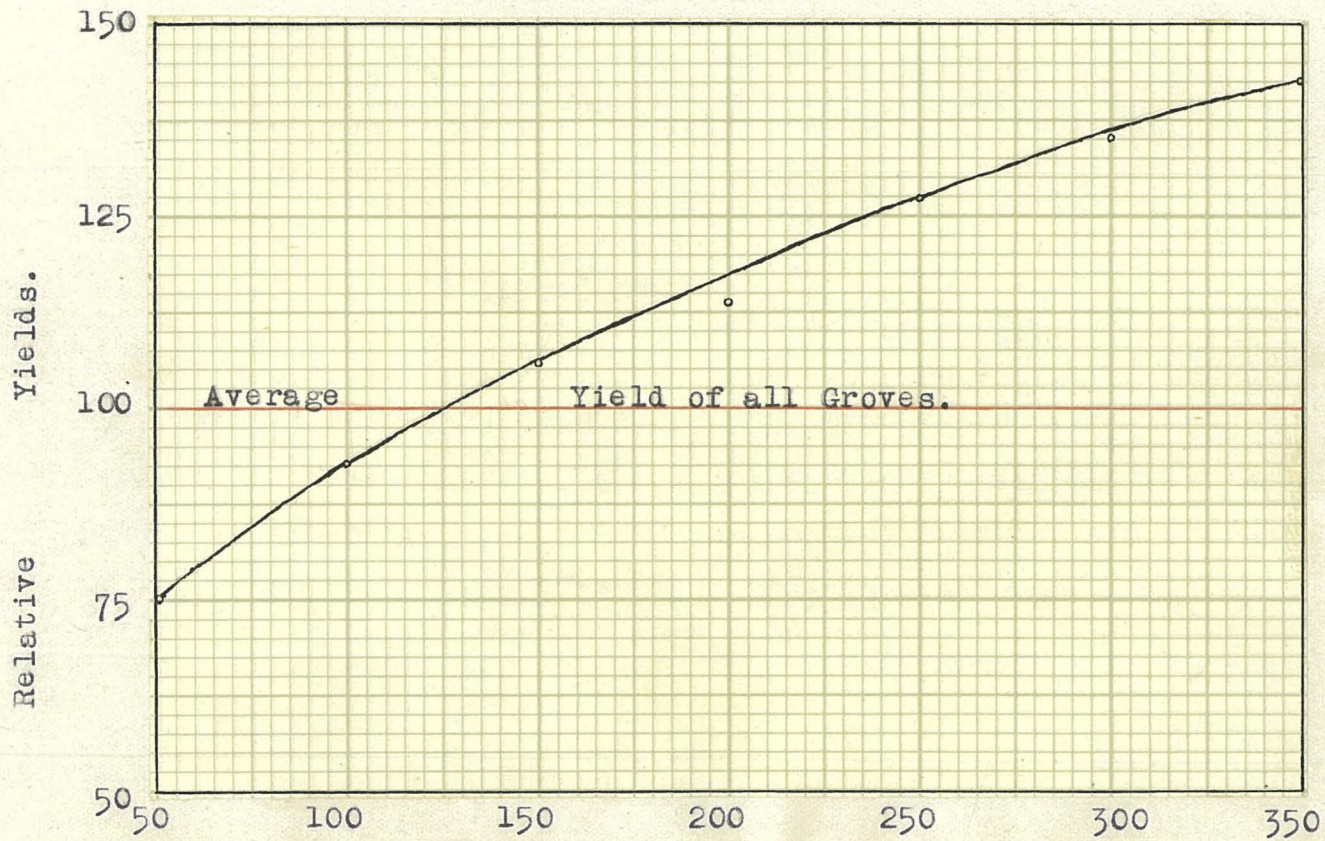
The results in favour of the application of nitrogenous fertiliser are then less markedly in favour of heavy applications, but still show a considerable increase in production for the larger amounts applied.

Vaile (37:I924) found a marked correlation between production and nitrogen applied in his survey of orchard practices in Southern California (see Fig. XI) and the general experience overseas has been that nitrogen is the principal element required in citrus fertilising, little or no result being obtained from applications of phosphate or potash. Vaile concludes that under California conditions it seems probable that the most productive use of nitrogen for citrus orchards has reached somewhere between 300 and 350 lbs. per acre

F I G U R E  X1.

Nitrogen Applied and Relative Yields.

With Curve of Diminishing Returns, (After Vaile 37:1924).




The circles represent average yields for each fertiliser class. The curve represents the yield to be expected in response to the law of diminishing returns, from additional applications of nitrogen.

annually, i.e. approximately equivalent to I5 cwt. of sulphate of ammonia.

Should such be the case, in New Zealand it appears that none of the growers visited have yet reached the limit of most profitable applications in the use of nitrogenous fertilisers. While it has been shown that those growers applying the largest amounts of nitrogen per tree are also securing the greatest production per tree, this is being secured only by the use of increasing amounts of nitrogen per bushel of fruit.

Thus in the three groups considered in Table XXIX the number of pounds of nitrogen applied per bushel ("corrected") yields) produced are 0.007, 0.016 and 0.03 respectively, while if the actual yield is taken the amounts applied become 0.03, 0.2 and 0.4 respectively.

The extent to which it may prove profitable to increase production by increasing applications of nitrogen is largely a matter of relative prices as between fertiliser costs and the value of the added product and no information can be derived on this point from the data available.

Overseas experience suggests that a considerable proportion of this nitrogen should be applied in the form of bulky organic manures but no experimental work has been done in New Zealand to confirm overseas results in respect of the type of nitrogenous fertiliser likely to give the most satisfactory results.

(II) Phosphatic fertilising.

The survey disclosed that while most growers regularly applied phosphate very few were entirely satisfied that it gave measurable results in terms of production or quality of the fruit.

In Table XXXI the amount of phosphate applied per tree in the lemon groves visited is tabulated together with

its relation to production per tree.

T A B L E XXXI.

Amount of Phosphate ($P_2O_5$) applied per Tree in Lemon Groves visited in the various districts and its Relation to Production per Tree.
No. of Growers in Group classed according to district.

| Phosphate Applied lbs. $P_2O_5$ per Tree: | Keri Keri | Auckland | Tauranga | Other | Total | Relative Average Production per Tree. Actual: Yield | "Corrected" for Age |
|---|---|---|---|---|---|---|---|
| Less I.0 lbs. | & 8 | 2 | 4 | 3 | I7 | I00 | I00 |
| I.0 - 2.0 lbs. | I | 5 | 3 | I | I0 | I03 | II2 |
| Over 2.0 lbs. | | 3 | 3 | | 6 | I30 | II9 |

& Not included in analysis of yield.

While the loss in production with the application of smaller amounts of phosphate does not appear to be so serious as is indicated for nitrogen, the indications are that the yield is definitely correlated with the rate of phosphatic fertilisation and the correlation exists whether the actual amount of fertiliser applied be taken or whether it is "corrected" by the application of the age factor and orchards subsequently re-grouped is shown in Table XXXII.

T A B L E XXXII.

Relative Average Production per Tree of Lemons when the amount of $P_2O_5$ has been "corrected" by the "Age Factor".

| $P_2O_5$ applied per "mature" tree - lbs.: | No. of Growers in Group | Relative Production per Tree: Actual Yields | "Corrected" for age |
|---|---|---|---|
| Under 2.0 lbs. | 8 | I00 | I00 |
| 2.0 lbs. and over | 9 | I64 | I44 |

In either case the group applying 2 lbs. or over of phosphoric acid ($P_2O_5$) per tree gives a markedly higher yield than those applying a smaller amount.

These results are a gain in line with the experiments conducted at Tauranga and this is rather interesting in view of the fact that overseas experience has generally indicated no response to the application of phosphate.

Chapman (6: I934) speaking of Californian conditions remarks that "the use of phosphate, or phosphorus containing materials, in nine different field trials for periods of from five to twenty years has in no case resulted in significant increases in fruit though the phosphate applied definitely penetrated into the rooting zone" Similar results have been obtained in all overseas trials which have come to the writer's notice.

Potash:

The grouping of the lemon groves visited into those using potash and those not using potash showed that a preponderance of growers were not applying potash in any form as a fertiliser but a grouping of the groves (Table XXXIII) showed that those using potash had a higher average yield per tree than those not using potash, although the difference was less significant than in the case of either phosphate or nitrogen.

T A B L E XXXIII.

Lemon Production per Tree in Relation to Rate of Application of $K_2O$.

No. of Growers in Group classed according to district.

| Amount. | Keri Keri | Auckland | Tauranga | Other | Total | Relative Average Production per Tree: Actual Yield | Relative Average Production per Tree: "Corrected" for age. |
|---|---|---|---|---|---|---|---|
| Not using $K_2O$ | 7 | 7 | 4 | 3 | 21 | I00 | I00 |
| Using $K_2O$ | 4 | 4 | 7 | I | I6 | I09 | I08 |

It would appear therefore that under New Zealand conditions a "complete" fertiliser is required in order to secure maximum production, and that in order of importance the three fertiliser constituents should be - nitrogen, phosphoric acid and potash. The data unfortunately give no indication of the form in which these elements should be supplied and it is necessary to consider overseas experience in this respect.

## B. THE TAURANGA EXPERIMENTS.

Under the auspices of the Horticulture Division (IO:I935) a series of manurial experimental plots ~~were~~ as laid down on 26th. September, I930, in the orchard of Messrs. Mayfield Bros. Bethleham, Tauranga.

The object"was to determine the effect of the following treatments upon yield, quality of fruit and tree growth:-

1. No manure.
2. Superphosphate 6 cwt.
3. " " " plus Sulphate of ammonia 6 cwt.
4. " " " " S/a 6 cwt. plus S/Potash 4 cwt.
5. " " " " S/Potash 4 cwt.

These treatments were replicated six times in the form of a "Latin square", with check rows between so allowing of careful statistical analysis of the results. Records have also been kept of the percentages of tree ripe, silver and green fruit picked from each treatment, and also the grading results.

T A B L E XXIV.

Average Production of Lemons per Tree on Fertiliser Trial Plots at Tauranga over the 5-year period - 26.9.I930 to I8.I2.I934 and relative yields.

| Treatment. | Average Weight of Lemons Produced: | Relative Yields: |
|---|---|---|
| No Manure | 647.4 lbs. | I00 |
| Superphosphate | 793.9 " | I22 |
| Superphosphate plus Sulphate of Ammonia. | 895.4 " | I38 |
| Superphosphate plus Sulphate of Ammonia plus Sulphate of Potash | 933.8 " | I44 |
| Superphosphate plus Sulphate of Potash | 855.9 " | I32 |

"The differences recorded during the first three yearly periods are not statistically significant but in the last period the treatments which included S/A. gave significantly higher yields than other treatments. In the winter of I934 the whole block was affected by frosts, the fruit and young growth being damaged. Prior to the frosts the trees which had received nitrogen had made much better growth than those without nitrogen and appeared to be less seriously injured. It seems therefore that the differences in yield in the last period may have been accentuated by frost injury".

"The trees of the 'NO MANURE' plots are now obviously poorer in condition (size, density, colour of foliage and debilitated lateral growth) than the balance of the plots comprising the experiment. Many of the trees in treatments 2 & 5 (which have not received S/A.) are slightly better in condition than the trees in the "NO MANURE" plots but are all inferior to the average of the trees in plots in 3 & 4".

It will be noted from the Table that each fertiliser treatment has given a significant increase over the 'no manure' plot, the remarkable feature being the marked response to the application of superphosphate and also to sulphate of potash. These are two treatments which in overseas trials have rarely, if ever, given significant increase in yields of crop.

## C. OVERSEAS EXPERIENCE.

The Rubidoux plots at the Riverside Citrus Experiment Station, California, are probably one of the oldest established fertiliser trials on citrus trees, having been planted in April, I907. The experiment consists of 20 plots, each plot containing six Washington navel orange trees, six Valencia orange trees, six Eureka lemon trees and six Lisbon lemon trees, all of which were planted 20 feet apart in squares giving I08 trees to the acre. The various treatments used were :-

(a) Nitrate of soda, blood, bone and sulphate of potash
(b) No fertaliser.
(c) Dried blood.
(d) Sulphate of potash.
(e) Steamed bone.
(f) Stable manure.
(g) Nitrate of soda, blood, and bone.
(h) Nitrate of soda.
(i) Muriate of potash.
(j) Superphosphate.
(k) Steamed bone and sulphate of potash.
(n) Superphosphate and blood to equal nitrogen in bone plots.
(o) Stable manure and rock phosphate.
(q) Nitrate of soda, blood, superphosphate and sulphate of potash.
(u) Stable manure, rock phosphate and leguminous cover-crop.

The yields over the period I9I2 /I920 are shown in Table XXXV.

# T A B L E XXXV.

## Rubidoux Trials.

Summary of Yields by Groups of Plots.
Average Annual Yield per tree in Three-Year-Periods (After Vaile 36:1922).

- - - - - - - - - - - - -

## O R A N G E S.

| Group: | 1912-1914: Navel: | 1912-1914: Val.: | 1915-1917: Navel: | 1915-1917: Val.: | 1918-1920: Navel: | 1918-1920: Val.: | Treatment: |
|---|---|---|---|---|---|---|---|
| U,V | 27 | 71 | 124 | 115 | 46 | 113 | Cover crop and manure |
| F,O | 20 | 55 | 69 | 126 | 26 | 85 | Manure |
| C,S | 42 | 64 | 86 | 120 | 20 | 56 | Dried blood |
| H | 40 | 59 | 34 | 17 | 9 | 1 | Nitrate of soda |
| A,Q | 35 | 52 | 94 | 102 | 42 | 20 | Complete |
| G,L | 29 | 56 | 74 | 74 | 28 | 19 | Two elements with nitrogen |
| E,K,P | 31 | 45 | 40 | 91 | 1 | 21 | Steamed bone |
| D,I,R | 16 | 26 | 3 | 26 | 0 | 3 | Potash |
| J | 13 | 33 | 12 | 49 | 0 | 10 | Superphosphate |
| B,M,T | 19 | 27 | 6 | 28 | 0 | 3 | Unfertilised |

## L E M O N S.

| Group | 1912-1914: Eureka: | 1912-1914: Lisbon: | 1915-1917: Eureka: | 1915-1917: Lisbon: | 1918-1920: Eureka: | 1918-1920: Lisbon: | Treatment: |
|---|---|---|---|---|---|---|---|
| U,V | | | 184 | | 124 | | Cover crop and manure |
| F,O | | | 139 | 115 | 33 | 115 | Manure |
| C,S | | | 126 | 99 | 23 | 68 | Dried blood |
| H | | | 40 | 56 | 0 | 1 | Nitrate of Soda |
| A,Q | | | 134 | 128 | 9 | 26 | Complete. |
| G,L | | | 85 | 98 | 4 | 26 | Two elements with nitrogen |
| E,K,P | | | 89 | 90 | 3 | 31 | Steamed bone |
| D,I,R | | | 40 | 33 | 3 | 2 | Potash |
| J | | | 99 | 34 | 7 | 2 | Superphosphate |
| B,M,T | | | 37 | 25 | 2 | 2 | Unfertilised. |

Vaile (36:I922) in reviewing the results of the Rubidoux plots stated - "Under the conditions of these trials there can be no question but that :

I. Nitrogen is the main limiting plant food element.

2. The use of nitrogen in the form of nitrate of soda, and to a less degree in the form of dried blood, without the use of bulky Organic manure of some sort, is conducive to the development of mottle leaf in citrus Following the continued use of liberal quantities of these materials under the conditions of the experiment, mottling developed to a point where certain of the trees were rendered entirely useless from the production standpoint.

3. Plots to which no nitrogen was applied failed, after a few years, to produce any crop of consequence. Phosphoric acid and potash, without nitrogen, produced no tree or fruit conditions different from those found on the unfertilised plots.

4. There is no clear evidence that phosphoric acid or potash, used in conjunction with nitrogen, has bettered the amount or the quality of the yield.

5. Bulky organic manures have supplied the required nitrogen and at the same time have limited the occurence of mottling as compared with the commercially fertilised plots. This is particularly noticeable with Valencias and Lisbons for in these varieties the manured plots have produced about 50 per cent more fruit than the dried blood or complete fertiliser groups.

6. Winter green-manure crops, in conjunction with the use of stable manure, have given better results in increased crop yields and improved tree conditions than have come from the use of stable manure with constant clean cultivation.

Later experiments have served to confirm the original results achieved on the Rubidoux plots and the value of bulky organic material as a source of nitrogen has been repeatedly demonstrated. Webber (42:I925) speaking in reference to the Rubidoux plot trials at Riverside remarks "Artificial fertilisers alone were found to be comparatively useless, while organic nitrogenous fertilisers were slightly better but still unsatisfactory. It was only on the plots to which bulky organic fertilisers were applied that the trees have remained bulky and produced good crops of fruit throughout the I8-year period over which the trial has been in progress, while the plots receiving stable manure and also leguminous cover-crops during the Winter have given regularly the best trees and the best crops".

In attempting to apply these results to New Zealand conditions it should, however, be appreciated that the decomposition of organic matter in the soil proceeds much more rapidly under the relatively arid conditions of California than is the case in New Zealand, and it is possible that the necessity for the application of heavy quantities of organic matter may not be so urgent in this country as overseas.

## D. GENERAL DISCUSSION.

### (I) Rooting habits of Citrus in Relation to Fertility.

In discussing the various aspects of fertilising it is necessary to consider many aspects of the problem, e.g., it is important to know something of the rooting habits of the citrus tree, and while this has been investigated under Californian conditions, no information is available locally, although such a knowledge would be valuable in timing fertiliser applications, date of ploughing, transplanting, etc. It is also necessary to have a knowledge of the downward movement of fertilisers after their application to the soil since it is possible that much of the phosphate and potash applied may be "fixed" in the surface layer of the soil and not reach the active rooting zone of the trees. The method of application also requires study. Should the manure be broadcast over the area, or should it be sown mainly under the spread of the tree, or should the application of fertiliser to this area be avoided ? These are all points requiring investigation under local conditions. However, a discussion at this point of results overseas may serve to direct attention to several major factors to be considered.

Waynick and Walker (38:I930) in a study of the rooting habits of citrus trees on sour orange root stock made the following observations (I) the growth of roots in the subsoil preceeded the growth in the upper foot of soil by nearly 28 days in the Spring (2) in no case did the time of growth of

root and top overlap (root growth preceding that of tops) until after the Fall growth cycle through which the two seemed to coincide if the growth cycle is the fourth of a season. They found that in general, active root growth preceded top growth by at least three weeks in the Spring and give some details of the factors influencing the growth of new root fibre on citrus trees. They found also that 90% of the active rooting area could be accounted for in the upper 22 inches of soil (this might vary on other root stocks).

In view of the early development of root growth in the Spring, it becomes problematical whether late Spring applications of fertiliser are ordinarily available in the rooting zone by the time growth commences and would suggest that the Spring fertiliser application should precede growth of the tops by at least a month and also suggests that deep tillage, assuming that it is necessary, should be done just before the active growth cycle so that the replacement of rootlets may be more rapid, since, if the growth cycle of the roots are not considered in following such a practice, it may be several months before a damaged feeder system is replaced. There are many other questions which a more intensive study of root development in relation to soil type and root stock might serve to elucidate.

With large trees Waynick (39:I93I) suggests that as much as 35% to 40% of the rooting area may be under the spread of the tree itself. If maximum utilisation of fertiliser is to take place, it therefore appears desirable that the area under the spread of the tree should be liberally dressed since this is the area of greatest rooting concentration. The only argument which can be raised against this method of application is that it induces greater weed growth under the trees where hand tillage may be necessary.

(II) Downward Movement of Fertiliser in the Soil.

While nitrates are easily washed down in the soil and so quickly reach the rooting zone, in the case of phosphate and potash these elements are fixed by the soil and by the usual method of surface broadcast will probably remain in the upper 6 to I0 inches of the soil column.

Waynick (39:I93I) says - " I would venture the opimion that 75% of the phosphoric acid and potash applied in citrus groves becomes ineffective for the reason that it fails to reach the active rooting zone".

While this fixation may not be so complete in sandy soils (e.g. Tauranga), it is possible that it has an important influence on the question of fertilising in the Auckland and Keri Keri districts and would suggest some other method of application than broadcast. Trials are being made whereby these substances are injected into the soil in soluble form by means of a "gun", but as yet no results of these experiments are to hand.

There is little question but that repeated applications of these fertilisers to a soil will in time accomplish their penetration in sufficient quantity into the rooting zone but the question of their more efficient application is one that requires investigation. It is possible that broadcasting over the soil immediately prior to the Spring ploughing might be advantageous.

The use of bulky organic material as a source of nitrogen should be followed wherever practicable. In the few groves visited where this policy was followed exceptionally favourable tree growth was occurring and production was high.

## E. SUGGESTED FERTILISER PROGRAMME.

Taking as a basis an application of 2.5 lbs. of nitrogen, 2 lbs. of phosphoric acid ($P_2O_5$) and I lb. of potash ($K_2O$) as presenting a satisfactory rate of dressing for a mature tree, the following programme suggests itself are being suitable, with modification for New Zealand conditions, -

| | | | N | $P_2O_5$ | $K_2O$ |
|---|---|---|---|---|---|
| August | Sulphate of ammonia | 6 lbs. | I.2I | - | - |
| | Blood and bone | 5 " | 0.32 | 0.57 | - |
| | Sulphate of potash | 2 " | | | I.0 |
| November | Sulphate of ammonia | 3 " | .6 | | |
| March | Blood and bone | 6 " | .39 | .69 | |
| | Superphosphate | 4 " | | .8 | |
| | TOTAL | 26 lbs. | 2.52 | 2.06 | I.0 |

The August application should probably be made prior to the Spring ploughing and at least one month before the commencement of top growth, while the November application should be made just prior to flowering. The March application should, if possible, precede the Autumn rains, the super being sown, in part at least, with a cover-crop. Other materials may be substituted in place of those suggested if they serve as a cheaper source of supply of the nutrient concerned, e.g. fish manure may replace blood and bone. For younger trees the amounts will be proportionately less, but there seems no valid reason why the proportions of the various elements should be materially different.

However, it should be expressed that every citrus grower should consider his farm methods as experimental and use system in planning and operating them so that he may observe results and after deducing conclusions alter

his management methods accordingly. Such a study adds interest to the work, stimulates an intelligent interest and makes a successful orchardist. It is not possible for any instructor to give detailed recommendations in respect of every orchard, no matter how firm may be the experimental basis of his advice.

## F. LIMING.

Approximately 30% of the growers visited during the survey had applied lime to their orchards within the last three years, but the general policy followed was spasmodic, and few growers were definitely sure that they had observed beneficial results. However, it appeared fairly certain that under Keri Keri conditions heavy liming was essential to secure satisfactory utilisation of phosphates. This soil is extremely acid (pH = 4.87), and has a very low lime status with the probability that applied phosphates are rendered unavailable to plants by forming insoluble compounds with the iron or aluminium in the soil. To rectify this position an initial dressing of at least two tons per acre is probably necessary, and the lime status should be sustained by annual dressings of smaller amounts. The position in other citrus districts is more problematical, but a carefully conducted trial at Tauranga with four replications and check rows suggests that liming increases yields.

The plots were laid down in I930, and have all received an annual dressing of complete fertiliser composed of

| | | |
|---|---|---|
| Superphosphate | 6 cwt. | ) |
| Sulphate of Ammonia | 6 " | ) per acre. |
| Sulphate of potash | 3 " | ) |

The limed plots have received in addition an application of two tons per acre of carbonate of lime applied at the commencement of the experiment. Sufficient lime has also

been applied to ALL plots to rectify the acidifying effect of sulphate of ammonia. About I20 lbs. of carbonate of lime is required to rectify the acidity caused by an application of one cwt. of ammonia. This has caused considerable confusion among growers as to the significance of the experiments and it would undoubtedly have been much better had some other source of nitrogen been used in the experiment so that the use of lime to counteract the acidifying effect of sulphate of ammonia would not have been necessary. The value of the experiment is not, as has been suggested by some growers, destroyed by the fact that lime has been applied to the 'no lime' plots.

Since the commencement of the experiment in I930, the total average production of the 20 trees in each treatment up to February, I934, is given in Table XXXVI,-

T A B L E XXXVI.

Effects on Yield of Applying Lime to Lemon Trees receiving complete fertilisation at Tauranga.

| | Yield (average 20 Trees) | Relative Yield: |
|---|---|---|
| Unlimed | 697.6 | I00. |
| Limed | 769.0 | II0. |

It appears from this experiment that one application of lime given in I930 has increased production by I0% over a four-year period, but the differences are not statistically significant. The question of liming is therefore still an open one.

# CHAPTER XVIII. DISEASES OF CHIEF ECONOMIC IMPORTANCE.

A. Bark Diseases (I) Economic importance (II) Contributory Factors and Suggested Remedies (III) Treatment.
B. Citrus Brown Rot.
C. Verrucosis.

As in other branches of fruit production, the citrus grower is faced with the necessity of combating various fungus diseases which cause damage to the tree and reduce production or affect the quality of the fruit produced. The number of diseases is not so large as in many other groups of fruit, but is of sufficient importance to attract serious attention.

Some locations are conducive to certain diseases and should be avoided since it is extremely difficult to overcome fundamental drawbacks of soil, drainage or climate, and too frequently these are given little or no consideration when selecting a location.

Many diseases are brought on by negligence or poor management, while others are associated with methods of cultivation and fertilising. Here as elsewhere the maxim holds good "Prevention is better than cure".

It is not intended at this juncture to discuss the life histories or identification of the various diseases concerned since these are fully dealt with in many publications.

## A.BARK DISEASES.

### (I) Economic Importance.

The survey disclosed that a major factor operating against efficient production was the serious extent to which Bark diseases were limiting production and reducing the useful life of citrus trees. The influence of age on the production of normal citrus trees has been shown in Table XXIV and it is obvious that if trees cannot normally

be grown to the age of maximum production a tremendous economic waste is occurring. Of the 25 full-bearing (over ten years) orchards included in the survey, 52% were more or less seriously affected with Bark disease. In some cases orchards of only five years of age were noticed severely affected and the cumulative loss occurring from this source must be considerable.

(II) Contributory Factors and Suggested Remedis.

The contributory factors appear to be (I) injury of the crown roots or stem by tillage implements or operators during cultivation operations or picking. The practice of using nailed boots when picking citrus fruits should be discouraged since abrasions caused to the bark permit entry of the causitive organisms. It is frequently recommended overseas to paint the trunk of the tree with Brodeaux paste in order to minimise the danger of infection, and this method might be tried under New Zealand conditions. (2) the piling of rubbish for mulching purposes or of organic manures about the trunks of trees is strongly condemned. When a mulch is placed round a tree, it should be kept at least I2" to I5" distant from the trunk. The moist conditions which ensue with banking of material about the trunk cause softening of the bark and render conditions suitable for the entry of fungus. (3) Strict attention should be paid to drainage so that no stagnant water is allowed among the trees. The water table should never rise above 30" below the soil surface. Even temporary water-logging such as may occur during heavy rain may cause difficulties in this respect. (4) When ordering trees from the nursery, specify that they shall be budded at least nine inches above the ground. This reduces the danger of infection at ground level. (5) in planting care should be taken to see that the tree is planted in the orchard at the same level as it was growing in

the nursery. On no account should it be planted deeper. (6) New plantings should, where possible, be made on resistant root stocks, the order of resistance being approximately as follows : sour orange, Citronelle, Trifoliate orange and sweet orange (I8: I926) (7) A great deal of the damage caused could be avoided by early treatment and it is suggested that growers should carefully inspect all trees at least twice a year in order to detect infections at an early stage. If promptly treated, trees will frequently recover. (8) Since the active organisms are in most cases favoured by damp conditions, the soil under the spread of the tree should, as far as practicable, be kept well-worked so that a layer of loose dry soil is maintained on the surface at all times; this is, of course, not possible during wet weather but every effort should be made to keep the soil well stirred and dry.

(III) Treatment.

Although a number of causitive organisms are responsible for a variety of root diseases, the treatment is very similar in all cases, and will be treated here together. The treatment consists in removing as far as possible the detrimental conditions to which reference has just been made, and particular attention should be paid to all factors conducive to the health of the trees. The diseased area should be carefully scraped with a sharp chisel extending some distance out into the healthy bark. Burn the material removed. The scraped area should be dressed with a suitable disinfectant and it is principally at this point that the main divergence of opinion occurs as to the most suitable material to use. The following dressings were recommended by growers :

Lime sulphur (full strength)
Coal tar
Bordeaux paste
Corrosive sublimate solution (I in I,000)

Stockholm tar
Red Oxide of iron

It is not possible from grower experience to state that any one of these appears to be more efficient than any other.

After trees have been treated, it appears that it may be worth while for growers to consider the advisability of "inarching" one or more vigorous young root stocks to support the tree while the diseased area heals over. The method has been tried out experimentallyin New Zealand and operated successfully - (see Plates XIX and XX). It appears, however, that in order to be successful, the "inarching" must take place at an early stage or the top may become debilitated before remedial measures are applied. For full particulars of the method of inarching reference should be made to U.S. DEPARTment of Agriculture, Bulletin No. I369, or University of California, circular No. 273.

If the injury is extensive and treatment delayed, a moderate thinning of the top is probably desirable. This should be accomplished by a thinning process rather than by "heading". Where the injury is extensive and trees are decidedly weak, skeletonising may be necessary if they are to be saved, but it is questionable whether trees in such a condition are worth saving, even if possible. It would probably be quicker to remove the affected tree and replant.

B. CITRUS BROWN ROT (Phythiacystic citrophthora

This disease is one of the most prevalent affecting citrus in New Zealand particularly in neglected orchards. It attacks all varieties of citrus and was first recognized in New Zealand in I9I2. In severe cases it may cause loss of the whole crop with defoliation of the tree or it may cause gummosis on the trunk and larger branches. The disease can only flourish under damp conditions and fruit bodies are produced only when excessive moisture is present.



PLATE XIX. (left). A young rootstock successfully inarched into a sweet orange tree damaged by foot-rot.

PLATE XX. (right) Two inarches placed above an area of bark damaged by foot-rot. This method of combatting the ravages of bark diseases seems worthy of wider trial in New Zealand.



Infection takes place by splashing of spores on to low branches or up the trunk of the tree. Fortunately the disease is easily controlled by the application of Bordeaux spray throughout the Winter months. It was at one time recommended that all branches should be cut at least one meter from the ground and that a cover-crop should be grown under the trees to prevent splashing, but the treatment which appears to be meeting with most success among orchardists is that of keeping the area under the tree clean and stirred throughout the Winter months and keeping the trees covered. with Bordeaux spray (3:5:50), the first application being made in May and a further application in July. Particular attention should be paid to covering the under side of the leaves and all of the main branches and trunks to a height of at least six feet above ground level. If this is done, it is not necessary for the branches to be lifted off the the ground.

C. VERRUCOSIS (Sporotrichum Citri).

This disease is fairly widespread throughout the orchards visited although in one or two isolated localities for some reason not apparent it is not sufficiently severe to warrant spraying except at irregular intervals. The disease affects the leaves, less frequently laterals and fruit, in the latter case causing large scabbed areas which distort the fruit and greatly reduce its commercial value. Fruit are affected in the young stage, being most susceptible immediately after petal fall. Fortunately control is comparatively easy, provided a thorough spray programme is adhered to. Bordeaux spray should be applied at blossom fall of the main crop and again at the Autumn flowering, but in cleaning up a heavily infected orchard, more frequent spraying may be necessary at the commencement.

The above list of diseases is by no means exhaustive but appears to the writer to cover the major diseases of economic importance on citrus in the groves visited. No attempt has been made to analyse control methods and their relative efficiency etc. since it was felt that such fell outside the scope of this survey in its present form.

# CHAPTER XIX. INSECT PESTS OF ECONOMIC IMPORTANCE.

A. Scale Insects.
B. Black Aphis.
C. Thrips.
D. Grasshoppers.
E. Broer.
F. Tortrix.

The injury caused by insect pests may be divided into two groups (I) those causing loss of vitality in the tree with consequent reduction in its production (2) those causing blemishes or disfiguration of the fruit so lowering its grade or rendering it unsaleable. In many cases, of course, one insect may be responsible for injury of both types, but it serves as a rough classification.

## A. SCALE INSECTS.

The chief scale insects of importance attacking citrus fruit in New Zealand are the red scale, the black scale and the cottony cushion scale. These insects live by sucking the juices of the tree, either on branches leaves or fruit and if the infestation is severe they may cause general debility of the tree. Infestation is usuall heaviest during warm dry seasons and every effort should be made to prevent their spread by early treatment. It is contrary to regulation for fruit to be marketed which is affected with scale insects and, prior to marketing, any fruit so affected must be thoroughly washed to remove the scale. This greatly increases the cost of handling and frequently impairs the keeping quality of the fruit. The question of their adequate control is therefore one of considerable importance and rigid inspection of old and neglected orchards is necessary to destroy sources of infection from which infestations may spread.

B. BLACK APHIS.

During warm dry weather young succulent growth is frequently attacked by myriads of small black aphids. These sap the juices from the young growth causing deformation of the leaves and stunting of the shoots. However, they usually disappear with the approach of cooler weather and in many cases no attempt is made to control them, but in young groves where it is desirable to build up a strudy framework as rapidly as possible, it is probably wise to spray with nicotine sulphate (I:600).

C. THRIPS.

Thrips are responsible for a peculiar type of blemish found on the surface of many citrus fruits and may damage a large proportion of the crop. The scars are smooth brownish or grayish sunken areas and they may be either in streaks, blotches or circles. Usually, particularly round the stem end of the fruit, such markings frequently result in what should otherwise be extra fancy fruit being graded down to fancy or choice, and hence their control is of considerable importance in securing finest grade fruit.

D. GRASSHOPPERS OR KATYDIDS.

These are often responsible for considerable injury to citrus trees. The foliage and tender twigs are eaten and the young fruit is by no means immune. Pieces are bitten out of the side of the young fruit and as it increases in size large depressed scurfy spots are formed. These render the fruit unsaleable or reduce its grade; while some of the young fruit drop off when injured. The injury occurring may be considerably reduced by keeping an orchard clean of weed growth throughout the Summer months.

## E. BORER.

Various species of beetles lay their eggs on citrus trees the larvae subsequently boring into the limbs or trunks of the tree and occasionally doing considerable damage by weakening branches so that they break under the weight of fruit or are snapped off by wind. In healthy, vigorous orchards the pest is rarely serious but may cause severe damage in semi-neglected groves. A considerable improvement in the degree of infestation can be achieved by careful attention to orchard sanitation, the destruction of all prunings, cutting off limbs in pruning so that they will quickly callus over and protecting all wounds made with some preparation such as paint, or grafting wax and tar.

## F. TORTRIX.

The Tortrix leaf-roller caterpillar or false codlin mouth is responsible for considerable annual loss of fruit in citrus groves. It causes damage by forming a shelter by fastening an adjacent leaf to a fruit and subsequently burrowing into the rind of the fruit. The fruit frequently gives off a gummy exudation and ripens prematurely. In some seasons the loss from this cause may be considerable.

# CHAPTER XX. GENERAL MANAGEMENT FACTORS.

A. Introductory.
B. Orchard Records. (I) What Records to keep (a) Orchard records (b) Accounts.(II) Analysis of Records.
C. Average Production.

## A. INTRODUCTORY.

From what has been said in the preceding section, it becomes very apparent that as in other branches of industry, management involves the bringing together of a considerable number of factors. Then, too, the object of management is to secure the greatest net return on the investment, while in the preceding discussion we have considered chiefly the matter of obtaining the greatest productivity. The successful manager is therefore the man who is able to so collate his management factors that he secures maximum production with maximum efficiency; he must consider his management policy in the light, not only of the increase in production which may accrue,but also in the light of increasing costs and these in turn have to be considered with a knowledge of probable prices for the crop to be produced.

The successful citrus orchardist must therefore combine technical knowledge in many branches of science with sound business principles and considerable foresight and judgment in attempting to shape his policy along sound lines, and one of the greatest aids he can secure to assist in the analysis of his management methods is the adoption of a sound method of farm records.

## B. ORCHARD RECORDS.

### (I) What records to keep.

If the orchardist is to intelligently control his business, he must be able to guide his future operations

in the light of previous experience. In order that the conclusions he reaches may be reliable, it is essential that he should have an accurate record of the methods adopted in the past and for this purpose some system of orchard records and of orchard costs should be kept in such a form that it can be analysed to give the required data. A certain proportion of growers do at the present time keep records, but these are frequently kept in such a way that they can provide little assistance to the grower in regard to management policy.

No matter how thorough may be the investigations conducted at a central experimental station it remains for the individual owner to demonstrate whether these recommendations are applicable to his own particular orchard and much study and experimenting must always be done by the individual grower at least in the solution of local problems. It is hopeless to expect the Government investigator to be able to tell farmers just what to do in every case; all they can hope to do is to give the principles involved in a case so far as they are known and the farmer must make the application. In order that that application may be made on a sound basis, it is essential that the farmer should have a record of the present condition and past treatment of his grove.

The features which are desirable in a system of orchard records are , -

(I) To provide accurate information in regard to past treatment of each individual tree, or at least of each individual block of trees

(II) To provide a written record of operations for future guidance.

(III) To determine ways of increasing profits.

(IV) To determine the details of farm investment, receipts, expenses and net income.

(V) To analyse marketing conditions and expenses.

(VI) The system must be within the reach of the farmer in respect of its complexity and the time and labour required to practise it. The individual need of data and the individual time and ability will determine the extensiveness of the records.

(a) Orchard Records.

The following system is suggested for growers who are wholly dependent upon citrus as a source of farm income, but the system is equally appicable as one section of a cost accounting system on a "mixed" farm. The records which should be kept are (a) an orchard record book (See Appendix IV) preferably of a loose leaf type, which should contain a map of the orchard showing the position of each individual tree, the position of drains or pipe lines in the orchard, shelter belts, sheds, etc. (b) either an individual record of each tree showing the stock, variety, date of planting and particulars as to disease infections, etc., and if possible a record of the annual production. If time and labour will not permit such detailed records, then the orchard should be divided into blocks of similar type, trees and such details should be noted for the individual blocks, and (c) a complete record of the orchard operations performed on each section of the orchard should be recorded in chronological order.

It is the considered opinion of the writer that an effort should be made to keep individual tree records if growers hope to get maximum efficiency in their orchards. A. D. Shamel has shown the tremendous variations which occur between trees under Californian conditions and there is no reason to believe that even the better class New Zealand orchards are any more unfirom. Just in the same way as herd testing has raised the average level of production of the New Zealand dairy cow so the writer believes that the keeping of individual tree records would materially increase

the efficiency of every grove and add interest to the work and direction to the management policy. There are no doubt labour difficulties to be overcome in certain cases, but the application of the method appears to present no insurmountable difficulties. At least in so far as the selection of bud wood for propagation purposes is concerned, it is felt to be essential that these buds should have a performance record backing and if by no other means it is felt that the work should be sponsored and organised with the aid of Governments assistance, but this is a matter where the growers should act co-operatively since they themselves are vitally concerned in the production of only the best high producing trees.

If the orchardist so desires the orchard record book may include a record of the number of orchard cases picked and a record of their subsequent grading at the curing house or any other details in respectof the crop, climate, or other features about which he desires information.

(b) Ledger Accounts.

The precise form of ledger account adopted will depend largely on the size of the crop being marketed, but it is suggested that separate accounts should be kept for each variety of fruit marketed and these accounts may be subdivided if the fruit is marketed through several different channels. It is suggested that a columner ledger account such as shown in Appendix IV should be used giving the following details - date of despatch, auctioneer to whom consigned, number of cases, gross price received, commission, freight, cartage, receiving and delivering, net price received.

The method adopted by some growers of merely recording the net price received from the auctioneer or broker is not considered to be satisfactory in so far as it fails to take account of several heavy items of expenditure and fails to provide information that will permit of future choice in the method of marketing.

At the end of the year each column in the various accounts may be totalled and transferred to their respective accounts, i.e. General Freight Account will consist of a series of totals transferred from the Lemon Account, Sweet Orange Account, Grapefruit Account, etc. Such a methodhas the added advantage of making an analysis of costs comparatively simple and saves much tiresome analysis of detail. A full sample of accounts is shown in Appendix IV.

It should also be noted that the purchase of young trees for an extension of planting or the purchase of new machinery (not for replacement of existing machinery) are not expenses for the current year, but should be charged to Capital Account.

(II) Analysis of Records

The keeping of records of such a type has little significance unless these are analysed to provide information to the grower and assist him in securing greater profits from the enterprise. The method of keeping ledger accounts outlined above appear to provide a system by which the material required for analysis is most easily obtained and permits of the working out of average costs of marketing per case when fruit are marketed through various channels, while average costs per case and per tree for fertiliser sprays, etc. may be worked out.

A Depreciation Account has been included since it has become apparent in the analysis of data that the purchase ofmuch expensive machinery for use on a small area may make depreciation, even at conservative rates, a serious charge per tree and it is felt that the inclusion of this account may serve to check unwise expenditure on expensive equipment. It is not intended to suggest that labour saving devices may not be a profitable investment on large areas,but there is little doubt that where the area is small they may prove a heavy overhead charge on the undertaking.

In order that the fullest information may be available from an analysis of costs and returns, it is probably best to make out an analysed Expenses Account and Returns Account on a "per case" basis showing costs and returns over a number of years in columner fashion. This will give an indication of variations occurring from year to year and whether any management policy such as, say, an increase in the amount of fertiliser used has been reflected in increased production.

Labour is one of the heaviest charges per case and requires careful management in order that it may not assume undue proportions. Making allowance for family labo labour expenses per case on bearing orchards have varied from I6½d. to well over 3/- per case; while in younger groves the costs have been proportionately higher per case While the per tree costs are more constant, the variation has still been remarkably wide varying from approximately 4/- per tree to over 8/- per tree.

It has not been possible to get accurate analysis of the proportion of time spent on productiom and on marketing and labour charges have therefore been kept as a separate item, but it appears that efficient labour utilisationis one of the major factors in securing economic

production,and it would probably prove illuminating for the average grower to work out his labour costs per case and per tree making allowance for family labour at a standard rate (say £I00 per male labour unit per year).

The criterion of efficient orchard management must in the long run be taken on a basis of cost of production per bushel of fruit or net returns per tree or per case. This feature will be more fully discussed under theheading of "Costs and Returns", but the point it is desired to express is that the individual orchardist should so analyse his expenses and returns that he may consider his management policy in the light of past experience and pursue a constructive policy in future years.

## C. AVERAGE PRODUCTION.

The returns of the 42 groves used in the preceding analyses and shewn in Table XXIII and in Appendix IIIare analysed in Table XXXV below to shew the average production per tree and per acre of I00 trees.

### T A B L E XXXV.

Shewing the average production of the bearing trees in the groves included in the analysis of production factors and the proportion of bearing to not-bearing trees in the several varieties.

| Variety | NO. OF TREES | | | PRODUCTION. | | |
|---|---|---|---|---|---|---|
| | Bearing | Not Bearing | Total | Bushels | per tree | per acre. |
| Lemon | 7,953 | 7,575 | I5,528 | 3I,638 | 3.98 | 398 |
| N.Z.Grapefruit | 2,056 | I,330 | 3,386 | 7,332 | 3,56 | 356 |
| Sweet Oranges | 968 | 2,47I | 3,439 | I,377 | I.42 | I42 |

In considering these averages it must be remembered that these represent better than average groves and were the whole of the bearing trees in the Dominion to be considered it is probable that the average would be considerably lower than that given above. However, crops vary

considerably from year to year and a series of crops must be considered in arriving at any reliable estimate of production in the Dominion.

Mr. O'Brien in his survey of the Grapefruit industry found an average production per mature tree of 4.5 bushel cases this being taken over 1995 trees which in 1933 produced 9063 bushels. The annual variation in crop therefore appears to be considerable and conclusions based on one year alone must be accepted with considerable reserve.

In the averages shewn in Table XXV it is also necessary to state that a small production occurs from trees classed as "not bearing" and these tend to a small degree to swell the average of the bearing trees, since it was not possible to separate production from the two age groups.

# PART VI. MARKETING THE CROP.

## CHAPTER XXI. PREPARATION FOR MARKET.

A. Lemons; (I) Picking (II) Curing (III) Grading Regulations (IV) By-Products.
B. N. Z. Grapefruit (I) General (II) Regulations.
C. Sweet Oranges.
D. Methods in Use Overseas. (I) Californian methods (II) Application to Local Conditions
E. Suggested Improvements in N. Z. Methods.

### A. LEMONS.

(I) Packing.

Lemons being a fruit which is purchased chiefly for its acid and juice content, it is not essential that it should mature on the tree prior to its use. It is customary to remove lemons from the tree when they attain the most satisfactory size for marketing, i.e. I80/2I6 to the bushel, irrespective of whether they have coloured or not. The pickers are provided with metal rings of the correct diameter ($2\frac{3}{8}$" approximately) and every lemon which fails to pass through the ring is removed from the tree during picking, while smaller fruit which have become "tree ripe" without attaining the requisite size are also picked.

Picking is done with the aid of clippers or secateurs, special types having been designed particularly for this purpose. These usually have blunt ends to the blades and minimise the danger of injury to the fruit by contact during picking. The fruit is usually removed by a double cut, one to sever it from the fruit lateral and the fruit "button". It is essential that this second cut should be made carefully and leave no projecting points which may cause damage to adjacent fruit in the orchard boxes.

Owing to the necessity for care in handling and

for picking fruit of only the correct diameter, lemon picking is a slow and expensive process. The number of cases which an expert picker can gather in a day depends very largely on the amount of fruit on the trees; in the Spring when the crop is heavy an expert picker can probably gather 20 cases a day but during the Summer period when the fruit are more scattered I2 cases per day would be an excellent result. In isolated cases picking is done by contract at the rate of 5d. to 6d. per case, but such a method is likely to be unsatisfactory since it is improbable that pickers under this method will take the same care as those on day labour.

One grower adopts the policy of providing each picker with a series of numbered labels of which one is placed in each case as it is picked in the orchard. Should the picking be unsatisfactory, as indicated by the condition of the fruit on arrival at the curing house, it is then possible to trace back to the careless workman. Such a scheme has much to commend it.

As a rule, however, growers pick the fruit themselves or use permanent labour, the main exception to this being the Tauranga district where quite a proportion is done by Maoris employed by the day, the usual rate being 3/- to 4/- per day. It is probably advantageous if the grower can do his own picking since this normally results in greater attention being paid to careful handling and a certain amount of shortening back and removal of worn out lateral growth may be accomplished at the same time.

Owing to the scattered nature of growers in most districts, it has not become feasible to establish picking gangs as is the case in California where the packing house has a body of pickers who pick for growers at regular intervals at standard rates.

It is important at this juncture to stress the necessity for careful handling and picking at sufficiently close intervals to ensure that the size of fruit gathered fall within narrow limits. The commercial value of the fruit when marketed depends to a considerable extent on its suitability for the retail trade and a premium is secured for fruit of the desired size. The grower therefore who picks at irregular intervals may have a large part of his fruit graded as "household" or "factory" rather than as "extra fancy", and since the average difference in price between extra fancy and factory fruit is in the vicinity of I2/- per case (I934), the grower has it in his own hands to considerably increase his marketing returns by careful attention to picking.

After picking, the grower may elect to market his fruit himself or he may forward it to one of the curing houses

(II) Curing.

Curing consists essentially of a process of partial but controlled dehydration of the rind with a consequent increase in the percentage of juice contained in the fruit while the danger of injury during transport is reduced. Under ideal conditions, humidity and temperature would be controlled so that the process could be effected with precision, but under commercial conditions in New Zealand such control is not attempted to any marked extent except in so far as variations can be secured by closer packing of the trays so diminishing air circulation and raising the relative humidity.

The practices adopted vary somewhat, but consist essentially in outline as follows. One the arrival of the fruit at the curing house a form is filled in and posted to the grower acknowledging its receipt, showing number of cases etc. (see Appendix V). The fruit is then graded into tree ripe, green and factory, or the factory grade may be taken out at a later stage. The proportion in which the three

grades are received is approximately as follows : -

T A B L E XXXVI.

Shewing approximate Proportions in which Fruit are received at one of the Curing Houses during the Season.

| | % OF SALEABLE FRUIT. Coloured & Tree-ripe | Green & Colour | % FACTORY: each Season. |
|---|---|---|---|
| SUMMER | 50 | 50 | - |
| Autumn | 60 | 40 | I5 |
| Winter | 40 | 60 | 20 |
| Spring | 60 | 40 | 65 |

The percentage of factory lemons shown includes rough and juice lemons as well as lemons specially grown for peel. The main period of supply of factory lemons is August, September, October and the lowest period February and May, since in these months trees are usually carefully picked for good prices and the fruit at this time is slow of maturing. During the period June/July, the lemons grow slowly and if the weather is frosty they tend to colour undersize.

The tree ripe fruit may be washed in warm water in order to clean it, but this practice is variable. Some shreds have discontinued the practice of washing prior to curing, as they consider that it spreads the spores of moulds and causes greater loss during curing. Other shreds wash in a solution containing 2½% borax or some other preparation to assist in cleansing and preventing decay. Washing in a fungicidal solution will not, however, prevent a damaged lemon from decaying. After washing, the fruit are placed on lath trays holding approximately half a bushel of fruit. The trays are then stacked and held until the curing process is completed. With tree ripe fruit it is not

usual to hold for any length of time since the fruit has not the keeping qualities of the green or silver lemons.

The green fruit may be graded according to degree of colour and coloured by placing in a gas tight room to which a small proportion of ethylene gas is admitted. The ethylene has a reducing action on the chloroplasts in the lemon rind causing the fruit to colour. The gas may be obtained in a pure form in steel cylinders or may be manufactured as required, while in some cases it is produced by incomplete combustion of paraffin in a stove. The time required for colouring varies somewhat with the condition of the fruit, the season, the temperature employed and the concentration of gas employed while at Tauranga a sweating process is employed. After colouring the fruit are washed and treated similarly to the tree ripe fruit. They are, however, superior in keeping quality.

After curing is completed the fruit may be washed again (this varies considerably) graded, sized and packed in standard export bushel cases, the "extra fancy" and "fancy" grades being wrapped in tissue paper, though this is not the usual practice with the lower grades. Fruit of larger size than will pack I40 to the bushel case is usually graded "factory" while a proportion of small, rough and mis-shapen fruit is also graded out and used for the manufacture of juices. These fruits are usually treated by a separate firm or organisation, but in the case of the Tauranga Association a by-product plant has been established in connection with the curing shed. The sizes usually packed are I50, I62, I80, I98, 2I6, 234 and 250 per standard bushel case, sizing usually being done by hand.

A considerable shrinkage occurs during the curing process. The average shrinkage from well filled bushel cases (orchard packed) to cured packed cases is usually in the vicinity of 20% to 24%. This shrinkage is made up of three

components (I) packing shrinkage probably averages about I0%, but will vary according to the tightness of the orchard case packed, (2) curing shrinkage due to the actual curing process, approximately I0%, (3) decay; probably 3% is a fair average, but the loss from this factor is very variable depending on care in picking and somewhat with maturity of fruit and season of the year. Fruit is rarely held for longer than two months or the loss by shrinkage becomes too great. When held in expectation of higher prices, shrinkage may offset the rise in price unless considerable judgment is exercised. Recent experiments suggest (35: I934), however, that lemons may be held successfully incool store, but the process has not yet been widely adopted commercially.

(III) Grading Regulations.

Up to the present time there are no regulations standardising the grading and sizing of lemons for market, but a scheme has been worked out by the Horticulture Division and approved by the growers and it is hoped that standardised market grades may become effective in the near future. A draft copy of the proposed grades is shown in Appendix VI a.

The chief difficulty under the regulations appears to be the determination of the point at which a lemon is "cured". If the regulations are to prove effective, they must be such that an Inspector can determine immediately whether or not the package is true to label and conforms with the regulations, otherwise their enforcement presents considerable difficulties.

In the draft regulations "cured, means any variety of lemon of approved size, cut from the tree when mature, green, silver or coloured in appearance, coloured

in an approved manner and conditioned until an appropriate refinement in thickness of skin shall be obtained".

This appears to present considerable difficulties in its interpretation by an Inspector and it might be advisable to consider the adoption of the American method, by which the only specification is in respect of juice content.

The "Sunkist" regulations (Appendix VI b) specify that all lemons packed under that brand "Shall have a minimum juice content of 25% by volume, which is approximately the equivalent of 2.75 gallons per packed standard lemon box.‡ The determination is made as follows :- "The volume of a representative sample of at least I2 lemons from the packing bin, to be measured by water displacement into a graduate‖. The juice is then extracted by reaming, screened by pressing through cheese cloth and its volume measured in the graduate" "The percent of juice by volume is found simply by dividing the juice volume by the fruit volume and multiplying by I00". Under the draft regulations appended, it is suggested that the juice content shall be not less than 20% by weight, but the method of determination is not specified.

It seems unwise that the Government Regulations should advertise the fact that New Zealand lemons are not comparable in juice content with imported lines and it is suggested that it would be advisable to alter this rule to 25% of juice by volume and permit a degree of tolerance, which can be stated in the Regulations.

It is desirable that these regulations for the compulsory grading of New Zealand lemons should, when gazetted, be as complete as possible and not require immediate alteration, so that although the delay which has occurred may seem unnecessary to some packers, it has probably been a wise precaution and permitted of their careful

‡ contains approximately 72 lbs.

‖ Graduate: measuring cylinder.

consideration prior to publication. Some method of standardising grades is essential on the New Zealand market and the sooner the industry can place a standardised product before the public the sooner it will command a satisfactory price.

The position, in the past,has been made more difficult by the number of small growers who have marketed haphazardly in the Auction Rooms and destroyed the confidence of the buying public. Much of the fruit has been low in quality, deficient in juice content and lacking in keeping quality, with the consequence that the prices realised for better quality lines have suffered. Standardisation is essential to successful marketing of any produce on the modern market and lower grade fruit must be removed from the Auction tables if the industry is to be placed on a sound basis.

(iv) By-products.

A considerable proportion of over-size and/or badly blemished fruit is annually disposed of to proprietary firms dealing in the manufacture of lemon by-products. It has not been possible to estimate accurately the total amount consumed in this way, but probably not less than 25% of the fruit consigned to the curing establishments eventually find its way into by-products. One proprietary firm alone handles I50 tons of lemons per annum for the manufacture of lemon peel and lemon squash. In spite of these large amounts supplied by the local trade, lemon peel is still imported in brine for manufacture in this country, largely owing to the fact that the New Zealand Growers, through lack of co-operation inmarketing, are not ina position to guarantee a regular supply to these firms.

The Tauranga Association have established a By-Product Plant and during the I934 seasonprocessed 22,7I3 pounds of lemons for peel and II,628 pounds for juice.

## B. NEW ZEALAND GRAPE FRUIT.

### (I) General.

New Zealand Grape Fruit have two main sources of demand :

(a) As Grape Fruit for dessert purposes;
(b) For the making of Marmalade.

They are frequently utilised for marmalade making before reaching maturity, since at this stage they are considered to "jel" better, while for dessert purposes they should not be utilised until later in the Season, when the ratio of soluble solids (Sugar) to acid has increased. This is usually subsequent to the month of July and the season may extend as late as Christmas.

Marketing methods in either case are similar, unless the fruit is for supply to a Factory. The fruit are picked by hand on reaching the desired stage of maturity. In some cases the fruit are clipped from the tree with special secateurs, but this practice is by no means universal. The fruit are placed after picking in field boxes and subsequently conveyed to a convenient shed or Grading Store, usually in or near the grove and sized and packed by the grower preparatory to sending to market.

In some cases the grading and packing is done by a Central Co-operative or Proprietary Shed but this is not done to the same extent as with lemons.

The total output from the various packing organisations is estimated at approximately 7,000 cases, which would represent a smaller proportion of the total crop than in the case of lemons.

After picking, the fruit is usually sized and in the larger organisations may be separated into "extra fancy", "Fancy" and "good"grades according to the percentage of blemish etc. on the fruits.

However, the total proportion, which is graded, outside of those mentioned above, is probably very small.

In some cases, the better grades are wrapped in tissue paper, or they may be marketed without wrapping.

No processing of the fruit is usual in the case of Grape Fruit for dessert purposes, but in the case of those destined for the marmalade trade, a certain proportion of the early pickings are sometimes coloured artificially by the aid of ethylene gas. There is considerable variation in the packs used, the pack varying from 55s. to 180 to the standard case. The most popular sizes ranging from 96 to 126 to the standard bushel.

(II) Regulations.

Draft Regulations have been issued covering the grading and packing of Grape Fruit for the local market (see Appendix VIc) by which it is hoped to standardise the packs and grades and render the fruit more acceptable to the retail trade. Such standardisation is overdue and should result in a marked improvement in the marketing of Grape Fruit in the Auction Rooms.

C. SWEET ORANGES.

The marketing of sweet oranges is in all respects similar to that used for Grape Fruit. The sizes vary from 120, or larger, to 260 to the standard bushel case, while grading of the fruit is rarely undertaken. However, with increasing supplies from Keri Keri group settlement scheme, it will be necessary in the near future to arrive at some understanding in regard to the grades and sizes that are to be made in marketing and draft Regulations have been prepared by the Horticulture Division (Appendix VId).

In regard to these draft regulations the suggestion is made that size should not enter into a grading standard which is designed primarily to indicate the quality of the fruit, while size is indicated by the count.

Such a compromise has not been found necessary under conditions overseas and its inclusion in our regulations is believed to be unnecessary.

Also the inclusion of a variety of size relationships in regard to variety appears as though it may delay the adoption of a few good standard varieties of oranges for our New Zealand trade since it appears to give offical recognition to a large number of minor varieties. It is understood that the Australian authorities have simplified their regulations by recognizing only three main groups of sweet oranges; viz. Navels, Valencias and Mediterranean Sweet. Owing to the small proportion of such varieties as Golden Nugget, Groverley Navel, etc. planted in New Zealand and the fact that Shamel's bud selection work in California suggests that under conditions there most of the named bud sports from Washington Navel are inferior in one or more respects to the original strain, it seems a doubtful policy in a young industry to recognize such strains, and it is suggested that the names placed on orange cases should be limited to the three selected for use in Australia and that the question of size as a determiner of grade be deleted.

D. METHODS IN USE OVERSEAS.

In many of the larger exporting countries, such as California, America, Australia and South Africa, much attention has been paid to the processing of all types of Citrus fruits prior to sale and expensive machinery has been installed in central packing and processing plants to ensure uniformity of the product and good keeping quality.

Our industry here, has, in the past, been too scattered and has lacked the requisite organisation for the establishment of large central co-operative curing sheds, but if the industry is to be organised to capture a larger

part, or the whole, of the local demand, then the better presentation of our products to the public will have to receive serious consideration, and it may be interesting at this point to review the methods in use in California and elsewhere.

(I) Methods in use in California - oranges.

The following account of the method of processing for oranges is taken from Pamphlet No. 7 of the Council for Scientific and Industrial Research of Australia (27:I928).

All the fruit is cut and the pickers wear canvas gloves. At all stages the fruit is handled with the utmost care. On arrival at the packing house the filled boxes are placed on an endless belt, which carries them to a washer, where the cases are automatically tilted and the fruit emptied down an inclined plane into the washing tank. This tank contains a series of revolving brushes, over which the fruit has to pass. The water has soap powder dissolved in it. The fruit then passes from its soaking tank through another series of brushes, over which pure water is constantly sprayed. This completes the washing operation.

The fruit is passed into a tank containing a solution of borax and boric acid in the proportion of one part of the former and two parts of the latter, in a 4½ to 5 per cent solution. The temperature of the solution is maintained at 95 to I00 degrees F, by means of a gas heater. A slowly rotating series of paddles causes the fruit to travel forward and be immersed for the period required, viz. 5 minutes. The fruit is then delivered to an ascending platform, at the top of which it meets a small spray of water which washes off any excess of Borax. The strength of the solution is determined by a hydrometer, and the concentration is maintained by the addition of more borax and boric acid as required.

The fruit is dried by passing it slowly through a drier, where air has drawn over it by a series of fans. This operation takes I5 minutes. After these operations the fruit presents a clean bright appearance, much superior to the natural appearance when picked from the tree. The skin shows a polish that much enhances the value.

The fruit is then passed to the grading belt where girls hand grade for quality. Various belts convey it to the sizing machines.

In the higher grade the oranges are passed through electrical marking machines which imprint the name "Sunkist" on each orange. This mark refers to quality only and not to the size of the fruit.

The fruit is sized by machines and subsequently packed by girls who are paid 3d. per box for normal sizes but 6d. per box for the small sizes (2 to 2½" in diameter). To give every girl the same chance the positions are changed every half hour so that no girl is handicapped by being always on the same size.

The packers place the full case on a travelling belt, where it passes to anautomatic nailer, which nails the two ends. A metal strip is nailed over the middle of the lid by hand and the case is then loaded directly into the railway car or placed in a precooler.

In many cases the above procedure has been varied somewhat by the adoption of the "Brogdex" process; this consists of 2 parts: (I) the Borax or Brogdite treatment effected in a somewhat different manner from the method previously described; and (2) the paraffin or Brogdex treatment, whereby the fruit is given an exceedingly thin coat of melted or dissolved paraffin wax. It is claimed that this restores the natural oil removed during the wash and borax operations, prevents

evaporation, and that it is sufficient to slow down the rate of respiration of the fruit but not sufficient to close the pores entirely. It also affords protection to any cuts on the skin of the Orange.

More fully the procedure is as follows :

(I) The fruit is first passed through a soaking tank containing a 4 per cent solution of borax. No boric acid is used. The temperature is maintained at about II5 degrees F. The fruit is completely immersed by a series of slowly revolving paddles as described previously, and the time of soaking is about 3½ minutes. (2) The fruit is then passed to the washer, where it is brushed in another borax solution of the same strength, to which soap powder is added when necessary. (3) The fruit passes through the drier.

(4) The fruit passes under a thin spray or mist of paraffin wax supplied from a small electrically heated tank. A series of revolving brushes removes excess of paraffin so that a thin invisible coating, only, remains.

(5) The fruit is carried by time-killing, elevators in order that the fruit may dry, to the grading table, after which the operations are as previously described.

Colouring by Ethylene: the use of ethylene is standard practice in all American citrus packing houses for oranges received too green for ordinary packing and for colouring lemons quickly when the market is favourable. The managers of the houses, however, are not enthusiastic over the process and only use it when it is really necessary. They state that the fruit is softened by the treatment.

Other exporting countries have copied Californian methods and have little to add to that outlined above.

In regard to the Brodex treatment, this is receiving fairly extensive use in California and many overseas packing houses and is used for all citrus exported by the Jamaica Citrus Producers' Association, who claim (private

communication) that it assists the keeping qualities and assures against shrinkage of the fruit during transit. The machinery for such a process is expensive in the initial cost and on the output of most New Zealand organisations would represent a heavy overhead charge.

The Brodex Company intimate (27:I928) that they are willing to execute a license contract for the use of their process and equipment on a royalty basis; the licensee to pay a royalty or license fee of 5½ cents per box, for each U.S. standard box packed or its equivalent.

The U.S. Standard box for oranges and lemons contains 72 pounds of fruit and the royalty could be figured on that basis, if the size of cases used and the weight of their contents differ from the U.S. standard.

The licensee would be required to pay the cost of construction, crating, freight, insurance and duty f.o.b. point of shipment, as well as the salary and expenses of a representative of the company who would go to your country and take charge of the installation and familiarize the licensee's employees with the machinery and methods of installation.

Our smallest type of machine is that which we instal in packing houses, having the capacity of 2 car loads of approximately 925 boxes per day (approximately I600 bushels) and the cost of that equipment crated but not including freight, insurance, consular charges or duty, would be approximately 4,650 dollars (approximately £I200). The additional equipment necessary to complete such a standard packing house unit would cost approximately 2875 dollars (approximately £730). While prices may have fallen somewhat since I928, it appears that including insurance and all other charges, the total landed cost of the smaller size unit available

would not be less than £2,000. Such a unit, however, would be capable of processing the whole of the present New Zealand output of sweet oranges and grape fruit in under a month. It becomes extremely questionable, therefore, whether present types of equipment available can be adapted to meet the small output of citrus in New Zealand, without undly increasing marketing costs, and serves to stress the point that if New Zealand is to meet overseas competition on an equal basis on the local market, attention must be paid to the development of central co-operative packing and processing plants. This would facilitate the time when it may be feasible to introduce up-to-date methods of processing, and is a further argument for the localisation of the industry, at a point where conditions are at an optimum.

E. SUGGESTED IMPROVEMENTS.

(I) All fruit should be cut, and not pulled from the tree;

(2) Gloves should be used wherever the fruit is handled, whether in picking grading or packing.

(3) In the case of lemons, greater attention should be paid to picking the fruit at the most desirable size for the retail trade, and by judicious management an effort should be made to have all fruit come to the desired size, either green or silver (not tree ripe or coloured).

(4) Sweet oranges and grape fruit marketed for dessert purposes should not be picked until they are well mature.

(5) Standardised grading and marketing is essential to secure the confidence of the buying public.

(6) Every effort should be made to remove from the Auction Rooms poorly graded, low quality fruit; it frequently spoils the sale of superior lines and causes dissatisfactionamong purchasers.

(7) The packing and processing of citrus fruits should, wherever possible, be entrusted to a central depot, preferably co-operative in ownership. Where two or more such organisations may be catering for one district, they should, if possible, be amalgamated since it is only by large scale operations that the most up-to-date labour saving machinery can be efficiently utilised.

(8) From overseas experience it would appear that the Brodex process should be investigated and, as soon as output warrants, should be adopted for all fruit being sent to southern markets.

CHAPTER XXII. SELLING.

A. Sale by Auction.
B. Direct trade. (I) To retailers.
(II) To consumder.
C. Organised selling. (I) California Fruit Growers' Exchange (II) N.Z. Fruit Federation (a) Objects
(b) Dominion Marketing Scheme.
(III) Benefits of Cooperative Marketing.

There are three main channels through which fruit are sold subsequent to packing and preparing for market:

(I) Through the fruit and produce Auctioneers.

(2) By direct trade to fruiterers, grocers, chain stores etc.

(3) By orders from private individuals - usually case lots.

It is not possible to give definite figures regarding the proportions sold by each method but the Auction trade undoubtedly markets the largest proportion of the fruit sold.

## A. SALE BY AUCTION.

The biggest single factor that has caused growers and shippers to sell fruit at auctions, is the concentration of buying power of an entire market at one time upon a single commodity, so that through competitive bidding the price level is raised to the highest point possible at which the buyers believe the commodity will move. Prices are known to everybody, which not only establishes a definite market in the whole surrounding trade territory, but likewise establishes confidence and encourages the trade to buy.

At Auction the highest price is always paid for the best fruit, and brands of good fruit that are sold in a market regularly command a premium over unknown brands, though unfortunately the presence of large quantities of poorly graded, badly sized fruit frequently has a depressing effect on the selling price obtained for the better lines. The auction is a short cut in a large congested market permitting quick and economical distribution of large quantities of perishables, daily with a minimum of turnover by

middle-men and a minimum of handling. The fruit could be sold by the private sale method in these big markets but it costs more money because it requires more salesmen and more handling. It takes more time, and most important, it is impossible to concentrate buying power.

One of the chief weaknesses of the auction system in vogue in New Zealand is the duplicating of facilities in the establishment of numerous small auctions in every centre. This to some extent nullifies the concentration of buying power; increases handling charges and lowers the efficiency of the operating units. A reduction in numbers of Auctioneers, even in the larger centres, would probably result in lower costs of handling and higher prices.

## B. DIRECT TRADE.

### (I) To Retailers.

A considerable amount of fruit is disposed of by the packing organisations and by private gorwers in a direct trade to fruiterers, growers, chain stores, etc. in the smaller centres. These are usually in small lots and the extent of the practice may be gauged by the fact that the Tauranga Association supplied fruit on direct order to 49 stations throughout the North Island during the last 3 monthly period of I934.

A considerable trade is also done in the larger centres in single case orders direct to the smaller fruiters. While this method is expensive from the point of view of correspondence charges, it eleiminates the charges associated with the auction method and is probably a more stable market so far as price is concerned, though price is largely governed by the ruling rate for similar lines sold at auction.

(II) To consumer.

The direct trade to private individuals whereby the consumer makes direct contact with the grower, has been considerably developed during the last few years, principally owing to the flat rate charges of the Railway Depsrtment on single case lots of fresh New Zealand grown fruit being sent for domestic use only. This trade is of considerable benefit to both parties, since it results in the consumer obtaining fruit at a much lower price level and eliminates the middle-man's profit.

Citrus fruit are not perishable in the ordinary sense and can generally be safely held for a period up to one month without serious loss from decay. They are, therefore, unusually suitable for the development of this type of trade, since the average family can quite well consume one bushel during the period of a month.

C. ORGANISED SELLING.

(I) California Fruit Growers' Exchange.

In California the sale of citrus fruits has beenundertaken by a Growers' Co-operative organisation, known as the California Fruit Growers' Exchange. The influence of this organisation on the citrus industry of America can scarcely be over-estimated. "The production has been increased from a 3 million case crop to one of 24 million and yet this crop is distributed and sold in an orderly and satisfactory way, at a selling cost far below that ordinarily obtaining. The Exchange has organised and developed the industry; it has standardised the packs and made the "Sunkist" brand famous. It has advertised citrus fruits and greatly increased the average consumption. By united effort it has lowered the freight

rates and the cost of growers supplies. It has followed and guided the agriculture legislation of the State along safe and helpful lines. It has fostered agricultural research and is responsible for the development of a scientific knowledge of the industry. It is a great and powerful force behind every good movement and ensures stability and confidence in the industry. In no other way could these things have been achieved than through co-operative organisation". (42:I925).

(II) N.Z. Fruit Federation.

(a) Objects.

If the citrus industry in New Zealand is to develop along sound lines, some similar organisation must be built up inthis country and an approach to a similar type of organisation is already in existence in the New Zealand Fruit Growers' Federation Ltd., which is incorporated under the Industrial and Provident Societies Act, I908, and its Amendments.

The objects of the Federation are stated as follows: (a) To engage in any business dealing with the fruit industry or in any enterprise calculated to advertise, extend or otherwise advance the interests of those it represents; (b) To act in any capacity for the Fruit Control Board, set up under the Fruit Control Act, I924; (c) To edit any literature relating to fruit or fruit diseases; (d) To carry on any business as merchants buy and sell anything that may be of use to fruit growers; (e) To promote, foster and protect the fruit industry throughout the Dominion and to establish a closer bond of unity and co-operation amongst all those engaged in the production of any kind of fruit; (f) The Federation (as representing the fruit growers of the Dominion) receives as revenue, the amount collected yearly as orchard tax under the Orchard Tax Act, I9I6.

(b) "Dominion Mark" Scheme.

As one section of its activities, the Federation has attempted to unify and standardise the marketing of all kind of fruit on the local market by the inauguration of a "Dominion Mark" scheme, i.e. a registered brand owned by the Federation, which may be affixed by members to fruit of "extra fancy" and "fancy" grades, complying with the standards set up by the Federation. Grades of fruit lower than "extra fancy" or "fancy" may not be sold under the "Dominion Mark" brand but are handled by the Federation under the packer's own brand. Every line bearing the "Dominion Mark" is inspected by the agent of the Federation in the town where the sale takes place and they are assisted in this by the officers of the Department of Agriculture. To cover the cost of marketing the Federation charge the sum of 2½ per cent commission, in addition to a charge for the label of ½d. cost, and Id. advertising levy.

The Federation does not attempt in any way to replace the fruit auctions, but aims at regulating the amounts arriving at each market, in accordance with the demand, and hope by a standardisation of packs and increased uniformity of grading to build up a demand for a better quality article at a more uniform price. The response to date has been excellent. During I934 the Federation handled approximately 23,500 cases of lemons and 5,000 cases of New Zealand Grape Fruit.

In view of the fact that the "Dominion Mark" scheme has been in operation only for a very short period, this must be considered as a highly satisfactory beginning.

The addition of Government Regulations respecting grading of citrus fruit will greatly facilitate the adoption of the "Dominion Mark" scheme. The organisation

deserves wider support and should be handling the whole of the citrus fruit shipped south of Auckland Province.

(III) Benefits of Cooperative Marketing.

Freight rates and general marketing costs are so heavy that the individual shipper cannot afford the risk of receiving low prices for fruit shipped to southern markets, and it is only by the wide spread support of some organisation, such as the Federation, to whom is entrusted the distribution of all fruit shipped, that gluts may be avoided.

Also, by united action, the growers place themselves in a position to secure better treatment in respect of freights, auction charges, etc. The individual grower acting alone is powerless to exercise any control over the sale of his product or better his market conditions. He is helpless in the hands of carriers, distributors and dealers and must take what they hand out to him whether it is satisfactory or not. Concerted action and unified co-operative effort is essential to any improvement in the marketing of citrus in the Dominion. Such an organisation is also in a position to collect marketing information in respect of the demands of particular markets with preferences for particular sizes, or for supplies at particular times of the year: - a service that is entirely beyond the scope of the private individual or the small organisation.

Practically no information is available at the present time in regard to the consumption of citrus fruits in the various markets, or the potential demand should prices be lowered to a more reasonable level from the point of view of the consumer. Such information is basic to the development of a stable market for an increasing supply of citrus fruits.