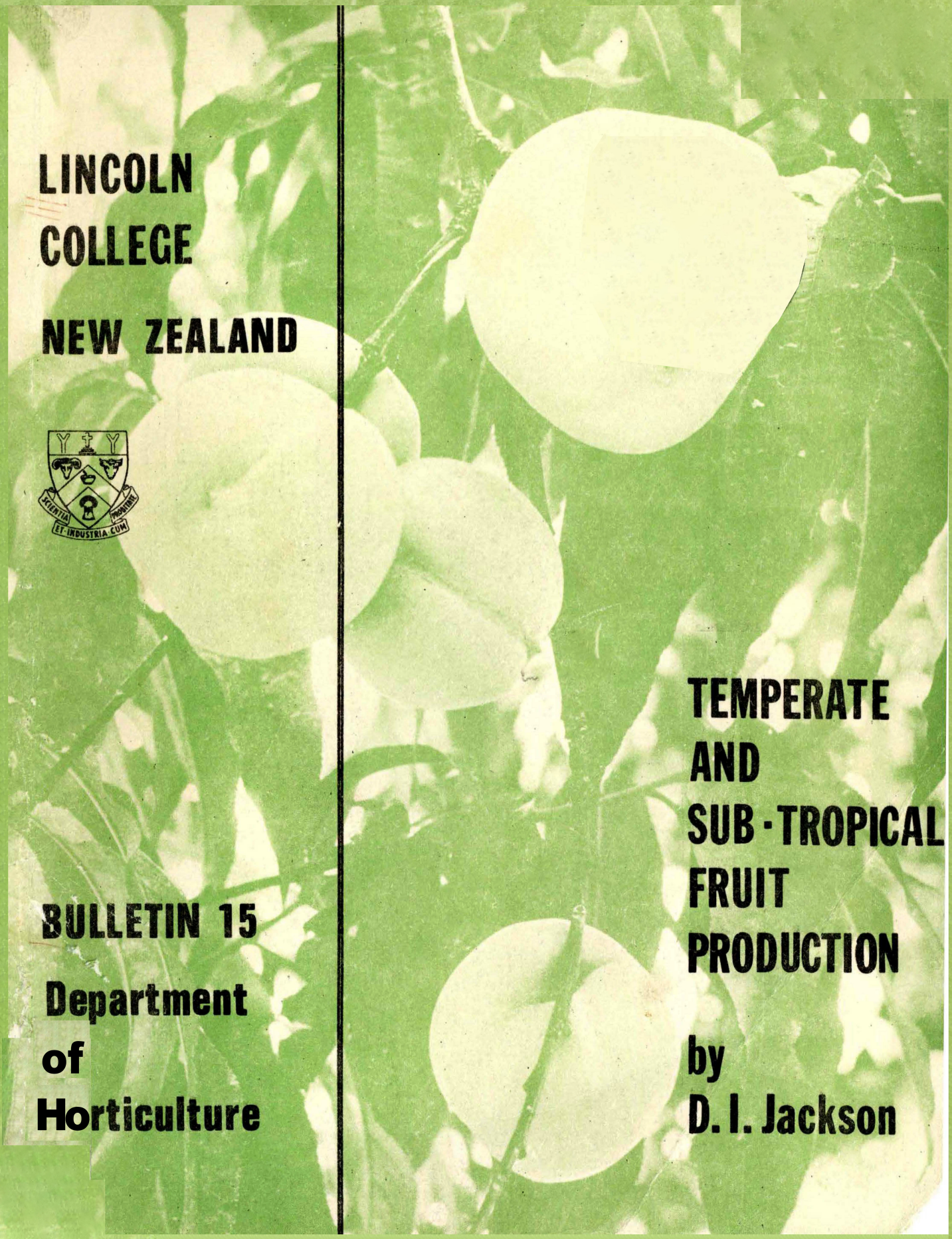


LINCOLN
COLLEGE
NEW ZEALAND

TEMPERATE AND SUB-TROPICAL FRUIT PRODUCTION

BULLETIN 15

Department of Horticulture

by
D. I. Jackson

Temperate and Subtropical Fruit Production

By Dr. D. I. Jackson
Reader in Horticulture
Lincoln College
New Zealand

Department of Horticulture
Bulletin No. 15,1974

FOREWORD

This book is not a complete guide to fruitgrowing. It is written for horticultural students at Lincoln College and would normally be supplemented by lectures.

D. I. Jackson.

Part 1

Background To Fruitgrowing

1

World Fruit Distribution

TABLES 1 and 2 give an idea of the importance of different fruit crops on the world scene relative to each other and to several non-fruit crops, i.e. cereals, sugar cane, sugar beet, and potatoes. You will also be able to gain an overall picture of the distribution of each fruit crop in different parts of the world. This will be further elaborated when you come to deal with individual fruits later in these notes where you will be able to compare N.Z.'s production with that of other countries.

Do not attempt to learn these figures but try to retain an overall picture of fruit distribution so that if called upon you could intelligently discuss world fruit distribution.

Table 3 shows the relative importance of different fruits in New Zealand. The temperate climate in most of the country favours the production of those fruits commonly grown in equivalent temperate areas of Europe and North America. Do not learn all the figures but a few facts from the table will help you to discuss fruit production and distribution intelligently.

TABLE 1. World Distribution of Fruit in Relation to Other Economic Crops

Crop	Yield in 1,000,000 tonnes (1970/71)
Cereals	1309
Sugar cane	585) 813
Sugar beet	228)
Potatoes	306
Grapes (wine and dessert)	54.8
Citrus	37.3
Bananas	28.2
Apples	20.0
Pears	7.4
Peaches	5.3
Plums and Prunes	4.8
Pineapples	3.8
Dates	1.9
Figs	1.3
Cherries	1.7
Apricots	1.2

Reference: F. A. O. Production Yearbook Vol. 25 1971

TABLE 2. Distribution of World Economic Fruit Crops in 1970/71

Figures are yield in 1000 tonnes

Crop	Europe	North America	Latin America	Near East	Far East	Africa	Aust., NZ Samoa etc
Total Grapes (wine and dessert)	35,273	2,896	4.047	5,277	303	2,171	775
Oranges and Mandarins	4,615	7,841	7,276	2,535	4,472	2,696	280
Grapefruit	13	2,266	287	357	72	123	15
Lemons, Limes and Others	1,006	765	725	421	606	103	29
Bananas	362	4	17,862	193	7,530	1,930	153
Apples	12,533	3,169	800	899	1,285	288	580
Pears	4,509	709	219	231	555	103	173
Peaches	2,442	1,474	550	163	361	186	145
Plums and Prunes	3,700	616	174	145	110	39	30
Pineapples	2	831	1,090	–	1,401	438	122
Dates	17	16	9	1,407	150	279	–
Figs	737	46	46	297	2	126	1
Cherries	1,377	233	7	104	13	–	9
Apricots	640	164	31	180	–	107	55

Reference: F. A. O. Production Yearbook 1971 (Vol. 25)

TABLE 3: **Production of Major Fruit Crops in New Zealand (1972)**

Crop	Trees or Vines (in thousands)	% Change 1968-72	Production in thousand tonnes	% Change 1968-72
Apples	2,005	+37	149.8	+32
Pears	192	0	18.5	- 5
Peaches	450	+10	22.4	+ 1
Apricots	208	+31	7.2	+47
Plums	130	+15	4.3	+50
Nectarines	88	+115	1.9	+46
Cherries	38	+65	0.5	+ 8
Oranges	222	+56	2.1	+100
Grapefruit	156	+246	4.6	+38
Lemons	60	+76	8.8	+56
Mandarins	125	+86	0.9	+72
Tangelos	119	+153	1.2	+392
Tamarillos	330	+100	2.3	+41
Chinese Gooseberries	273	+507	2.8	+53
Passionfruit	26	+53	0.3	+55
Area (Ha)				
Strawberries	196	+ 4	3.7	+ 3
Raspberries	312	+49	1.6	+42
Boysenberries	119	+145	0.7	+156
Blackcurrants	81	+93	0.3	+39
Gooseberries	21	-18	0.1	- 3
	litres ($x10^6$)	increase 1967-1970		
Wine	18.9	+85		

2

Factors Affecting Distribution of Fruits

A. TEMPERATURE

Probably the most important single variable determining the distribution of crops, its importance however, varies with the crop; thus apples will grow in a wide range of temperatures while dates will survive only in areas with sufficient heat.

Temperature is determined by:—

(a) Latitude
(b) Altitude
(c) Proximity to water
(d) Unusual geographic factors

Thus in Africa, Queensland and Central Asia temperate tree fruits are grown in inland areas at moderately high altitude, while areas closer to sea level produce tropical crops. In Norway apples are grown close to the Arctic Circle because the warm Gulf Stream moderates the temperature.

A most important aspect of temperature in determining fruit distribution is frost. Many plants will not tolerate frosts at all, and most tropical fruits fall into this category: others, the majority, can withstand frosts at certain periods but not at others. Temperate tree fruits will tolerate frosts during the dormant period but once the buds begin to grow frosts can be damaging. Except in very severe climates, frosts will not harm these trees during the dormant period. Frost control will be considered in greater detail in a later lecture.

Sometimes plants may have an actual *cold* requirement. This takes three forms:—

(a) *Breaking of Dormancy*: The buds on most deciduous fruit trees need a certain amount of time exposed to low temperatures before they will form flowers or leaves in the spring. If this is not forthcoming buds open very unevenly and some do not open at all and eventually drop. Genera, species, and even varieties vary in their cool temperature requirements. Dormancy will form part of a later lecture.

(b) *Vernalisation*: This is the cold requirement needed before plants are able to *form* flowers. More important in cereals, brassicas, and some bulbs than fruit crops.

(c) *Thermoperiodism*: This can be a requirement for a seasonal variation in temperature, as in deciduous tree fruits, or daily fluctuations, as in tomato, potato and maize. Without this variation the plants will not flower. For best growth and fruit set of tomatoes daily temperatures should be 26°C (79°F) and night temperatures 15-18°C (59-64°F). The cold period is only effective in darkness or greatly reduced light.

B. WATER

Although certain horticultural plants such as date and olive will produce crops in arid climates, most require an adequate level of moisture. Nevertheless excessive water may produce waterlogging which can be just as serious as water shortage. Crop distribution is therefore dependent upon either a reliable rainfall or acess to irrigation.

C. HUMIDITY

This is important in horticultural plants, not so much for its direct effect on the crop but for its effect on fungal diseases. With modern sprays many fruits can be grown in humid areas where once a high incidence of disease would have prohibited them.

D. LIGHT

Some crops, for example grapes, seem to produce highest yields in areas of highest summer radiation, but, generally, adequate light is available for most crops grown outdoors. There is probably a very close relationship between light and temperature; when man tries to control the environment by erecting glasshouse, etc., it is often lack of light which causes problems rather than low temperatures. High temperatures generally promote vegetative growth but, if there is insufficient light to provide adequate photosynthates, this growth is long and thin and leaves tend to be small and light green. These conditions seldom favour reproductive growth.

Can you think of any other crops whose distribution might be dependent upon light intensity?

E. WIND AND HAIL

Wind and hail can do considerable damage to any fruit crop and can affect their distribution. Shelter belts can be useful in the initial stages of establishing an orchard, although once trees are full grown they may shelter each other and the shelter belt may be redundant. There is no practical way to combat hail and areas subject to either strong winds or frequent hail storms are generally avoided for fruit growing.

F. SOIL

All fruits do best on fertile, deep and well-drained soils but different fruits vary in their ability to grow in less-favourable conditions. Man can greatly alter soil pH and soil fertility—he can even improve drainage and destroy or break up hard pans, however these latter are expensive and not generally practical.

After the lectures on individual fruits you should consider the following question, "How important is the soil in determining the distribution of the various types of fruit grown in New Zealand?"

G. TOPOGRAPHY

This can affect fruit distribution in the following ways:

1. Cultivation and other mechanical operations may be impractical or impossible on steep slopes; thus, with the trend for the use of machinery and higher standards of living, much land which was cultivated by peasant labour may go out of production or be used for other crops.
2. Temperature effects: sloping land may have the advantage that it is frost-free.
3. Soil erosion: land cannot normally be cultivated if it is subject to erosion.
4. Drainage: a problem of low-lying areas.
5. Exposure to wind.

H. PESTS AND DISEASES

These can often prohibit the growing of fruits in many areas. Modern sprays reduce the problem but where there is no known control (silver leaf) or the cost of spraying is too great, they still can modify distribution.

I. ECONOMIC FACTORS

Fruits tend to require more capital for their establishment than other agricultural and horticultural crops. This is because (a) the crop may be perishable and proximity to market is required—this means expensive land, (b) trees themselves are quite expensive, (c) there is generally a long delay between planting and economic return which means the grower has to have other means of support, (d) equipment is expensive (sprayers, etc.) fertilisers, sprays and labour need to be provided even before the trees yield crops.

J. PROXIMITY TO PROCESSING INDUSTRIES

Sometimes these industries are established to service already-established orchards but once present they often stimulate further planting.

K. AVAILABILITY OF LABOUR

This has been partly considered under 'Economic Factors'. Although mechanisation has reduced this problem in some ways, it also provides problems of its own. Thus nowadays one or two men can run an orchard of 10-20 acres for most of the year except at harvest time. This means there has to be an itinerant work force available for just 3-4 months of the year. Previously the orchardist could have guaranteed all-year-round work for a larger work force who could then have handled a great proportion of the harvesting load.

L. CUSTOM

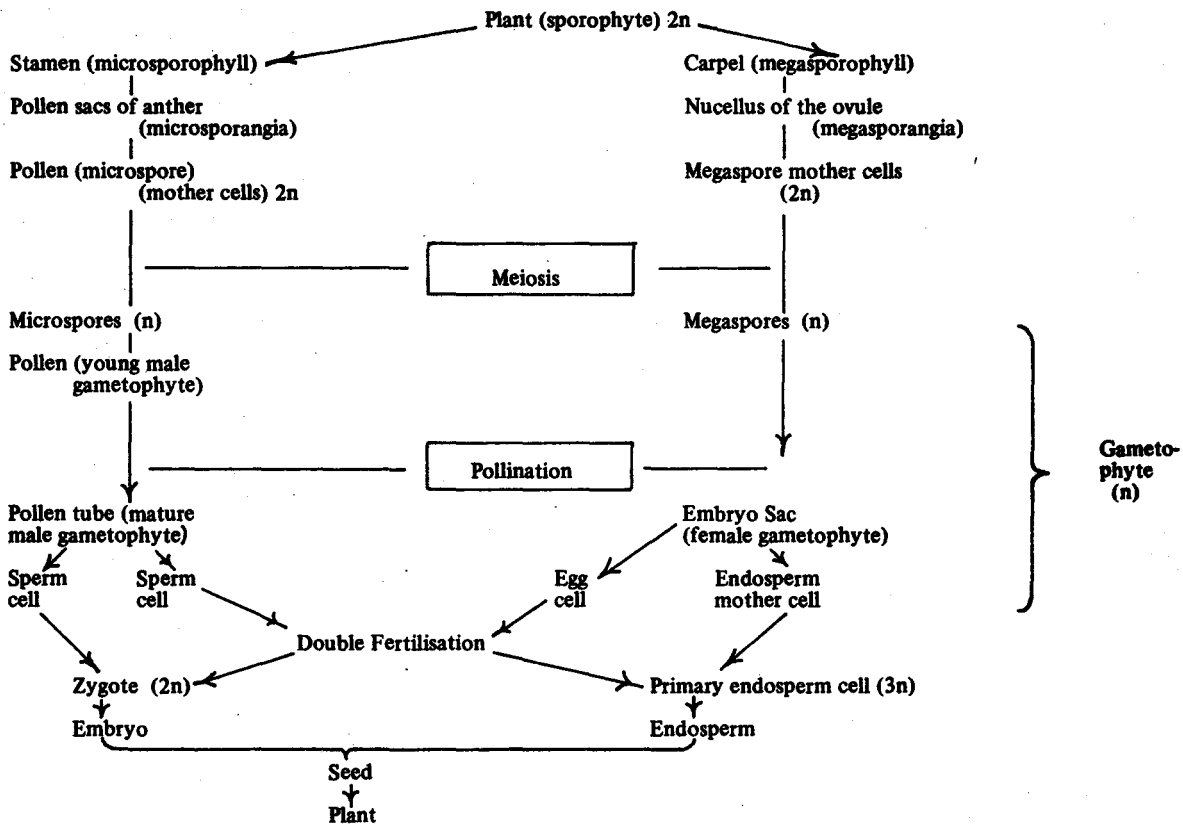
Give examples where fruits are grown in areas where the conditions are poor and the land might be more profitably used for other crops.

3

Morphogenesis of Flowers

BEFORE THIS LECTURE you should return to your Botany lecture notes and refresh your memory about the basic differences between reproduction in Angiosperms and other plants. What features have the Angiospermae developed to differentiate them from more primitive plants?

A. THE LIFE HISTORY OF AN ANGIOSPERM



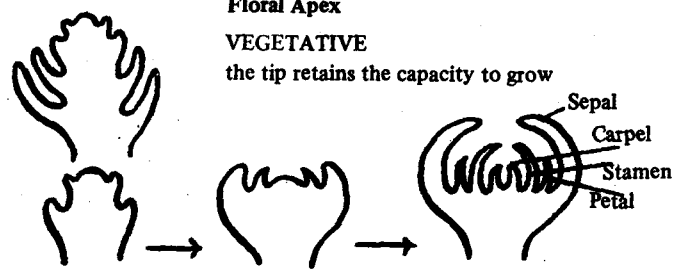
B. WHAT IS A FLOWER?

A flower is a stem or branch, bearing leaves which are specially adapted to carry on reproduction.

This stem differs from the normal stem or branch as follows:—

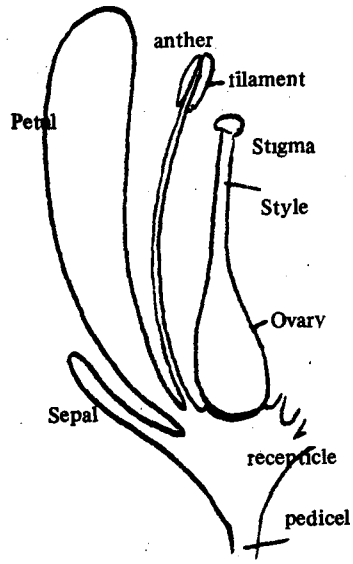
1. The promeristem of this branch does not continue to grow but is entirely converted to the formation of floral tissue.
2. The floral leaves are bunched together, not separated by long internodes.
3. There are normally no buds on the axils of floral leaves.
4. Some floral leaves are modified to produce pollen, others bear the ovules.

Difference Between a Vegetative Apex and Floral Apex



Carpels are the floral leaves which give rise to the ovaries.

C. STRUCTURE OF A FLOWER



Note:
The sepals are collectively known as the *calyx* and the petals as the *corolla.* Calyx and corolla together make up the *perianth.*
A group of flowers is an *inflorescence.*

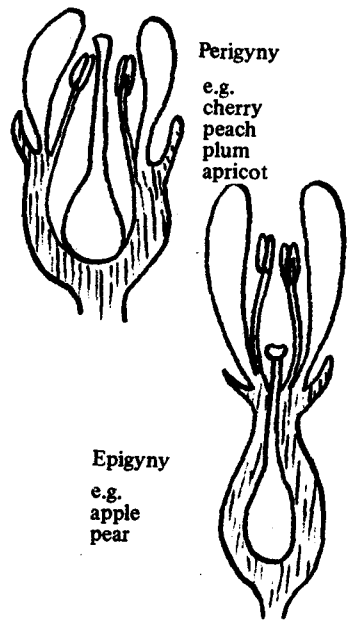
The stalk of a flower is called a *peduncle* if the flower is single; the stems of flowers of an inflorescence are called *pedicels* while the stalk of the inflorescence is a *penduncle.*

D. TYPES OF FLOWERS

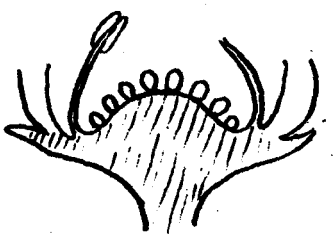
Flowers vary tremendously in their structure and this fact is used a great deal in plant classification. Modification of flower parts is generally considered to be a sign of a plant higher in the evolutionary scale. It is not essential to this course to be familiar with all types of flowers and their use in classification, but certain divisions should be known and understood.

Some divisions and types of flower:—

1. A flower having a full complement of flower parts is called a *complete* flower (give some examples).
   A flower lacking various parts is termed *incomplete.*
   Examples of incomplete flowers:—
   (a) Flowers without perianth. This is characteristic of the monocotyledons where sepals and petals are modified to scales and hairs.
   (b) Flowers lacking pistils or stamens. These flowers are termed *imperfect* to distinguish them from *perfect* or hermaphrodite flowers. Some plants may have pistillate and stamenate flowers on the same plant, e.g. maize, cucumber, pumpkin. Others have them on different plants, e.g. hop, asparagus, papaya, gooseberry.
2. Hypogyny, perigyny and epigyny.
   Hypogyny—see diagram under IIIC, e.g. Tomato.



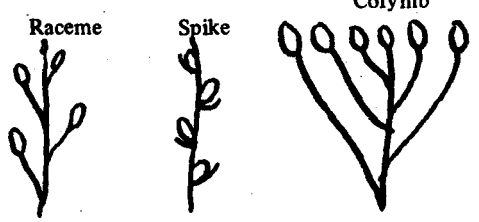
3. Flowers with unattached carpels. Normally flowers with several carpels have these united to form composite pistils (see below) In strawberry, raspberry and blackberry there are many carpels in the flower but these are not attached to each other.



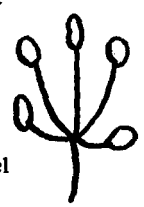
4. Composite flowers. These are flower heads which give the appearance of a single flower. Examples are all the *Compositae* including daisies, dandelion, globe artichoke. The so-called petals of daisies are in fact leaf bracts.

E. TYPES OF INFLORESENCES

Flowers born other than singly form part of an infloresence.



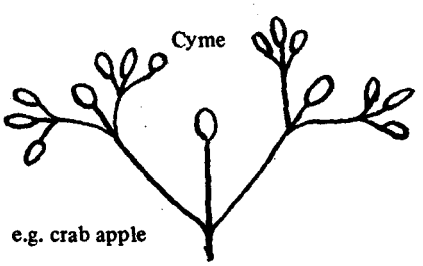
e.g. black currant plantains e.g. cherry



Umbel

Head

e.g. onion e.g. daisy



Cyme

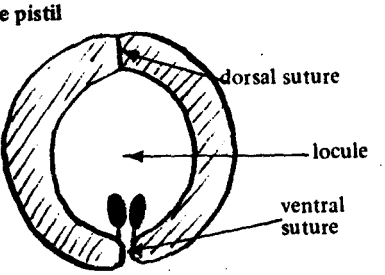
e.g. crab apple

F. THE FORMATION OF OVARIES

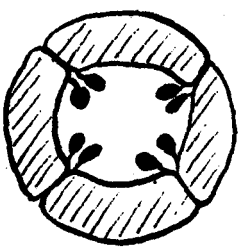
A pistil formed by a single carpel is called a *simple pistil,* e.g. strawberry, stone fruits, avocado, legumes.

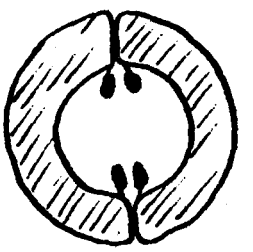
When a number of carpels combine to form a single pistil it is called a *compound pistil,* e.g. apple, pear.

Simple pistil



Some types of compound pistil:





Parietal, e.g. Gooseberry, currant

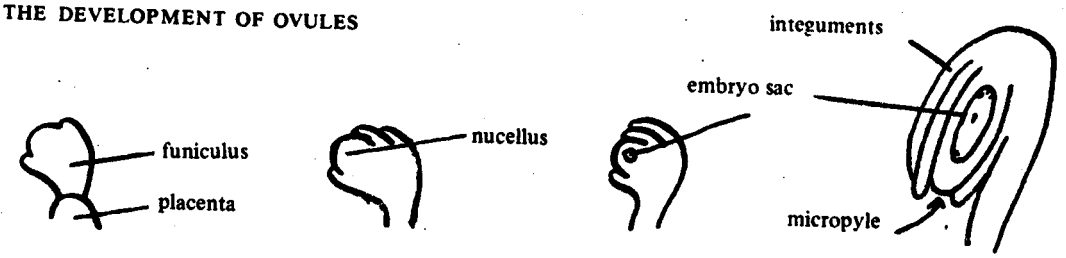
Axile
e.g. Citrus

Free central placentation

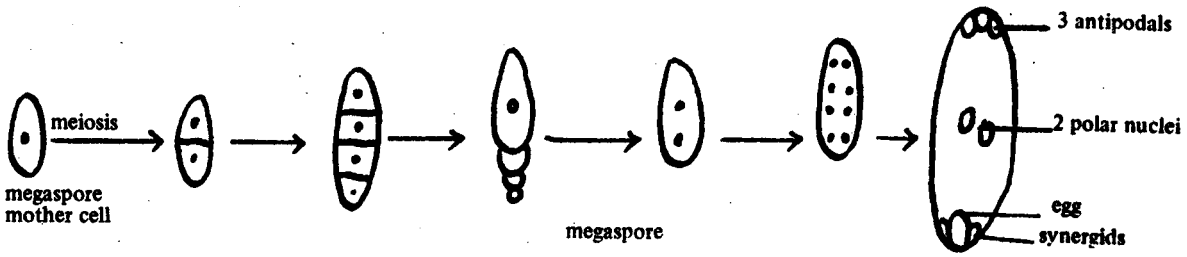
The *dorsal suture* corresponds to the midrib of the leaf; the *ventral suture* is formed by the juxtaposition of the leaf edges. In the developing leaf the leaf edges contain meristematic tissue and in the carpel this tissue gives rise to the ovules.

The *placenta* is the tissue which connects the ovule with the ovary walls. Generally the numbers of placenta correspond with the number of carpels, but each placenta may contain many ovules, so that there may be no relationship between the number of carpels and the number of ovules.

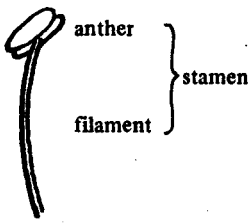
G. THE DEVELOPMENT OF OVULES

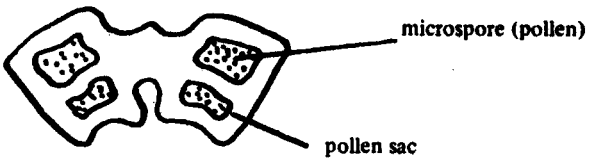


megaspore mother cell develops from one cell in the nucellus

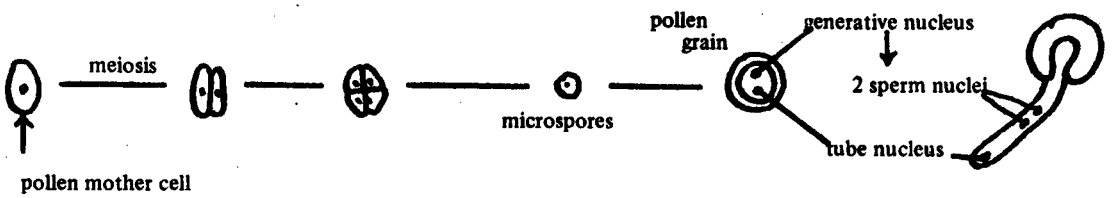


H. THE DEVELOPMENT OF THE STAMEN AND FORMATION OF POLLEN GRAINS





T. S. of anther



4

Pollination and Fertilization

A. POLLINATION

When pollen is mature anthers open and pollen grains escape. There are two main methods whereby the pollen reaches the stigma.

(a) Wind pollination. Occurs in plants with inconspicuous flowers such as grasses. Pollen production is generally profuse and stigmas may be much branched to catch pollen. Also occurs in walnut, mulberry and partly in grape and strawberry.

(b) Insect pollination. In insect-pollinated plants the pollen does not fall from the opened anthers but sticks to the outside of the shrunken anthers till it is transferred to stigma by insects (especially bees). Except in the case of certain nuts insects are necessary for the pollination of most orchard trees. Plants which are insect pollinated are often showy; in addition secretions of nectar by the nectaries, which are generally situated on the receptacle at the base of the petals, serve to attract bees and other insects.

There are two types of pollination:—

(a) Self-pollination. The pollen fertilises the ovules in the ovaries of the same flower or same plant.

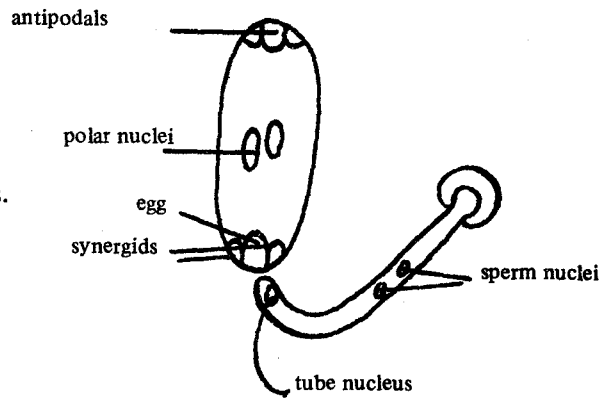
(b) Cross-pollination. The pollen fertilises the ovules of another plant.

If, as in many horticultural crops, different plants come from the same source via vegetative reproduction—e.g. budding, grafting, dividing roots or using cuttings—then pollination between different plants is not strictly cross-pollination. For true cross-pollination the plants must not have an identical set of genes.

Sometimes pollen will not fertilise the ovaries of the same plant under *any* conditions, and these plants are said to be self-sterile. Other times the plant is self compatible but imposes various conditions which make self-pollination almost impossible. For example, the anthers may shed their pollen before the stigmas are receptive or the stigmas mature before the pollen is released, staminate and pistillate flowers may be borne on different plants, etc.

Pollen may be retained on the stigmas by a sticky secretion called the stigmatic fluid or, as in many wind-pollinated plants, the pollen grains may become trapped in short outgrowth of a much-branched stigma. In that position the pollen grains germinate and the pollen tube grows down the style and penetrates the embryo sac via the micropyle and the nucellus.

B. FERTILISATION



The pollen tube enters the embryo sac and releases the two sperm nuclei and the tube nucleus. One of the sperm nuclei unites with the egg cell to form a zygote (2n), this is the act of fertilisation. The second sperm nucei moves to the centre of the sac where it unites with the 2 polar nuclei to form the endosperm, antipodals and synergids seem to play no further role and disintegrate.

The zygote soon becomes surrounded by a cell wall and begins division to form the embryo.

The endosperm nucleus also undergoes division but this is not attended by the formation of cell walls. The embryo sac then becomes a group of cells, the embryo, surrounded by cytoplasm containing numerous 3n endosperm nucei. Later there is an almost simultaneous formation of cell walls between the endosperm nuclei to form the "cellular endosperm".

C. ABNORMALITIES IN SEED AND FRUIT PRODUCTION

1. *Apomixis* = a-sexual *seed* formation, i.e. reproduction without fertilisation. This may be of 3 types:
   (a) Parthenogenesis: in which the unfertilised egg grows into an embryo, e.g. *Datura*, tobacco, dandelion, onion.
   (b) Apogamy: other parts of the embryo sac may grow into an embryo without fertilisation, e.g. antipodals (onion), polar nuclei (*Heliosis*), synergids (onion).
   (c) Apospory: parts outside of the embryo sac may grow into an embryo, e.g. nucellus and integument. Nucellar embryos are common in Citrus (where up to 12 extra embryo may be produced in one seed in addition to the normal sexual embryo), Indian apple (*Malus sikinensis*) and other plants.
2. *Parthenocarpy* = fruit formation without fertilisation of the seed. This may be of 2 types:
   (a) Stimulative (or aitionomic), pollination but not fertilisation, is needed for the fruit to grow, e.g. W.B.C. pears, currant-grapes.
   (b) Vegetative (or autonomic): no pollination is needed, e.g. banana, persimmons, Sneed peach, Washington navel orange.
3. *Stenospermocarpy* = *fruit* formation in response to abortive seed growth. Fertilisation is needed and seed growth begins but it subsequently stops due to some irregularity in its development, e.g. sultana grape, and many of the "seedless" grapes which set among normally seeded grapes.

5

Fruit Set in Deciduous Tree Fruits

THE STAGE when the flower is fully open, the stigma is ready to receive the pollen, and the pollen is released, is called "full-bloom" or "anthesis".

In stone fruits full-bloom occurs prior to growth of vegetative shoots, in apple and pear it occurs at the same time as leaf emergence while in grapes, currants and persimmon full bloom occurs some time after leaf emergence.

Anthesis

Pollen is released over a period which varies with the species. Anthesis lasts for 1-2 days in sour cherry, 1-3 days in strawberry, 1-5 days in peach, 1-5 days in apple, 2-7 days in pear and 2-9 days in raspberry.

Stigma receptivity

The stigma is receptive as soon as it becomes covered with the sugary exudate in which the pollen grains can germinate. Stigmas in this condition glisten and remain receptive until they dry and turn brown, the duration of the receptive period depending on variety and climatic factors. In apple and pear not all stigmas in a single flower become receptive at the same time, so that the duration of receptivity is prolonged. In the blackcurrant the stigma becomes receptive before the petals unfold and remains in this condition for about 5 days.

Fruit Set

Fruit set is a somewhat general and vague term, it means the retention of fruit on the tree for a certain inprecise period after full bloom. For example, if an apple tree blossoms in October and there are a large number of small fruits present one month later, one would talk about a "good set". If, however, a lot of fruit dropped in December, one would talk about "heavy drop" ("December drop"—"June drop" in the Northern Hemisphere). The term *set* implies that the flower has been pollinated and fertilised and, in consequence, the ovary and accessory tissues will be capable of growing into a fruit. If fertilisation does not occur the fruit normally drops.

The physiology of set will be considered in greater detail in a subsequent lecture.

A. REASONS FOR POOR FRUIT SET

1. *Lack of pollination*

   Pollination may not occur if pollen is absent or if it is not transferred to the stigma.

   (a) *Absence of pollen.* This may be brought about in several ways, male sterility, dioecious plants, dichogamy and destruction of pollen.

   Male sterility (imperfect stamen development), occurs in several fruit varieties, e.g. J. H. Hale peach, Washington Navel orange, Gravenstein apple, Bristol Cross pears, and certain plum and strawberry varieties.

   Dioecious plants, with male flowers on one plant and female flowers on another, are in effect sterile unless male and female plants are together, e.g. paw paw, asparagus and some strawberry and fig varieties. Monoecious plants, with male and female flowers separate but growing together on one plant, are mostly fruitful, e.g. walnut, pecan, cucurbits and some figs.

   Dichogamy is the maturation of the stigma before or after the stamens are mature (before = protogyny, after = protandry), e.g. plum, walnut, avocado and to some degree some varieties of apple and pear.

All of the foregoing may be regarded as devices to encourage cross-pollination. Unless a source of pollen is provided near enough and at the right time, pollination will not occur.
The failure of anthers to dehisce may be another cause of no pollination; strawberries need temperatures above 12°C for this to happen.

(b) *Lack of pollen transfer*: Even though pollen may be available it still has to be transferred; this can be a frequent cause of poor set. The most common cause of failure is insufficient insect activity (specially of bees) during the flowering period.

2. *Lack of fertilisation*
This may be due to infertility of the pollen or the egg cells, or to failure of the pollen tube to grow to the egg (incompatability).

(a) *Infertile pollen*: Pollination may be achieved but this is no help if the pollen is infertile. The remarks above on male sterility apply here to some extent because many of the varieties mentioned produce small amounts of pollen of low viability. The pollen of triploid varieties is usually of low viability, e.g. Bramley's Seedling, Gravenstein and Belle de Boskoop apple. Seasonal conditions may alter pollen viability markedly. Cold, wet weather can reduce it in apples and grapes. Apple pollen fails to germinate below 4.5°C. Rain can wash pollen grains from the stigma or cause them to burst. Pollen from nitrogen-deficient trees may give poorer set than pollen from high-nitrogen trees.
It seems that stigmas secrete certain substances which reduce the germination of pollen grains of the same variety but which are comparatively inffective against pollen of non-related varieties. By contrast, pollen grains are mutually stimulative; hence the more grains present the better their germination percentage.

(b) *Infertile eggs*: Some fruit varieties are inherently female-sterile, e.g. flowering cherry, Washington Navel orange, Currant grape (note that the last two are nevertheless fruitful because the fruit develops parthenocarpically).
Many varieties show a proportion of female-sterile flowers. In stone fruits up to 20% of all flowers may be found to be lacking pistils. These flowers are often smaller than normal and may come from smaller flower buds.

(c) *Incompatibility* is a common cause of failure to achieve fertilisation despite successful pollination. The pollen tube is incapable of growing down the style due to genetic, and hence biochemical, factors within these two units. Both may be quite fertile as shown by the fact that other pollen or other eggs will combine with them. Usually the pollen tube commences to grow but soon stops after penetrating a short distance into the style. Incompatibility is genetically controlled; pollen cannot function in a style which has the same incompatibility alleles as the pollen itself.
Self incompatibility is the most common form, i.e. between styles and pollen of the same variety. It is shown in nearly all varieties of cherry and almond, many plum varieties, and some apple and pear varieties. Cross pollination is essential, so these varieties must be interplanted with pollinators. Sometimes *cross-incompatibility* occurs in which case the right pollination variety must be selected.
There are many degrees of compatibility. Some apple varieties are partly self-incompatible and hence benefit by being cross pollinated.
Environmental factors may alter the degree of incompatibility. Temperature is very important because of its large effect on the rate of pollen tube growth; given optimum temperatures some "incompatible" pollen tubes may grow fast enough to reach the ovary before the death of the style. In varieties of apples with marked biennial bearing habits, the self-incompatibility is normally greater in the "off" year than in the "on" year.

3. *Seed Abortion*
Even though pollination and fertilisation may have been achieved successfully, young fruits may still fail to set if the seed or

seeds stop growing (except, of course, in parthenocarpic fruits). The growth of the seeds has large effects on the growth of the fruit during set and subsequently. In single-seeded fruits, abortion causes non-setting, but in many-seeded fruits there are gradations in the degree of set depending on the total number of seeds which grow. The induction of parthenocarpy by hormones and the role of seeds in fruit growth will be dealt with at a later date. Frost will cause seed abortion and subsequent fruit drop.

B. EXTERNAL FACTORS INFLUENCING SET

1. *Mineral nutrition*
Nitrogen has been reported to increase fruit set in apples—it seems possible that the closer to blossoming it is applied the better will be the response. Excessive nitrogen application on the other hand may reduce flower-bud initiation (see later). Fruit set can be reduced by faulty nutrition in general.

2. *Pruning, thinning and girdling*
Pruning may or may not improve set depending on the degree and type. It might be expected, on theoretical grounds, that if pruning reduces the number of blossoms in relation to the volume of the tree more food reserves would be available for the remaining blossom which would be healthier and have a better chance of surviving. Thinning of blossoms at or near blossoming is now possible using chemicals and this too should improve the nutrition of the remaining blossoms. Evidence is available to indicate that both practices improve set. However, this may not improve yield, especially if too many blossoms are removed or if the treatment is followed by a severe frost which kills most of the remaining blossom. Girdling or cincturing has been shown to improve set in grapes, especially the seedless variety—Currant. There is less substantial evidence that it improves set of other fruits.

3. *Rootstocks*
Vigorous rootstocks tend to delay blossoming in apples but this is probably chiefly an effect upon flower-bud initiation. It is possible, however, that rootstocks also can affect set. Thus in grapes the stock, Rupestris du Lat, imparts great vigour to the scion but set is poor.

4. *Age and vigour of the plant*
Young trees tend to initiate and set less fruit than older trees.

5. *Locality and season*
Variations in set due to locality or season are common; reasons are not always understood but some of the factors listed below are likely causes.

6. *Temperature*
Temperatures below 0°C (particularly -2°C or less) during bloom kill the pistils. Low temperatures above freezing can interfere with set by reducing bee activity and hence reducing pollination. Bee activity is not at its greatest until temperatures are well above 15°C; at these temperatures they can effect pollination of an orchard in 2 or 3 days. Low temperatures may also reduce set by preventing pollen germination or slowing pollen tube growth. Rome Beauty pollen takes 90 to 120 hours to traverse its own style at ordinary temperatures and hence is self unfruitful. At 32°C, however, this only takes 24 hours and it becomes self-fruitful. Jonathan pollen only takes 48 hours to traverse Rome Beauty styles, hence these are cross-fruitful. High temperatures can sometimes dessicate stigmas.

7. *Light*
The effect of light on set seems to be important on species which flower after leaf formation. Tomatoes in glasshouse for example do not set well under poor light conditions. Low light intensity on individual clusters will reduce set in grapes.

8. *Rain*
Rain during bloom is regarded as a common cause of poor set. Rain may prevent anther dehiscence and wash stigmatic secretions and so reduce set; however it is considered more likely that rain reduces set because of associated weather conditions such as low temperatures, low light, reduced bee activity, etc.

9. *Wind*
Hot dry winds may desiccate the stigmas, or injure flowers directly. Bee activity is greatest when wind speed is less than 2 m.p.h. and decreases gradually with increasing wind speed to nil at 25 m.p.h.

or more. These effects have been well demonstrated by wind-breaks.
For wind-pollinated plants, such as walnuts, some wind is an advantage.

10. *Insects*
The most noteworthy insects which affect set (apart from bees) are thrips. Thrips consume pollen, destroy anthers and stigmas and can cause heavy losses in apples. Conditions favouring thrips build up are unfavourable for best flowering and fruit setting. Thrips control has been shown to improve set of apples.

11. *Diseases*
Diseases may, by destroying general vigour. reduce set. Are there any diseases which specifically affect set?

12. *Sprays*
Sprays during bloom may affect set indirectly by reducing insect population. It is generally considered unwise to use insecticides during blossoming.
The problem of set will be considered further (a) under the physiological section and (b) under individual fruits.

6

The Fruit and its Development

IN THE BOTANICAL SENSE, a normal fruit is a matured ovary of a flower, including its one or more seeds and any part of the flower which may be closely associated with the matured ovary. This includes so-called grain or "seeds" of corn, oats, and wheat, tomatoes, pods of peas and beans, walnuts and acorns. The seed is the mature ovule.

Generally the growth of the fruit is dependent on the presence of seeds. In grapes, apples, and tomatoes, size of fruits can have a direct relationship to the number of seeds present. The term parthenocarpy is applied to the development of fruit without fertilisation.

The wall of the ovary after it develops into the wall of the fruit is called the pericarp. Three distinct layers are generally present—these are the exocarp on the outside, the mesocarp, and the endocarp on the inside.

A. KINDS OF FRUITS

There are three principal kinds of fruits—simple, aggregate and multiple.

1. *Simple Fruits* consist of a single enlarged ovary with which some other flower parts may be incorporated. These are the most common types of fruits and can be subdivided as follows:—
   (a) Fleshy Fruits (Pericarp fleshy).
   (i) Berry. The ovary wall is fleshy and may consist of one or more carpels and seeds, e.g. grape, pepper, tomato, black currant and date. The outer wall may be hard, as in pumpkin, or leathery, as in orange and lemon.
   (ii) Drupe or stone fruit. Derived from single carpel and single seed. Exocarp is thin, mesocarp is fleshy and endocarp is stony. Examples are cherry, peach, apricot, plum, almond and olive.
   (iii) Pome. Derived from several carpels and epigynous flowers. The receptacle and the outer portion of the pericarp are fleshy and constitute the "flesh" of an apple, the inner portion of the pericarp is papery and constitutes the core. Examples are pear, apple and quince.

   (b) Dry Fruits (Pericarp dry).
   (i) Dehiscent fruits (splitting open when ripe)—this includes several subdivisions but few of these fruits have any importance in this course. Examples are pea, bean, poppy, crucifers.
   (ii) Indehiscent fruits (not splitting open when ripe).
   (a) Achene—one-seeded; seed attached to ovary wall at one point only. Examples are sunflower, buttercup (strawberry is an aggregate achene).
   (b) Caryapsis (grain)—one-seeded; pericarp firmly united to seed all around. Examples are cereals, grasses.
   (c) Nut—a hard, one-seeded fruit, generally produced from a compound ovary. (Almond, botanically, is not a nut, a horsechestnut or Brazil nut consists of seed only.)

2. *Aggregate Fruits.* An aggregate fruit is one composed of a single receptacle upon which are massed similar fruitlets. It is derived from a single flower having many pistils. In blackberry and raspberry the individual fruits of the aggregate are drupes.

In the strawberry the individual fruitlets are achenes.

3. *Multiple Fruits.* A multiple fruit is derived from the ovaries of many separate yet closely clustered flowers, e.g. mulberry, pineapple, fig.

B. THE SEED

1. *The seed coat.* These are derived from the integuments.

2. *The endosperm.* In most plants the endosperm is digested by the developing embryo during growth and is absent at maturity. In such plants the first two leaves, the cotyledons, are often thick and contain most of the stored food reserves needed for growth of the embryo upon germination. In some plants, e.g. cereals, the endosperm remains at seed maturity and acts as a store of food reserves.

3. *The embryo.* This consists of the following parts:
   (a) The plumule—a rudimentary shoot.
   (b) The cotyledons—seed leaves.
   (c) The hypocotyl—the part of the embryo between the attachment of the cotyledons and the upper end of the radicle.
   (d) The radicle—the rudimentary root.

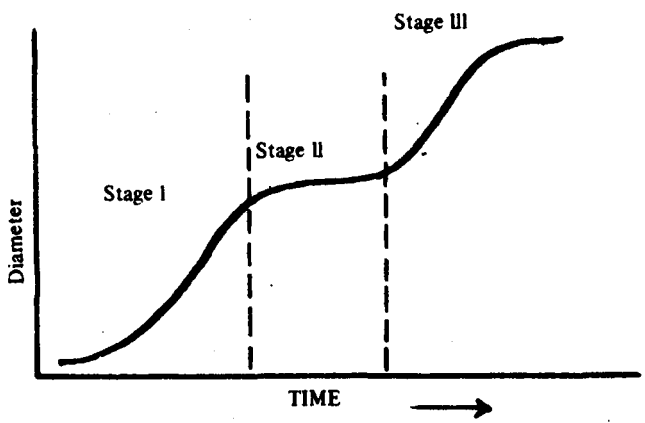
C. FRUIT AND SEED GROWTH

The accompanying diagram shows the various phases in the development of the peach fruit.

The increase in volume associated with fruit growth is the result of cell division or cell enlargement or both. The relative importance of these processes varies from one species to another. Generally cell division predominates in the first few weeks but overlaps the cell enlargement phase which lasts until fruit maturity. Duration of the cell division phase is 2-3 weeks in the apricot, 3-4 weeks in the apple, peach, plum and grape, 6-8 weeks in the pear, 4-9 weeks in the orange and to maturity in the avocado and the strawberry.

If the cumulative increase in volume, fresh weight, or diameter of a fruit is plotted against time after anthesis, the resulting curve may be either sigmoid or double sigmoid in character. The type of curve bears no relationship to the structure of the fruit. The following fruits have a sigmoid growth curve:—Tomato, avocado, date, orange, various cucurbits, apple, pear, strawberry and almond. The apricot, cherry, peach, plum, olive, raspberry, currant, grape, and fig have double-sigmoid growth curves. The three distinct growth phases in the latter are termed Stages I, II, III.

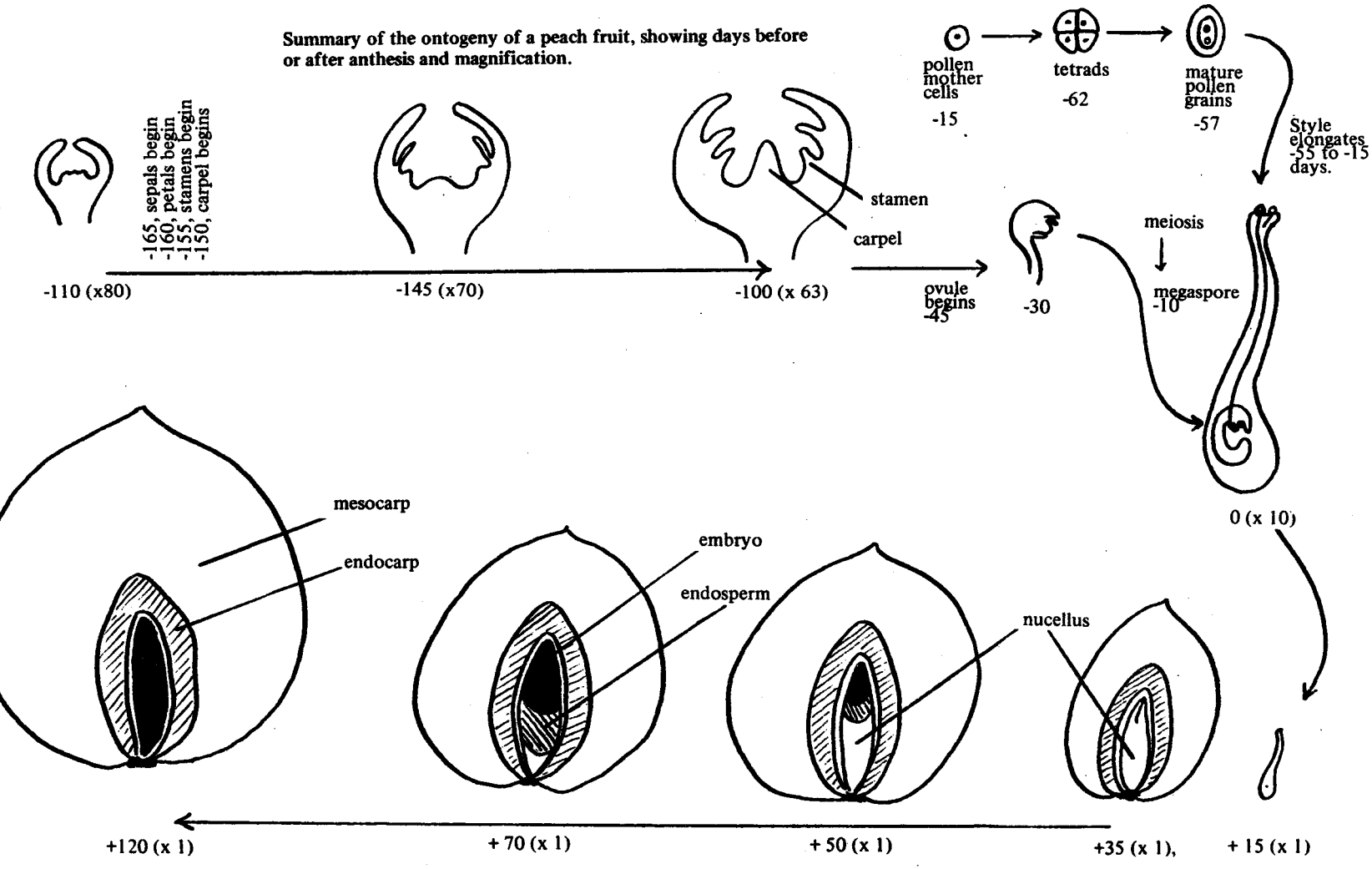
In the seed of stone fruits the nucellus grows rapidly during Stage I and this is followed by rapid growth of the endosperm and embryo at the end of Stage I and during Stage II.



Double-sigmoid growth curve of Apricot

Stage II is also known as the *'plateaux'* or, in stone fruits, the stage of 'pit-hardening' because during this period the stone or pit hardens.

Summary of the ontogeny of a peach fruit, showing days before or after anthesis and magnification.



7

Buds and Their Development

BUDS MAY BE CONSIDERED as incipient or unelongated shoots with or without flower parts.

Small sections of the apical meristem remain in the axils of leaves. These develop a short axis, protective scales, leaves, and/or floral primordia. The initiation of floral primordia (the determination of fruitfulness of a bud) generally occurs towards the end of the growing period ot the shoot which carries it. Some development of parts occurs during the subsequent winter until the bud opens the following spring. Buds may be classified as follows:—

Leaf buds: Unexpanded shoot bearing leaves and primordia of buds which will develop in the axils of these leaves.

Flower buds: Unexpanded flowers with or without leaves. They are generally larger than leaf buds. There are three types:—

Simple buds—Flower parts only, e.g. stone fruits, loquat.

Mixed buds—Containing flowers and leaves, e.g. apple, pear, quince, grape.

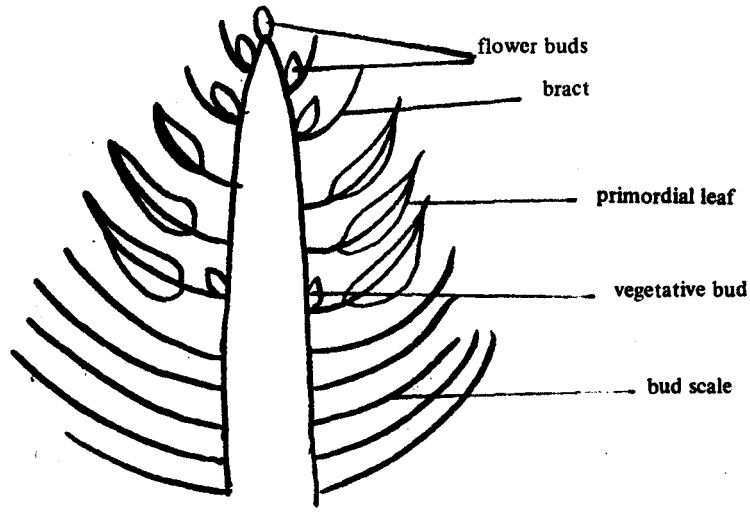
Double or triple buds—Two or three simple buds in one axil, e.g. peach.

In general every bud is a potential flower bud, but critical nutrition and other conditions are essential for flower bud formation. In deciduous trees and vines, differentiation occurs during the summer preceding the bursting of the bud.

A. THE PROCESS OF BUD DEVELOPMENT

1. *Pome Fruits*

The terminal bud of an apple spur consists of approximately 20 leaf formations in a close spiral sequence on a short axis. The outer 8-9 are the bud scales—hard



membranous and dark brown—followed by 10-13 leaves and bracts. In the axils of 2nd and 3rd foliage leaves are meristematic regions which remain vegetative. The flower primordia are formed in the axils of the upper leaves and the axis of the bud is terminated by a flower.

In November, prior to differentiation in the bud, growth consists of splitting off of leaf formations from the dividing apex. The axis of the bud is short and there is no microscopic difference between leaf and fruit buds at this stage.

Mid-December - late December: Differentiation occurs—there is a general enlargement of the axis of the bud broadening of the apex and the primordia of the first flowers appear in the axils of the upper foliage leaves.

End December - Mid January: Apex flattens preparatory to formation of the terminal flower.

Mid-January - End January: Sepals form in terminal flowers. Axillary primordia flatten and a ridge is formed from which sepals later develop.

End January - February: Petal initials in the terminal flower, sepals in the lowest axillary flower.

February - Mid-March: Stamen initials can be detected in the terminal flower.

March: Carpels (five) appear on the base of the receptacle in the terminal flower.

April: Similar development of axillary flowers.

May - August: Buds show little development during winter, stamens differentiate slowly into anthers and filaments.

From Mid-August: Flower parts enlarge rapidly and pollen-bearing tissue develops.

When the bud bursts in spring, scales and bracts drop, leaves expand and a cluster of flowers opens at the apex of the elongating axis. Growth continues from a leaf primordium in the axil of one of the lower leaves.

2. *Stone Fruit* (European plum is used as example)

The flower bud consists of 16-18 bud scales in spiral sequence on the axis, the outer 2-3 are short, thickened and dark brown, succeeded by 9-10 thinner scales, inner 4 are tripartite, finally 2-3 small bracts develop from the growing point and flower primordia appear in the axils of these bracts. Growth ceases in the apex and the flower assumes a terminal position as it develops.

November - December: No apparent difference between flower and leaf buds.

Early January: Differentiation occurs, the growing point enlarges and prepares for flower formation.

Mid-January - End January: From the enlarged apex, bracts form and flower primordia arise in the axils of each bract.

February - March: Successive development of sepals, petals and anthers and carpels.

End May: Sporogenous tissue in the anthers and a well defined loculus.

June - July: Slow development.

August: Rapid development prior to budburst, several ovules develop but only one survives.

3. *Grapes*

Fruit-bud initiation occurs progressively as the shoot elongates. Two buds develop in the axils of each leaf but are enclosed in common protective scale, one of these later may give rise to short vegetative shoot 4-5 in. long. The other bud develops two accessory buds, one on each side and the three are enclosed in a common scale. The central bud will form a cane next year.

By November about eight rudimentary leaves have developed in most buds. Flower bud or tendril primordia may appear opposite the ninth leaf primordia. Development of leaves ceases about the end of December when 12-13 rudimentary leaves are present.

Enlargement of flower primordia takes place till about March. There is little development from March till August, after this flower primordia further expand and primordia that are going to become tendrils begin to develop. Thus from the 9th to the 12th leaf 4-5 primordia occur which may develop into flowers or tendrils. Those forming flowers develop before those forming tendrils. The size of the bud in March is an indication of the number of flowers that have been initiated. Bud burst occurs in September but the flowers are not conspicuous till several leaves have developed.

4. *Citrus*

Unlike most fruit trees which have only a short flowering period of a week or ten days, citrus trees blossom for five or six weeks. Blossom production is profuse but only 50 per cent or less of the blossoms may set fruit and of these only 10 per cent or so may reach maturity.

In citrus, *bud* initiation takes place in early mid-summer, however, *floral* initiation occurs quite close to flowering. These buds may be formed terminally or in the axils of leaves, i.e. laterally . Prior to opening in the spring the citrus bud consists of an axis with scales in a close spiral sequence. There are 4-5 outer scales and above these six rudimentary leaves but there is no visible differentiation of flower primordia. With proper nutritive conditions in the plant any partly developed bud may undergo differentiation, form flower parts and develop as a fruit bud. That is, up to a certain stage of development every bud is to be regarded as a potential flower bud. Flowers actually originate in the axils of rudimentary leaves, the leaves themselves may or may not develop.

When the flower bud unfolds it may give rise to any one of three distinct types of flower-bearing structures.

(i) It may contain flower parts only and develops a single flower as in apricot and peach or a flower cluster as in cherry.

(ii) It may be a mixed bud and develop a short or long leafy shoot terminating in an inflorescence as in apples.

(iii) It may be a mixed bud and develop a short or long leafy shoot bearing flowers or flower clusters in some of its leaf axils (as in fig and persimmon), i.e. laterally. These forms of growth are independent of whether the fruitful bud is terminal or lateral so that there are 6 main groups into which fruits can be divided.

B. THE TYPE OF BUDS AND THEIR POSITION ON THE TREE (Bearing Habit)

Buds may contain single or multiple flowers, with or without leaves.

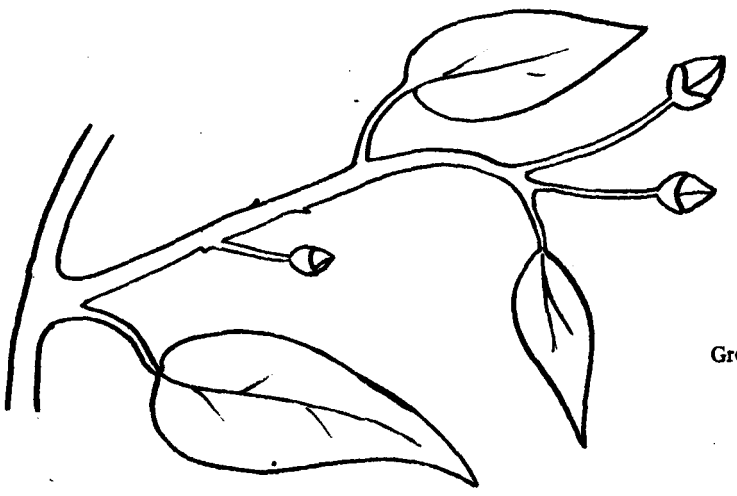
Buds can be classified into six groups.

Group 1

Fruit buds borne terminally containing flower parts only and giving rise to inflorescences without leaves. None of the common deciduous trees has this habit; best example is loquat. Vegetative growth is continued by laterals arising below the inflorescence.

Group 2

Fruit buds borne terminally, unfolding to produce leafy shoots that terminate in flower clusters. This bearing habit is characteristic of most of the pome fruits and a few others of minor importance. Growth continued by laterals from base of bud.



Growth from Citrus bud,type (iii).

Group 3

Fruit buds borne terminally unfolding to produce leafy shoots with flowers or flower clusters in the leaf axils, e.g. Guava, olive.

Group 4

Fruit buds borne laterally, containing flower parts only and giving rise to infloresences without leaves or if leaves are present they are much reduced in size, e.g. stone fruit, currant, gooseberry.

Group 5

Fruit buds borne laterally unfolding to produce leafy shoots that terminate in flower cluster, e.g. blackberry.

The blackberry, raspberry, dewberry and their hybrids form fruit buds either on primary shoots that come up from their crowns or roots each year, or on their secondary lateral shoots.

When first initiated, the grape inflorescence is terminal to a leafy shoot also within the bud, like that of the raspberry and blackberry. As the bud develops, the bud in the axil of the topmost leaf of this developing shoot, continues the growth of the shoot. This results in pushing the flower cluster to one side so clusters are formed terminally at successive intervals on the same shoot and in turn are crowded to one side and hence appear in lateral positions. Later flower clusters are replaced by transitional forms or tendrils.

Group 6

Fruit buds borne laterally unfolding to produce leafy shoots with flower clusters in the leaf axils, e.g. fig.

There is another group of plants which have fruit buds in axils of leaves and in which these buds unfold and develop their flowers and fruits very soon after the flower parts are differentiated, e.g. citrus.

It should be apparent that a knowledge of bearing habit of the species and of particular varietal differences is an essential basis of enlightened pruning.

The following table may help you to remember these data.

	No. leaves in flower bud	Buds contain leaves & flowers	
		Inflorescence terminal	Inflorescence lateral
Buds produced terminally on shoot	Loquat	Pome fruits	Guava, Olive
Buds produced laterally on shoot	Stone fruit currants gooseberry	Raspberry blackberry etc.	Fig.

8

The Process of Maturation

A. CHANGES TAKING PLACE DURING MATURATION

The following changes take place as a fruit matures:

(a) sugar increase
(b) increase in flavour components
(c) decrease in acid
(d) softening of the fruit
(e) change in respiration rate
(f) colour changes.

1. *Increase in Sugars*
These accumulate rapidly in most fruits during ripening, however the mechanism of accumulation is uncertain. The accumulation is certainly against a concentration gradient (in other words it doesn't accumulate by simple osmosis) and energy is expended. Sugars themselves may not be the first carbohydrate to accumulate, apples and pears initially have high concentrations of starch and sorbitol, bananas have high starch, these are later wholly or partly coverted into simple sugars.
Type of sugar in various fruits:
Apples and pears:
Fructose > glucose = sucrose
Apricots and peaches:
Sucrose > glucose > fructose
Grapes:
Glucose = fructose > sucrose

Amount of sugar:	
Grapes	20%
Pome and stone fruits approx.	10%
Oranges approx.	9%
Lemons approx.	2%
Amount of starch:	
Bananas approx.	12%
Apples and pears	4%
Grapes and stone fruit	0%

2. *Increase in Flavour Components*
Flavour is determined by many compounds including amount of sugar, starch, acids and specific flavour components. These latter are aromatic compounds, generally esters and alcohols, and several dozen of these may give the characteristic flavour to various fruits. Some examples: amyl formate, amyl acetate, amyl butyrate, nonyl alcohol.
3. *Decreased in Acid*
In most fruit, acid level increases to a peak at some stage during development, but as fruit mature acids gradually decline. Lemons may have 5% at maturity but most fruit have less than 1%.

Acid	*Occurs in*:
Malic	Apple, pear, quince, peach, cherry, banana, raspberry, blackberry, red currant, rhubarb
Tartaric	Grape, cherry
Citric	Citrus and most other fruits
Acetic	Fig
Oxalic	Rhubarb, some plums
Benzoic	Cranberry
Quinic	Peaches (with malic and citric), gooseberry
Galacturonic	Apples, tomatoes
Shikimic	Gooseberry

4. *Softening of the Fruit*
During the later stages of fruit enlargement there is considerable increase in size of cells and concomitant thinning of cell walls. Such fruit are softer and easier to eat. If there are large intercellular spaces fruit tend to be mealy and lacking in texture. Softening of the cell walls is probably due to the breakdown of pectic acid and protopectin, which bind the walls together, into

soluble pectins. However the process is not fully understood.

5. *Changes in the Respiration Rate*
Some fruits have a high respiration rate and cannot be stored for long periods (stone fruits, strawberries, raspberries), others have a slow respiration rate and may store for a considerable time (apples, pears, citrus). (Respiration rate indicates the degree of metabolic activity taking place in the fruit. Naturally if this activity is high then maturity and senescence will proceed rapidly.)
One characteristic of the respiration rate in some fruits is the *climacteric rise.* At a certain stage of development the rate of respiration rises to a peak which generally coincides with the time when the fruit is at optimum condition for eating. After the climacteric, senescence begins. The following fruits show a climacteric rise: apple, pear, apricot, peach, plum, avocado, banana, passionfruit, mango, tomato. Fruits without a climacteric are cherry, cucumber, fig, grape, grapefruit, lemon, melon, orange, pineapple, strawberry.
It is chiefly the rate of respiration which is reduced during cool and controlled-atmosphere storage. This will be dealt with more fully in a separate lecture.

6. *Colour Changes*
Green is due to chlorophyll in the chloroplasts. Yellow and orange are due to carotenoids in plastids and flavones in sap.
During ripening the green colour fades due to the destruction of the chlorophyll. This reveals other colours, especially yellows, which were previously masked by the green. The following affect the breakdown of chlorophyll and/or the sythesis of anthocyanins.

(a) Light. Carotene tends to be more abundant in fruit ripening in the sun than in the shade.
Flavones and anthocyanins develop only in direct sunlight in the following: apples, pears, peaches, apricots; however, in cherry, strawberry and some grapes they will develop in the dark just as well.

(b) High nutrition tends to reduce colour development.
(c) Temperature. Cool conditions tend to favour good colour development.
(d) High water may reduce or delay colour development.
What cultural practices could affect colour development?

B. FACTORS AFFECTING MATURITY

1. Temperature. High temperatures hasten maturity.
2. Nutrition. Low nutrition (particularly nitrogen) and drought may hasten maturity.
3. Light. Although light will alter colour development, it is not known whether it affects other aspects of maturity.
4. Pests and diseases. Codlin infected apples ripen earlier. Reduction in leaf area due to damage may increase the light falling on fruit and so affect their rate of colouration.
5. Growth substances. GA_3 will delay ripening in lemons but promote it in peaches and apricots. 245-T will cause apricots and figs to ripen earlier.
6. Date of blossoming. This can vary from year to year.

C. WHAT IS "MATURITY"?

Maturity can mean the time at which a fruit has optimum flavour and texture for eating directly after picking, it can be used to mean the time when a fruit should be picked so that it will keep for the longest period in cool storage or it could be used to mean the time when a fruit should be picked for cooking, processing, etc. The optimum periods for each may be different. The determination of optimum maturity is extremely difficult and no satisfactory method has been found for many fruits. New Zealand is particularly unfortunate in this respect for the following reason:

Due to our mild winters the blossoming period of apples, pears and stone fruits extends over 2-3 weeks. Thus fruits do not begin their growth at the same time and therefore seldom reach maturity together. Methods used to determine maturity will be discussed later.

9

The Physiology of Fruit and Tree Growth

WE HAVE DISCUSSED the anatomy and development of various fruits, we now have to look into the causes of the various growth phenomena encountered.

A. FLOWER-BUD INITIATION

Flower-bud initiation in deciduous fruit trees and shrubs occurs sometime between leaf formation in the Spring and leaf fall in Autumn; the exact time depending on the species concerned. Some fruits, for example strawberries and blackcurrants, initiate flowers following a period of short days such as occur in Autumn before the leaves fall, but most are not sensitive to day-length. It will be appreciated that factors controlling flower-bud initiation are operative 6-12 months prior to the actual emergence of flowers. We shall now consider some of these factors.

1. *Competition effects*

   We must assume that the capacity of a tree either to produce photosynthates or to absorb nutrients and water from the soil is only moderately flexible. In other words if the demand for these food materials becomes too great a shortage will be experienced. Research seems to indicate that there is a definite priority order for the allocation of food materials. This is as follows:—

   1. Growing shoots (and possibly roots), 2. developing fruits, 3. developing flower buds. Consequently if a shortage exists, flower-bud initiation will be the first and fruit development the second process to suffer. The following examples tend to support this suggestion:

   (a) In experiments with apples and apricots all developing shoots were removed at blossoming time and for a limited period afterwards. Fruits grew quite satisfactorily using reserve food materials stored over winter in the tree Once, however, shoots were allowed to grow again fruits immediately dropped. It therefore seems that as soon as the shoots were able to grow they monopolised the remaining food, and fruits in fact starved.

   (b) Biennial bearing is a common phenomena in apples. A heavy crop of fruit probably limits the food materials available for bud-initiation. Because of the ensuing low number of flower buds, the crop in the following year is greatly reduced (see also notes under 'biennial bearing').

   (c) Bending down branches of apples, pears, and plums will reduce vegetative growth of that branch and this is generally paralleled by increased flower-bud initiation. Likewise rootstocks which induce dwarfing tend to promote earlier flowering.

   (d) Certain growth inhibitors, e.g. B995 (Alar) will restrict vegetative growth and promote flower-bud initiation of apples, pears and cherries. Other hormones, for example gibberellins, will promote vegetative growth and restrict bud development.

2. *Nutrient effects*

   If poor fruit-bud initiation is a consequence of heavy competition for food materials it should be possible to overcome this by increasing the nutrition of the trees. Experiments at Plant Diseases Division (D.S.I.R.) have shown that for apricots improving the fertility of the soil can increase bud initia-

tion. Nitrogen seems to be the important element and this has also been shown to promote flower-bud formation in apples. There may be conditions, however, when *excessive* nitrogen will have the opposite effects.

3. *Light*
   Low light intensity will tend to promote long vegetative growth and restrict flower-bud initiation. The increased growth of stems is probably due to the effect of light on hormone or inhibitor production. Reduced light, which limits photosynthesis, and increases vegetative growth no doubt means that the supply of food materials in the plant is depleted so that bud formation is reduced.
   For many years a popular theory to account for increase in fruitfulness of branches has been that they must have a high carbon/nitrogen (C/N) ratio for satisfactory bud initiation. Although there is some evidence for this it is not completely convincing and the theory will not be considered further in this book.
4. *Temperature*
   High temperatures tend to accentuate the depressing effects of poor light intensity on bud initiation by stimulating vegetative growth.
5. *Water*
   Markedly reduced water levels can limit bud initiation but the effect is not so great as the effect of nutrition. In citrus grown in dry areas, it has been found possible to control the time of F.B. initiation by withholding irrigation at the time initiaton is required. Thus limited water stress may in certain plants be conducive to initiation.
6. *Gravity*
   Bending down branches of apple, pear and plum trees will tend to reduce vegetative growth and promote flower-bud initiation.
7. *Rootstocks*
   The reduced vigour imparted by various dwarfing rootstocks is paralleled by greater flower-bud initiation in younger trees. Possibly reduced vegetative growth allows more food materials to be diverted to bud formation.

8. *Growth Substances*
   Plant-growth substances (hormones) probably take part in every process discussed above. However, their precise role has yet to be determined. There are several major types of plant hormones; the promoters which generally stimulate growth, the inhibitors which restrict it, and ethylene gas which has a varied role. The promoters include the *auxins* such as IAA, NAA, 2,4-D, IBA, the *gibberellins* such as gibberellic acid (GA), and the *cytokinins* such as zeatin and kinetin. The main natural inhibitor is *abscisic acid* but several synthetic inhibitors such as Alar, CCC, Phosphon are available. *Ethylene* stimulates ripening, and has several other effects on plants.
   It was once thought that another type of hormone was present which was responsible for flowering in plants. This was called the flowering hormone or 'florigen'. However no one has isolated such a compound and it is now believed by some people that flower initiation may occur when the levels of all or some of the above hormones approach a ratio which is conducive to flowering.

You will notice that earlier we accounted for flowering by discussing competition for available food materials. All the environmental factors discussed could be said to affect flowering by increasing or reducing the availability of these materials. How then do hormones come into the picture. The true answer is that we do not really know.
We have already mentioned that inhibitors may restrict vegetative growth and promote flowering, while gibberellic acid will promote vegetative growth and inhibit flowering. It appears that by modifying the growth of the shoots these hormones make more or less food materials available to the bud. But we cannot be sure of this, the hormones may act directly on the bud to promote or inhibit its development and it may be just coincidental that it promotes or inhibits shoot growth at the same time. It is also not easy to understand how some plants respond precisely to the length of the day on the theory of nutrient competition. Why do some plants only flower under long days and some only under short days and why are the plant requirements in this respect so exact?

Probably flowering is controlled by a variety of factors and the relative importance of the factors may vary from plant to plant. In some instances plant hormones in the correct concentration may directly cause the buds to initiate flowers and the number of flowers then formed may be dependent on the available nutrients. In other plants the hormone level may always be conducive to flower initiation and the amount of initiation may thus be solely dependent on availability of food materials. Some plants may go through phases of growth which are controlled by internal hormone levels and external environmental factors. Thus apple trees in the Spring probably burst into growth because of warmer temperatures and because inhibitor levels over the Winter have dropped, promoters increased and dormancy has been broken. After a certain period shoots stop growing and for a while the plant seems to do nothing. This may be because leaves have produced hormones to form a new balance which in fact restricts the further growth of shoots. But this new balance may promote the formation of flower initiais or, by cutting down the demand for food materials, may enable buds to use the extra materials for their formation.

There may be other ways plant hormones and environmental factors interact to affect flower formation and perhaps considering the great diversity in the plant kingdom this is not surprising. It indicates that in trying to account for the behaviour of plants we must always try to avoid making generalisations about all plants on our experience with one or two.

B. BUD DEVELOPMENT AND DORMANCY

1. *Bud Development*

After buds are initiated development takes place very slowly over the rest of the summer and during winter. At almost any time buds may drop and the severity of this varies with variety and with location. It is possibly a bigger problem in areas with warmer winters and may be one of the reasons why certain peaches, most apricots and most European plums do not grow well in the North Island. The real cause of *bud drop* has not been discovered.

2. *Dormancy*

Dormancy is a state in which viable buds or seeds will not germinate under conditions of moisture, temperature, and oxygen favourable for vegetable growth. There seems to be *degrees of dormancy* in buds and seeds.

(i) *Predormancy, preliminary rest, preliminary-dormancy.* The tissues will no longer grow in response to favourable conditions but are easily forced by hot or cold or by removing seed coats or bud scales.

(ii) *Dormancy, mid-dormancy, mid-rest.* Drastic treatments are necessary to break dormancy.

(iii) *Post-dormancy, after-dormancy, after rest.* Similar to predormancy.

(a) *Response to Temperature.* As the dormancy of buds or seeds increase the range of temperatures over which they are capable of growing becomes increasingly narrow; as they emerge from dormancy they become capable of growing over an increasingly wide range of temperatures. The range of temperatures at which buds of fruit trees will develop at different stages of dormancy has not been worked out.

(b) *Breaking of Dormancy.* Generally the most effective way to break dormancy of buds and seeds is by exposure to low temperatures. There seems to be a *threshold temperature* below which any temperature (as long as it does not kill the plant) will be effective. Also it can be calculated how many hours below this temperature are required before dormancy is completely broken. Threshold temperatures and hours of chilling vary with species, variety, location and even the position of the bud on the branch. In some parts of the world the number of hours below the threshold temperature required to break dormancy has been obtained. For example, in California and Spain the apricot variety 'Royal' requires 850-900 hours below 7°C. Elberta peach requires 850-950 hours in California and 1000 hours in France, Mayflower requires 1050 hours in California, 1150-1250 hours in Georgia and 1200-1300 hours in France. It is

obvious that if we, in New Zealand, wished to discover chilling requirements we should have to investigate them under our own conditions. What advantages would this have?
The symptoms of inadequate chilling are delayed blossoming and foliation (blossom time is later in the north than in the south) an extended period over which blossoms open (3 or more weeks in Auckland), and possibly, extensive bud drop before blossom time.
There are other methods used to break dormancy in various tissues but none have been particularly successful in deciduous fruit trees.

(c) *Causes of Dormancy.* Some research workers believe that dormancy is caused by bud scales and seed coats which are impermeable to oxygen and water and tend to restrict growth either physically or because the normal process of metabolism is prevented. Others believe it is due to the balance of promotors and inhibitors being tilted in favour of the inhibitors. This latter theory is very popular at the moment but the correct interpretation may include both. This discussion will consider mainly the role of inhibitors in bud dormancy.
In many deciduous trees short days (SD) cause the cessation of extension growth and the formation of dormant winter resting buds. This is not so in most common fruits except blackcurrant and strawberry. It is believed that somehow a signal is perceived by the leaves in SD which is transmitted to the buds. It has been shown that leaves grown under SD conditions have a greater quantity of inhibitor than leaves under LD and it is therefore suggested that the signal received by the leaves causes inhibitor formation which is then transferred to the buds. Whether dormancy is initiated by SD or by other factors, there does seem to be one inhibitor common to many plants and which is closely associated with dormancy. This is *abscisic acid* (ABA). It is believed that dormancy is primarily due to a balance between ABA and gibberellic acid (GA). Thus in blackcurrant buds in July there is no GA but high ABA, by August GA begins to appear and ABA falls, by September when the buds are ready to break there is a great deal of GA but insignificant amounts of ABA. However, not all experimental results fit into this picture and certain modifications may need to be made from time to time or for different plants. Other inhibitors exist (e.g. coumarin, naringenin) and other growth promotors (e.g. cytokinins) may also play a part in the release of buds from dormancy. It is likely that a great improvement in our knowledge of dormancy will occur over the next few years. What questions do you think are likely to be answered by current research?

FACTORS AFFECTING VEGETATIVE GROWTH OF FRUIT TREES

1. *Apical Dominance*
Apical dominance can mean two things: (a) the inhibition of lateral buds by the terminal bud or growing apex of the shoot or (b) the stronger growth made by the upper or leading shoot on a branch, in comparison with the weaker growth of lateral shoots. One major point of difference between the two is that inhibition of buds in the former decreases in intensity with increasing distance from the apex, in the latter the growth of lateral shoots is more inhibited the further they are from the terminal or dominant shoot.
(a) *Lateral bud inhibition.* Auxin production in the apex of growing plants is believed to restrict the growth of lateral buds and maintain apical dominance. Gibberellin and cytokinin also are involved in apical dominance but it seems as though their role is less direct. The release of buds from apical dominance may be assisted by providing adequate light and nutrients; it may also be achieved by treating the lateral buds with cytokinin, although the resultant growth is usually not very strong.
(b) *Growth of shoots.* Growth of the apex, although it is maintained by the

hormone balance in the plant, is also dependent on external factors such as water and nutrients. Initially it is seen as the proliferation of nodes, leaves from the tip, further extension is conditioned by the elongation of the internodes. Control of internode elongation is probably effected by auxin and gibberellin produced in the apex and young leaves and by inhibitors manufactured in the older leaves. This may be under the external influence of light intensity. Thus growth of the shoot is a consequence of two processes, proliferation of nodes and elongation of internodes. Both of these may, via the hormone system, attract metabolites to the apex and internodes and perhaps restrict availability to the lateral buds.

(c) *Inhibition of lateral shoots.* The physiological distinction between the inhibition of lateral shoots and inhibition of lateral buds are not known. Most of the factors which inhibit lateral buds also inhibit lateral shoots.

2. *Gravity*
In apples, pears and plums, it is known that pulling down branches will check the rate of growth and promote flower-bud initiation. Training branches horizontally can also affect apical dominance. For example, a leading shoot, if pulled down, will no longer exert apical dominance over the other shoots and another dominant shoot will emerge. Not a great deal is known about the reasons why horizontal branches form more flower buds, although some experiments with hormones may give some suggestions. In horizontal shoots of various plants it has been shown that auxin tends to accumulate on the lower surface. Now in a horizontal shoot it is usually found that all the shoot growth takes place on the upper side, this is because high concentrations of auxin inhibit bud growth. Thus the angle of the shoot to the vertical may determine the distribution of auxin and this may, in addition to its effect of shoot growth, influence flower-bud initiation as well.

3. *Inhibitors*
B995 (Alar) and CCC have been used to reduce vegetative growth in apples, pears and cherries. The exact mechanism by which they affect the plant is not known. They probably tip the balance of promotors and inhibitors in the plant in favour of the inhibitors.

4. *Rootstocks*
Dwarfing rootstocks reduce vegetative vigour and tend to cause more flower-bud formation in younger trees. Two ways in which they could reduce vigour have been suggested. Firstly cross-sections through the trunk of dwarfing rootstocks reveal a higher proportion of bark than in vigorous rootstocks. This may alter the pattern of translocation in such a way that vegetative growth is reduced. The second possibility is that hormones produced by the roots affect vegetative growth of stems. Thus dwarfing rootstocks may produce less growth promotors and/or more inhibitors. This idea is attractive but there is, as yet, insufficient evidence to prove it one way or the other.

5. *Other Factors*
Some of these have already been discussed under the section flower-bud initiation. You should go back to these notes and continue this list.

D. THE PHYSIOLOGY OF FRUIT GROWTH

We shall consider the growth of fruits from the time of full-bloom until maturity. You should revise at this stage lecture notes "VII C—FRUIT AND SEED GROWTH".

1. *Growth Substances*
Normally if a seed is not pollinated and fertilised the fruit will drop at, or shortly after, full bloom. The most common exceptions to this are, of course, fruits which are naturally parthenocarpic, e.g. seedless grapes, such as currants or sultanas, seedless oranges, such as Washington Navel, and bananas. Since seeds are normally required it is believed that they contribute some substance necessary for fruit development. This is now felt to be a hormone since unfertilised fruits can often be induced to grow by the application of a hormone. The type of hormone required can vary; sometimes auxins, gibberellins, and cytokinins will induce parthenocarpy, sometimes only one or perhaps two will be effective, sometimes a combination is required, and

sometimes none seems effective. Nevertheless the obvious explanation that a hormone is manufactured in the seed which migrates to the flesh where it stimulates fruit growth, may be too naive. A number of studies have been made where levels of hormone in the seed during growth have been compared with either growth rates of the whole fruit, or patterns of fruit drop. These seldom seem to be related. In other words hormones produced in the seed do not seem to directly stimulate growth of the flesh or promote or prevent fruit drop. More commonly levels of hormone in the seed correspond to growth of the seed, high levels being present during rapid growth periods. Similarly high levels in the flesh are related to rapid flesh growth. Another interesting point is that in apples, cherries and peaches the seed can be removed or destroyed after a certain stage of development without deleteriously affecting fruit growth or inducing fruit drop. Thus, although fertilisation and seed development are essential early in the season, the fruit can exist without the seed later on.

At this stage it is impossible to make any dogmatic assertion of the role of fertilisation and hormones in fruit development. Nevertheless it seems clear that hormones are essential to fruit development, that the seed is an important source of hormones at certain growth stages and that if fertilisation does not occur this source must be replaced by an external application (or else the plant must have developed some way of coping with the situation as in natural parthenocarpy). It is also likely that the other fruit tissues, such as the flesh, are also a source of hormones and that at certain times during growth this is adequate to main growth of the fruit as a whole. There are probably phases in the growth of a fruit when the growth of different tissues dominate the others. If these particular tissues are damaged at this crucial stage, or if they fail to develop, then development of the whole fruit may be restricted and it may drop.

2. *Competition*

In most deciduous fruit trees flowering precedes leaf and branch growth. In apricots and peaches, for example, leaf buds may not open until about a week after blossom buds burst. In apples the bud is a mixed bud and some leaves emerge at the same time as the flowers, nevertheless the main flush of leaf growth is dependent on the development of the bourse shoot which originates from the base of the bud after it has opened and flowered.

Food materials used in early growth are in the form of reserves laid down in the tree last season. It is not until leaves are well-developed that they begin to export carbohydrates and other food materials to other parts of the plant. Therefore early in the life of the fruit it will compete with other fruits and, a little later, with developing leaves, shoots and probably roots for available reserves. This is a crucial time in development and if competition is too tough fruits will drop. It seems possible that hormones play an important role in competition for it has been found that these compounds will attract carbohydrates and minerals to their point of origin or application. Thus early in development there is far more hormone present in the seed than in the rest of the fruit; this may help the fruit as a whole to attract food materials which might otherwise go to developing leaves or unfertilised fruits. Later the level in the seed drops and consequently its role in fruit growth may diminish so that seeds may be removed without affecting growth. Hormones produced in other parts of the fruit may then be sufficient to maintain the fruit on the tree.

3. *Fruit Drop*

The first period of heavy drop occurs at flowering and shortly afterwards. Fruits that survive this period are said to have been *set*. As suggested previously fruit drop at this stage may be due to the fruit's inability to compete with other growing tissues for food. Hormones may help the fruit to compete, and, in addition, may play a direct part in the process of abscission.

Fruits that have set may still fall and the next period of heavy drop occurs about midway in the growing season—we speak of this as *'December Drop'*. The cause is unknown but it may be associated with changes in the seed, perhaps the transition from the phase of nucellus growth to that

of the endosperm and embryo, or perhaps the termination of all seed growth. These changes will be associated with changes in hormone levels which may affect abscission either directly or via effects on food distribution.

The last period of drop is at maturity or just before. If it occurs before the fruit is ripe it is commercially undesirable and the problem is called generally *'Pre-harvest Drop'*. Again the cause is not known for certain but it may be due to the premature reduction of hormone levels in the fruit.

4. *The Use of Hormone Sprays*

Auxins such as napthtalene acetic acid (ANA or NAA) will, when sprayed on apples shortly after blossoming, cause fruit drop, and these materials are used as thinning sprays. The cause of drop is unknown: NAA may upset the normal hormone balance in fruits at this stage, it may act directly on abscission or it may produce distortions in seed growth which lead to their malfunction later on. The same hormone, at almost the same concentration, if sprayed before harvest will prevent pre-harvest drop. Clearly it must be having a different effect at this stage. The simplest explanation of this latter effect seems to be that it supplements the natural hormone which may be dwindling.

One final effect of applied hormones can be considered. In apricots, and figs, which display a double-sigmoid growth curve, the slow phase of growth can be made shorter or eliminated by applications of 2,4-D or 2,4,5-T. This implies that the slow growth phase may be due to low concentrations of endogenous hormone.

5. *Inhibitors*

So far we have mainly considered growth in terms of the effects of growth promotors. Growth inhibitors are probably also involved but their function in fruit growth is less well understood and we cannot consider them any further here.

Overall it will be seen that hormones have some rather diverse and complex effects. It no longer seems likely that each hormone has a specific action, since different types will produce similar effects—for example parthenocarpy. Each process may in fact be dependent on a balance between various hormones; at some stages one hormone may predominate while growth at another stage may be primarily under the control of a different hormone. The effect of applied hormones may depend on this balance. If the application causes a gross imbalance deleterious effect may be experienced, if it increases the endogenous level of any hormone without upsetting the balance, a beneficial effect may be produced.

PART 2

Establishment and Husbandry

10

Buying or Establishing an Orchard

REMARKS IN THIS SECTION mainly refer to apple and pear orchards but the principles apply to most other fruits. We will divide the section into two parts—firstly planning a new apple orchard and secondly buying an established one.

A. PLANNING A NEW ORCHARD

When dealing with a long term investment such as apple growing where a large capital outlay is involved, a grower cannot afford to make serious mistakes. Careful planning and preparation is time well spent and results in greater returns in the years to follow.

A potential grower must be aware of the essential management aspects of orcharding. He must choose the district carefully and within the district he must carefully investigate the advantages and disadvantages of available sites Once the site has been chosen he must lay out the orchard in the most economical and productive way and give thought to careful budgeting.

Management

Fruitgrowing has a special appeal to the young man who prefers an out-of-doors life and wishes to be self-employed. It is important that beginners should realise that modern apple growing is a specialised occupation requiring a scientific outlook and the professional economic skill equal to the acumen of an experienced business man. (Speculators investing in orchard land should remember this point and be willing to pay for experienced managers.) In particular, those wishing "to retire to the country in an apple orchard" should abandon the idea of an "easy way of life". The days of apple growing as a small cottage industry have long since passed.

Co-operation

Members of the apple-growing industry in New Zealand have evolved a strong co-operative spirit in matters of mutual concern and it is important that new members should realise the economic and political advantages that have been built up over the years.

There are many sources of advice for the fruitgrower and new orchardists should be aware of these. The Ministry of Agriculture and Fisheries, the New Zealand Fruitgrowers' Federation, the New Zealand Apple and Pear Board and local district fruitgrowers' association can all be called on for advice on layout, methods of culture, sprays, varieties, costs and equipment, etc. The New Zealand Fruitgrowers' Federation has a nursery at Levin which has the best selection of trees in the country.

It is essential to assess the correct amount of money to invest in land and buildings and equipment and an account of expenditure and return on investment should be prepared. Adequate cash reserves and/or alternative employment must be available to provide working capital during the early non-productive years and a living allowance until the income from the property can fully support the grower. Banks and other financial institutions can be approached for short term finance, and they appreciate careful planning and management accounting. At all times the financial situation of the orchard must be well documented.

Locality

The essential requirements of a tree orchard are fertile soil, readily available water and good drainage, while a level ground surface is important in mechanisation and drainage. High sunshine hours are favourable for high yields, good fruit colour and finish and relatively low rainfall discourages fungal diseases although mite infestations are promoted. Shelter from wind

can be ensured by shelter belts, but their disadvantages (shade, root competition, pests and disease, and maintenance problems), have led to reliance on self-sheltering, especially in semi-intensive plantings where the first three or so windward rows provide protection from the prevailing winds. Areas prone to frosts or hail storms or other adverse climatic effects should be avoided.

Availability to services such as A and P Board depots, cool store facilities, transport, advisory services, labour, nursery supplies and co-operative organisations are important to consider.

The Orchard Site

An area of four hectares is usually regarded as the minimum requirement for one man. Ideally the land should be a square block of flat clean pasture with boundary and roadside fences in good repair. Apple trees prefer light well-drained soils. Recently-laid tile drains add to the value of the land.

Ground that has never been planted in fruit trees is preferable, while topography should be studied to avoid frost pockets. Tall or diseased fruit trees on the boundary of neighbouring properties may create problems due to shade, competition and pests and diseases.

The site may be more attractive if there is adjacent land which could be bought at a later stage should the grower decide to expand.

Layout

Not all the orchard area can be planted in trees, but careful planning can reduce the non-productive areas to a minimum.

Savings in travelling time can be obtained by placing the packing-shed depot centrally. Initially this depot could be about 100 m² for shed storage and the pumphouse, with a 200 m² extension for the packing unit and storage later as the orchard enters production. These facilities could be extended as the fruit volume increases and allowance in the planning and development should be made for 600 m². Access to the central depot (axial thoroughfare) and the headlands (marginal) should be made about 6 m wide to allow for the free movement of orchard traffic.

Where adjacent orchardists are agreeable a common headland may be used with 3m from each property to save non-productive space. If the rows are at right-angles to a road, a headland may not be required if tractors can turn on the roadside verge. On flat land a well-planned orchard would not have much more than 5% of the total area occupied by sheds and headlands.

Traditionally, apples, pears and stone fruit have been planted on the square at distance up to 6m x 6m. However, semi-intensive planting of apples is now widely practised. With the use of semi-dwarfing rootstocks such as MM106, the number of trees per hectare can be doubled, mainly through the elimination of waste space between trees and no longer sticking to a square plan.

traditional:

6m x 6 m planting—30% waste space

semi-intensive:

4.5m between rows—25% „ „

On a mature orchard, this 5% saving can represent an increase in net profit of $250 per hectare. Through the adoption of the centre-leader pyramid system of training, reduced costs of production can be obtained.

In semi-intensive plantings, the distance between the rows depends on the scion vigour, from 2.8m apart for weak scions such as Sturmer and Democrat, to 4.3m apart for vigorous Kidd's Orange and Red Gravenstein. As there is no cross traffic the trees can alternate with gaps in the adjoining rows to reduce waste space. For efficient orchard management, the distances between rows should be standardised.

An exact plan of the property indicating future tree arrangements is also advisable.

Fruit varieties are subject to fashion changes and the grower should observe any tangible alterations in consumer preferences, trade trends and research reports and respond quickly to them. Varieties of declining popularity should be excluded. Although wishing to maintain a sequence of varieties for effective labour use, the number of different varieties should be limited. Criteria for the choice of varieties are; heavy yields (extra return at no extra cost); versatility in storage, export gate-sales and processing, popularity, durability to rough handling without being excessively tough, and disease resistance for cheaper production.

Budget

After purchase, a detailed budget to cover 20 years operations should be prepared, and examined by an advisory officer or expert to confirm a realistic analysis. The benefits of preparing this budget are:—

1. that it forces on the management some knowledge of orchard operations,
2. it is instrumental in establishment of contact with the fruitgrowing industry,
3. it is a persuasive factor for potential financial supporters.
4. it enables the grower to compare achieved results with planned results and allows long-term forecasting of evasive action against excessive taxation or death duties.

B. THE VALUE OF AN ESTABLISHED ORCHARD

Anyone interested in apple growing as an occupation should investigate the range of established orchards that may be available for purchase. Not every orchard would be worth considering, but some would certainly be a good investment, more particularly for an older man who would not be prepared to slog through the developmental non-productive period of a new planting. The advantages and disadvantages of buying an established orchard should be weighed carefully.

Advantages

1. An established apple orchard in good condition would provide immediate *full-time employment* for the new owner and would produce a *reasonable income* from the start.
2. In general, investment in equipment over the years by the previous owner, would exceed sale value and as a result the *level of re-investment by the new owner would be reduced* in comparison with a new planting of the same area. An orchard between 10 and 20 years of age would usually provide the maximum benefit of this sort.
3. Existing permanent staff and some casual workers would probably continue to work on the property which would solve any labour problems.
4. Usually an established orchard would contain a house. This may be convenient if the new owner wished to live on the property. Alternatively an old house in sound condition may sometimes be converted into a useful storage space or even provide building materials for a new shed.

Disadvantages

1. An established orchard, over 20 years of age, would require a *continuous programme of tree replacement* as old trees 'decline' in health. The cost of replanting and training new trees would be an added expense, and non-productive trees would reduce total yields. Younger orchards between 10 and 20 years of age would remain in full production and should not suffer from this disadvantage.
2. Total yield per acre may be *limited by the waste space* between trees, according to the planting pattern used in old orchards. Changes in tree training technique may be used to reduce this non-productive space to a minimum, but yields would never reach the peak production of the new semi-intensive orchards.
3. The cost of production would tend to increase as trees became older. As the trees become *taller and denser*, the cost of pruning, thinning, harvesting and spraying would increase. In particular, old trees exceeding 25 years of age, would tend to become expensive to manage and this must be considered a disadvantage.
4. *Unpopular varieties may persist* in old orchards, and some of these trees would require to be reworked to new varieties. This would cost money, and the trees may take 3-4 years to return to full production.
5. *Old fashioned or worn equipment* may need to be replaced, and the layout of packing shed or pump-house may be inconvenient. Conversion may be expensive *but necessary* to avoid high labour costs in later years.
6. *Disease and pest control* would generally become more difficult and more expensive in older orchards, and this may reduce fruit value.

Evaluation

When inspecting an orchard the following points should be considered and experienced advice from government departments and other organisations mentioned previously should be sought.

a. Locality
   This will affect cartage and travelling expenses and determine whether roadside sales are feasible.
b. Soil type, drainage and water supply
   Soils should be fertile and well drained. An adequate water supply is essential.
c. Waste Space
   Waste space because of shelter belts, open drains, wide headlands, low-producing or missing trees, deficient, water-logged or diseased soils reduce orchard productivity and should be taken into consideration.

d. Varieties
Low-value varieties are an embarrassment and reduce the potential value of a property. An orchard where the varieties are popular, high yielding and selected to ripen over a long period is most desirable.

e. Rootstocks
Trees planted on Malling XVI tend to be relatively short-lived and may require replacement by the age of 15-20 years. Trees planted on the rootstocks recommended later in this booklet are likely to be the most valuable.

f. Age of Trees
In general, healthy trees between the ages of 10 and 25 years can be classified as mature trees, and these should be estimated at maximum value. Younger trees will be immature and produce relatively low yields of poor quality fruit. Juvenile trees of the standard type, less than 5 years of age, produce no yields.
All trees exceeding 30 years of age are likely to decline in vigour and require replacement and should be devalued.
Trees over 20 years old gain in volume and height and this increases spraying, pruning, thinning and harvesting costs.

g. Buildings and Equipment
These should be thoroughly inspected to ensure they are sound and will not incur heavy additional costs for extension or repair.

h. Labour
The labour force *may* be inherited from the previous owner. An established orchard has an immediate requirement for experienced labour—generally one permanent hand per 4 ha of mature orchard and up to 7 casuals for the four month season are required.

i. Finance
Finance requirements should be accurately assessed before apply for loans. An account of proposed expenditure and levels of income for a 5 year period should be prepared. Working capital requirements for several thousand dollars per hectare may be serviced by short term finance.
After purchase, a detailed budget to cover the following 10 years operations should be prepared.

11

Culture of Apples

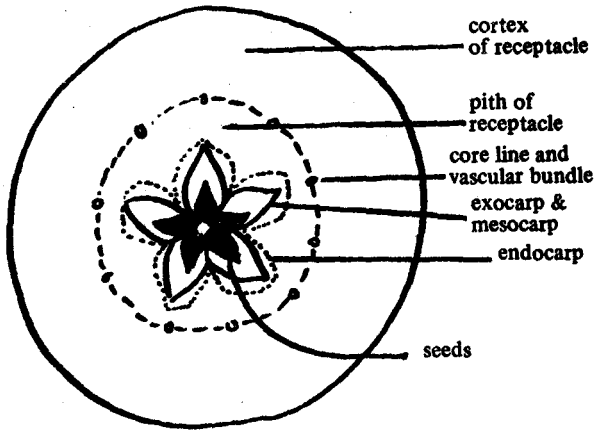
THE COMMON APPLE (*Malus domestica*) probably has no single wild parent but is a collection of clones from hybridisation between *M. sylvestris* and *M. punila* species native to Western Asia. They were probably introduced into Europe in prehistoric times. After grapes, citrus and bananas, apples, with an annual world production of 20 million tonnes, is the most important fruit crop. The following countries produce annually over one million tonnes:—France (2.8); U.S.A. (2.8); Italy (1.7); West Germany (1.9); Japan (1.1). Australia produces 452,000 tonnes and New Zealand 128,000 tonnes (1971). Many of these apples, especially in European countries, are used for the production of cider.
In 1972 New Zealand produced 150,000 tonnes. In order of importance the main districts are: Nelson and Marlborough, Hawkes Bay and Gisborne, Auckland and Waikato, Canterbury, Central Otago.

A. BOTANY AND GROWTH

The apple belongs to the family *Rosaceae*. Flowers are produced in umbellate clusters of 5-8. The mixed bud contains approximately the same number of primary leaves which appear at the same time as the flowers. At the base of the bud a secondary of bourse shoot appears a little later which continues the growth of the branch or spur. The central flower, which is called the king flower, tends to open earlier than the rest and is slightly bigger.

Flowers contain 5 sepals, 5 petals, 5 pistils (5 carpels) and about 20 stamens. Flowering occurs in October, nearly one month later than stone fruits. There seems to be no correlation between the time apples flower and the time they mature.

Apple growth is of the simple sigmoid pattern.
A cross-section of the mature fruit is shown in the diagram.



Each carpel may contain 0, 1 or more seeds. Fruits with more seeds tend to be larger, and uneven distribution of seeds can lead to uneven growth of fruits—why is this?

Most flowers and fruits are borne on spurs carried on 2 year or older branches. Some however, result from buds formed at the tips of one-year-old shoots and in certain varieties, such as Irish Peach, Rome Beauty, Gravenstein and its sports, tip bearing is more common than spur bearing.

B. CLIMATIC REQUIREMENTS

Apples are found over a wide range of climatic conditions, but predominate in the cool temperate zones. This is because of the winter chilling requirement of their buds. If chilling is not forthcoming many buds fail to open, shoot growth is weak, crops are small, and flowering and ripening takes place over a long period.

1. *Temperature Effects*

(a) *Frosts.* Although the apple is resistant to very cold temperatures in winter, as soon as spring growth begins this resistance is lost. Temperatures below freezing can either completely kill the flower or fruit or may later cause russetting malformations. The most dangerous situation is when an early warm spell is followed by a cold snap—the warm period induces early growth which is accompanied by reduced resistance to frost. In areas susceptible to spring frosts it would be desirable to keep the trees dormant as long as possible, yet no satisfactory method has been found to do this. Inhibitors in theory should help but so far no promising results have been gained. Temperatures at which damage can occur are:—Open Cluster, Pink, Full Bloom, Petal Fall -2 to -3°C, Small Fruitlets -2°C.

Although frost can cause considerable damage to apples this is seldom as big a problem as stone fruits for the simple reason that flowering, being so much later in apples, occurs in a relatively warmer period of the season. Frost control will be considered in greater detail in the section on stone fruits.

(b) *Other temperature effects.* Temperature affects the rate of growth of apples. High temperatures especially early in the season can advance the time of maturity of a crop by several days. In the U.S.A. the number of days with a minimum temperature above 7°C can be estimated for the first 9 weeks after FB. The figures obtained give a very good idea of the date of maturity. Higher figures indicate earlier maturity. In addition to growth rate, temperature will also affect the shape of apples. Apples in the north tend to be less elongated than the same varieties in the south. Some other effects may be due to a combination of light and temperature, for example, apples on the exposed portion of the tree tend to be more highly coloured and generally keep better in cool store.

2. *Rainfall and Irrigation*

The amount of water required for best growth varies with soil conditions. Where there is lack of water trees often produce small fruit of excellent keeping quality. Colour may be dull and become more bronze than red if the supply is inadequate during the weeks prior to harvest. In a wet season, particularly if soil nutrients are readily available, fruit is likely to be large and of poor colour. Such fruit are unsuitable for long storage.

Irrigation is now becoming much more widely used in orchards in N.Z. There are two reasons for this. Firstly sprinkler irrigation can give good frost control in spring as well as providing increased yields when applied later in the season. Secondly, the advent of trickle irrigation has made a cheap and effective method available in these orchards where frost is not a problem. You will hear more about irrigation in lectures.

3. *Winds*

High winds may reduce fruit set by interference with pollination and also cause losses due to fruit drop and skin blemishes. They may delay application of sprays so that these are not applied at a critical time. Shelter belts are often quite useful but also have disadvantages. They take up considerable space, they restrict growth of adjacent trees due to root competition and light interference, and they cost money to cut and trim. Sometimes losses due to these factors may exceed the losses due to wind damage in an unsheltered orchard. It may be advantageous to plant shelter belts for protection while the trees are young and remove them when established, allowing the outer rows of trees to provide the majority of wind protection. A new development in wind protection is the use of high fences of wire netting to cut down the flow of air. Although expensive they are quite effective, are quick to establish and do not take space, interfere with light, or provide root competition. We will discuss shelter in a little more detail in a separate lecture.

C. SOILS AND FERTILISERS

Apples will grow on a wide range of soil types and in fact will produce crops where few other plants are economical (e.g. the Moutere Hills of Nelson). Nevertheless they do grow and produce better crops in good deep well-drained soils and these should be chosen whenever possible. The best pH range seems to be 5.5-6.5 although they

will grow between pH 4.5 to 8.0. Some rootstocks have a greater tolerance for poor soil types than others.

Before buying or planting an orchard it is wise to have a complete soil analysis done on the property to find whether there are any major deficiencies and, if so, whether they can be easily rectified. Soil analysis, however, does not give a satisfactory measure of nitrogen levels and the only effective method of determining this is by leaf analysis. Before he can get a leaf analysis done a grower must gain the approval of his local Ministry of Agriculture Adviser. No fertiliser can be recommended for general use since requirements in different districts vary so widely.

D. VARIETIES IN NEW ZEALAND 1971

Variety	Trees	% Inc, Dec. 1968-71	Harvesting Period
Gravenstein (incl. red strains	64,000	+ 12	Early Jan-Feb.
Cox's Orange	162,000	+ 14	Early Feb-March
Gala	36,000	+495	Early Feb-March
Kidd's Orange Red	44,000	- 1	Late Feb-March
Spartan	11,000	+102	Late Feb–March
Golden Delicious	196,000	+ 42	Late Feb-Mid April
Jonathan	91,000	- 15	Early Mar-April
Red Jonathan	10,000	- 23	Early Mar-April
Delicious	117,000	- 8	Early Mar-April
Red Delicious	221,000	+111	Early Mar-April
Sturmer Pippin	228,000	+ 5	Late Mar-May
Splendour	30,000	+ 57	Late Mar-May
Granny Smith	441,000	+ 48	Mid April-May
Rome Beauty	19,000	- 3	Mid April-May
Dougherty	19,000	- 2	Mid April-June
Red Dougherty	49,000	+ 85	Mid April-June

E. NEW VARIETIES AND VARIETY SELECTION

Most work on the selection of new varieties has been done by Dr. D. W. McKenzie of Plant Diseases Division, D.S.I.R., in Havelock North. Dr. McKenzie collected, mainly from overseas, over 900 varieties which were grown on dwarf rootstocks in Hawkes Bay. Promising varieties were further tested for such qualities as flavour, cooking ability, storage ability, appearance, resistance to diseases and pests, yields, etc. Out of this vast number of apples he found very few which were as good as the present varieties being grown and even fewer which looked like replacing existing varieties. The two which seemed to show the most promise were Gala and Splendour; both originated in New Zealand. Gala was bred by Mr Kidd of Greytown and Splendour was a chance seedling found in a Napier garden. Gala has proved very popular. In 1972 it was, after Red Delicious and Granny Smith, the most popular variety being planted. Splendour has all the qualities an apple should have—good colour, flavour, and storage but it has been found to have one serious drawback—the skin is thin and the apple is too easily damaged, for this reason many growers have pulled out trees they planted. If it can be harvested without damage however it is a very popular variety with the consumer. Spartan was another variety recommended by Dr. McKenzie—it is a deep red apple which has quite good prospects as an export apple—but it has not been nearly as popular with growers as Gala and Splendour.

Most apple varieties grown are the result of chance seedlings or sports. No seedling will resemble either of its parents in all details and most are inferior to both. Nevertheless occasionally a seedling occurs which has desirable properties and is worth propagating further by vegetative methods. Occasionally a portion of a tree such as a branch may mutate with the result that the leaves, fruit, or some other tissue is distinctly different from the rest of the tree. Quite often colour mutations (sports) are found and these may be of considerable value. With the present market conditions favouring bright red apples, red sports of common varieties have been extensively sought and propagated.

The varieties listed above are those of which there are more than 10,000 trees in New Zealand. You will notice that standard varieties like Delicious, Dougherty and Jonathan are decreasing in numbers while red sports of Delicious and Dougherty are increasing. Most of the remainder except Rome Beauty are growing in numbers. None of the older varieties like Lord Wolseley, Ballarat, Dunn Favourite, Statesmen are now recommended. There is in fact a world wide trend to reduce the number of varieties grown, limit the use of culinary apples to perhaps a few early ones like Gravenstein or dual purpose ones like Granny Smith, and use as far as possible, varieties which are bright red or bright green.

The following very early varieties can be recommended for limited local sales:

Lord Nelson, culinary—pre Christmas; Scarlet Pimprnel—Dec. 20-31; Early McIntoch—Jan. 1-7; Lobo—Feb. 7.

The variety list is not a blanket recommendation for all districts. This is, in fact, a common misconception and one that will have to be rectified. Granny Smith is really a northern variety and not 100% successful in Canterbury and southern districts. On the other hand Red Delicious is the ideal apple for the south and much less useful in Auckland. Russet susceptible varieties are not so good in the north, e.g. Golden Delicious, Splendour, Kidd's Orange and Cox's Orange but excellent in the south. Splendour may have a tougher skin in southern districts.

Budwood selection is very important from the point of view of variety improvement. For instance we now have a Red Kidd's Orange with some russet-resistance called Captain Kidd, which will transform the variety from a position of declining value to a rapid return to full popularity. Without sports like Hawkes Bay Red Delicious and Red Dougherty we would not be able to compete with foreign producers. A vigorous policy of further selection in the field is being instituted and in coming seasons great emphasis will be placed on the location of improved mutations in commrecial orchards notable for brighter red colour and russet-resistance.

We still require a good late red export apple to replace Red Dougherty which has very inferior eating quality. Because Dr. McKenzie was unable to find one in his varietal assessment he is being forced to breed for it. This is being done by crossing Red Dougherty for colour, keeping ability, and lateness with Golden Delicious for eating quality. The seedlings are now coming to production and are being assessed for their suitability.

After selection of budwood for variety improvement it is important to ensure that it is free of virus. This normally means that the material should be sent to P.D.D. in Auckland for virus elimination.

F. ROOTSTOCKS

Rootstocks are used for the following reasons:

1. Varieties do not come true from seeds.
2. Few varieties propagate easily from cuttings and the root systems they make are seldom satisfactory.
3. The vigour of the tree can be determined by selection within a range of rootstocks of known vigour.
4. Rootstocks can also be selected which are suitable for various soil types or which may have resistance to certain diseases.
5. Fruit quality and earliness of cropping are also influenced, and can therefore be predicted, with rootstocks.

Main rootstocks in New Zealand

Northern Spy. This makes a good medium-sized tree, it is resistant to woolly aphis and comes into bearing at a reasonably early age. Once almost the only rootstock used, it is still considered valuable for new plantings. It is not recommended for replacement trees.

The East Malling series. These originated at East Malling in England in 1927.

(a) *Very Dwarf*
M IX—used in New Zealand only for home-garden trees. Produces early crops but the tree is weak and usually needs staking.

(b) *Semi-dwarfing*
M VII and M IV—again mainly used for home gardens. Make good small garden trees and suitable for cordons and espaliers. Now being replaced by MM 106.

(c) *Vigorous*
M II—although popular overseas it has proved less suitable for commercial planting in New Zealand than M XII or M XVI and is seldom used.

(d) *Very Vigorous*
M XII and M XVI—have been planted extensively but are now being replaced by MM 115 and Merton 793 respectively.

The Malling Merton Series. One of the chief drawbacks of the Malling series is their susceptibility to woolly aphis. The Malling Merton series were bred jointly by workers at East Malling and at the John Innes Institute at Merton. They have generally a higher resistance to woolly aphis.

MM 115 has similar size to M XII
MM 106 has similar size to M IV and VII
MM 109 and 111 have similar size to M II

M XXV has similar size to M XVI. All except M XXV have resistance to woolly aphid although even this is generally better than the Malling series.

The Merton Series. Bred or selected by the John Innes Institute. Four stocks are common overseas; arranged in order of increasing vigour these are 778, 789, 793, 779. Merton 793 is the most promising, having resistance to woolly aphis and collar rot.

Generally we now recommend MM 106, Northern Spy, Merton 793 and MM 115.

Malling XVI is no longer recommended because of poor yields and 'tree decline' in older trees, and Merton 793 will take its place.

Malling XII will soon be dropped because of excessive vigour, light crops and poor nursery behaviour and will be replaced by Malling-Merton 115.

For good soils the preference is for MM 106 used in *semi-intensive plantings* or Merton 793 to produce equivalent trees on poorer soils.

Current planting and replacement recommendations for *normal orchards* with standard trees are as follows:—

New ground—good soil
- Merton 793 for *weak* varieties
- Northern Spy for *strong* varieties

New ground—poorer soil
- Northern Spy or Merton 793 for *moderate to strong* varieties
- MM 115 *weak* varieties

Replanting
- Merton 793 *good soils*
- MM 115 *poor soils*

The following groups of varieties are arranged according to their vigour as scions:—

Group 1 (most vigorous) Gravenstein, Lord Nelson
Group 2 Kidd's Orange
Group 3 Delicious, Splendour, Ames, Gala, Cox's Orange
Group 4 Granny Smith, Frimley Beauty, Spartan
Group 5 Golden Delicious, Jonathan, Dougherty, Summerland.
Group 6 (very weak) Sturmer, Democrat, Statesman).

G. FRUIT SET

Most apple varieties are partly self-fruitful and may set fair crops without cross pollination. However, cross pollination usually leads to better set and interplanting of varieties is common practice.

Ideally the pollen trees should not be more than two rows from the variety to be pollinated. Triploid varieties such as Gravenstein can be pollinated by diploid ones but the pollen from the triploid is generally poor and will not fertilise the diploid. Closely related varieties, such as bud sports and their parent varieties, may be cross incompatible (e.g. Delicious and Red Delicious). Obviously pollinators should be good commercial varieties, should flower at the same time as the main variety and should not be biennial bearers. It may also be desirable to choose a variety which is sufficiently different in appearance from the main variety for inexperienced pickers to detect.

The Ministry of Agriculture holds lists of good pollinating varieties and these should be consulted when planning an orchard.

H. BUD INITIATION AND BIENNIAL BEARING

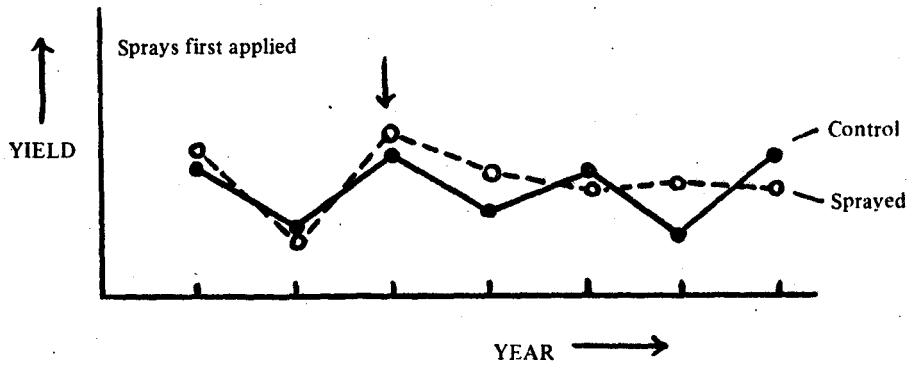
Revise the process of bud initiation in pome fruits (7. Buds and Their Development).

Biennial bearing is chiefly a problem in apples although it does occur in pears, some plums and some tropical fruits. It means the alternation of a heavy crop with a light crop and it usually involves the whole tree or even the whole orchard. However, it can also be apparent in individual branches which may become "out of phase" with the rest of the tree.

Biennial bearing often begins with some event such as frost or disease causing a severe reduction in crop in one particular year. The energy which would have been absorbed by the fruit presumably is directed into the formation of buds. Next year there is a heavy crop which in turn *limits* bud formation and so the cycle is established.

The control of biennial bearing depends on influencing 'on' and 'off' crop trees in such a way that they behave more like their respective opposite in any one year.

A spur which fruits in one year rarely carries fruit the next—i.e. *individual spurs* exhibit a biennial tendency. Biennial bearing occurs when all the spurs on a tree are in phase. One obvious way to reduce the effect of fruit on biennial bearing is to thin heavily in the 'on' year. However, it has been found necessary to thin *within 3-4 weeks from FB* to significantly affect biennial bearing. The only economical and practical way to do this of course is to use chemical thinners at



or near blossom. The promotive effect of sprays on blossom formation in the 'on' year is dependent on tree vigour. Trees of low vigour will not necessarily show a repeat of blossom the following spring.

The diagram shows the spectacular effect of chemical-thinning sprays over a period of eight years. With establishment of more regular bearing habit overall yield increases of up to 25% have been recorded. With some varieties (e.g. Golden Delicious) the pattern of biennial bearing can be broken with only one spray, with others repeat applications may be required (e.g. Statesman) although the concentration can often be reduced in later years. There seems to be no difference in the response to various sprays now used for thinning.

The Physiology of Biennial Bearing. In some way or other the presence of fruit tends to inhibit the development of flower buds. It may do this in several ways. *Firstly* the demand of fruits for nutrients may be so high that there are insufficient to allow initiation of flower buds. *Secondly* it has been found that there are more leaves on non-bearing spurs than on bearing ones and that a certain leaf area per spur is necessary for satisfactory initiation. Thus fruits, by inhibiting growth of leaves, may indirectly depress initiation. *Thirdly* growing fruits are active sources of growth substances and it may be that the balance of hormones produced are inhibitory to initiation.

The effect of fruits on leaf area is interesting and it has been suggested that by reducing leaf area in the 'off' year we might reduce the heavy crop next year and thus even out the biennial bearing cycle. However this does not seem as easy to do or as effective as the method previously described of thinning fruits in the 'on' year.

In considering hormones as reasons for phenomena such as biennial bearing we ought to look at the areas in the plant which actively produce them. These are the leaves, especially young leaves and shoot tips, the cambial layers, the fruits, especially the seeds, and the root tips. All these will be contributing to the overall hormone balance in the plant and the balance at any particular point will also be affected by its proximity to sites of production. Thus the hormones in developing buds might be particularly dependent on the fruits and leaves in the vicinity. Changes in the ratio of the two would change the balance of hormones and the propensity of buds to produce flowers. When we also consider that leaves by producing food materials and fruits by consuming them also affect the nutrient availability, we can see how complicated the whole process is and how difficult it is to arrive at a simple explanation.

Not all buds bear biennially. On our best varieties, young buds bear heavily every year, but as soon as a spur exceeds the age of 5-6 years, it becomes weakened and begins to crop biennially. Renewal of old spurs overcomes this problem. If a mature tree is improperly pruned and left with a lot of old spurs intact, the whole tree will bear biennially.

I. FRUIT THINNING

(See Davison, R. M. 1966. Chemical thinning of apples in New Zealand. *D.S.I.R. Information series No. 60.*)

1. *General Considerations*
   Under conditions where a heavy set of fruit takes place on apple trees, some thinning is usually required to produce good-sized clean fruit, to avoid biennial bearing, or to prevent limb breakage. The amount of thin-

ning required varies between varieties and also between fruitgrowing districts. It may also be conditioned by climate and market requirements. Growers may tend to thin less in areas subject to late frosts, heavy winds or hail—under these conditions he may prefer to harvest a crop of small fruits than run the risk of losing everything. Market requirements are also important—Consumer preferences do change and at one stage large apples may gain best prices while at another smaller apples may meet the demand. Apples grown for processing or for long storage may be required to be within certain specified size ranges.

Normal thinning seldom reduces yield unless it is excessive, or climatic factors cause heavy post-thinning losses as mentioned above.

Apples require 30-50 leaves per fruit to come to size under most conditions.

Dougherty nearly always sets very heavily and generally need most thinning. Granny Smith, and sometimes Jonathan, are regarded as self-thinning varieties and need little thinning. (The tree tends to adjust the crop load by shedding of fruitlets).

2. *Timing the Thinning Operation*
From the point of view of optimum yields under ideal conditions the earlier the crop is thinned the better (why?), however, a number of factors mitigate against this. Thus natural drop, frost, or wind damage, may occur after thinning and cause overthinning. If thinning occurs later a better idea of the amount of thinning can be obtained. In many crops (pears, stone fruits) thinning sprays are not generally effective and hand thinning at an early stage is too costly.

3. *Type of Thinning*
(a) Hand Thinning. This is certainly the most accurate method but on a commercial scale it is extremely costly (220 man hours/hectare or 17% of the total cost of production) and may be the highest single cost item in an orchard.

There is no reliable guide to the amount of thinning required; as a general rule trees are thinned so that there is fruit to every 3in. of fruiting lateral, but this could be modified according to vigour of the tree or the amount of leaves produced. There are some other guides which are occasionally used. These are (a) no. of leaves per fruit, (b) no. of fruits (on a whole tree) per inch butt circumference, and (c) size at reference date. These are of course too time consuming for use on all trees and are usually applied to one or two trees in a block to set standards for thinning by the spacing method.

Reference date refers to a period in the development of the fruit when experience shows that the size of fruits correlates closely with their size at maturity. If therefore the size at reference date is too small then heavy thinning may be required to produce the required size at maturity.

Why do you think these methods have not become established in New Zealand?

(b) Chemical thinning. The aim is seldom to thin completely by these methods but to remove about 70% of the **surplus** blossoms leaving 30% margin for safety which is later thinned by hand if necessary.
Materials used:—

(i) *Dinitro materials,* e.g. sodium dinitroorthocresylate (DNOC), are applied at or near full bloom. They seem to have a burning and debilitating effect on open blossoms, leaving unopened blossoms unharmed. They should be applied when 80% of blossoms have opened using 0.02-0.03% active ingredient. Some damage to primary leaves may result but this is not generally serious. Delicious, Cox's Orange and Kidd's Orange are not suitable for thinning with this group of chemicals.

(ii) *Growth substances,* e.g. alphanaphthaleneacetic acid (NAA), alphanaphthaleneacetamide (NAAmide). The mode of action is unknown although it probably somehow interferes with the internal hormone balance. They have the advantage over DNOC in that they can be used over a longer period. This makes it possible to gain a better idea of natural set. Best time of application is at 100% petal fall, or 10-12 days after FB, but they can be applied as

late as 24 days after FB. Concentrations:—NAA use 5-20 ppm, NAAmide 25-50 ppm. Higher concentrations will be needed at later stages of application. It is generally advisable to add Tween20 to the spray and this enables the concentration to be reduced one-third or one-half. Some flagging of foliage is often found after spraying but this is reduced if lower concentrations are used together with Tween20. Flagging is most severe on Kidd's Orange and Delicious. Cox's Orange, Kidd's Orange and Sturmer should not be thinned with NAA or NAAmide.

Some side effects. (1) Retention of small fruits. These fruits would normally drop but this is prevented by the action of the spray. Most noticeable on Delicious and on this variety and for this reason NAAmide should not be used. It is also more common with late sprays. (2) Inhibition of fruit growth. This is serious on Cox's Orange only. (3) Russet development. There can be slightly more russet on russet-susceptible varieties. (4) Fruit maturity. This can be advanced, especially on Sturmers which do not store well after thinning with hormones.

(iii) *Carbaryl* (Sevin). This compound was originally marketed as an insecticide but was later found to have thinning properties. It will thin at any time from FB to some four weeks later, however, it should not be used during blossoming since being an insecticide it will kill bees. Suitable time is FB + 10 days. Carbaryl is used at 1-2000 ppm generally without an additive such as Tween20. Cox's Orange and Sturmer thin readily and may need lower concentrations. There has been no reported leaf damage due to carbryl, although some russetting on Delicious has been found.

Since overthinning is very easy with chemicals of any sort, the following table is given summarizing the conditions under which sprays may overthin.

Tree Factors	Environmental Factors
Weak Trees	High humidity for several days preceding application
Weak spurs and wood	
Trees badly pruned	Slow rate of drying
Trees too closely spaced or shaded by shelter belts	Moderate rain within several days following application
Inefficient pollination	
Young trees	

Some practical aspects

1. Because thinning sprays tend to overthin the lower parts of the tree these areas should be avoided whenever possible during spraying.
2. High volume sprays are more reliable than low volume sprays.
3. It is often wise to go through the orchard carefully and pick out any trees with light blossom so that these can be avoided or sprayed very lightly.
4. Double thinning using DNOC at blossom at low concentration followed by NAA or Carbaryl later has obvious advantages.
5. Advice of the Ministry of Agriculture should always be sought before thinning. They should be able to advise the grower on any recent developments in this field.

J. PRUNING

1. *The Aim of Pruning* (Some people prefer the term tree training—pruning always suggests cutting back and we do less hacking now, particularly in young trees.)
   (a) To provide, as quickly as possible, a strong framework in young trees to carry fruit, and eliminate the need for extra support in older trees.
   (b) To encourage the production of maximum yields at all times for the least effort, i.e. lowest cost.
   (c) To ensure light penetration, to promote fruit bud formation in all parts of the tree, and provide adequate fruit colour.
   (d) To permit easy access for spray penetration and provide good pest and disease control.
   (e) To promote easier harvesting—manual at present but possibly mechanical in the not-too-distant future.
   (f) To eliminate biennial bearing in mature trees by renewing ageing fruit-spurs.
   (g) To remove diseased or damaged wood.

Pruning generally depresses yield—at least in the short term—and delays the time when a young tree will produce a reasonable crop of fruit. Therefore the less we prune the sooner will we get a return on our investment. Modern pruning attempts to achieve the above aims with minimum effort and minimum disruption to the growth of the tree.

2. *The Response of Trees to Pruning*
Most trees are pruned in the winter (dormant pruning) but on certain occasions summer pruning is beneficial. We shall consider winter and summer pruning separately.

Winter Pruning
Heavy dormant pruning has an invigorating effect on the shoots which are produced the following year, even though the total growth of shoots will be less than if the tree had not been pruned or was pruned only lightly. After pruning, branches are longer because of longer internodes, leaves are larger and deeper green, shoots are more succulent and they continue to grow for a longer period. In many respects the growth of a heavily-pruned older tree has many similarities to that of a vigorous young tree.

Normally pruning a proportion of a tree will invigorate the new branches over *all* the tree. Thus, if one side of the tree is weak it is no good pruning that side hard to invigorate the next year's branches. It would in fact be more effective to heavily prune the vigorous side of the tree. If however the tree is somewhat deficient in nitrogen, is generally weak, or is bearing heavy crops, localised pruning may invigorate only the pruned section of the tree.

How Winter Pruning Invigorates Shoot Growth
A tree which has been heavily pruned has less buds available to shoot the following season. Because of this the stored food materials are available to fewer branches which can then make greater growth. The roots of course are undisturbed and the supply of nutrients and water available to the reduced number of branches is also greater thus also encouraging further growth. By the end of the season, however, the roots and shoots have compensated in their growth for the inbalance caused by heavy pruning and the invigorating effects of pruning usually only last for one season. Spring growth is dependent on food materials which are stored over winter in roots, trunks and particularly young branches. Because heavy pruning removes a considerable proportion of the latter the total shoot growth is less and we must re-emphasise that the invigorating effect refers only to the remaining shoots and not to the total growth of the tree. The larger number of shoots on an unpruned tree means more leaves which in turn produce more photosynthates for growth and storage.

Effect of Winter Pruning or Fruiting
Heavy pruning reduces flowering not only by removing wood on which flowers might be produced but also because the resultant longer period of shoot growth inhibits flower production as it does in young trees. Possibly the extended growth into the season leaves less time for the process of flower initiation or the hormone balance is somehow changed to one unfavourable to initiation or alternatively nutrients used for the additional growth are unavailable for flowering.

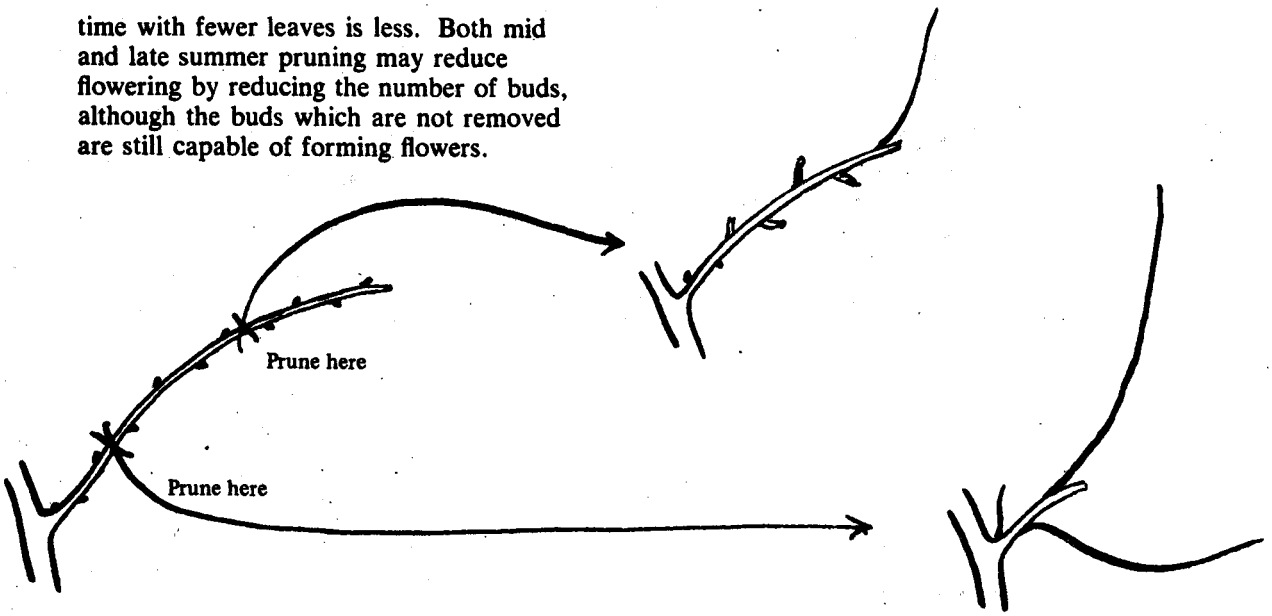
Summer Pruning
In Spring, deciduous trees make a flush of growth which lasts for several weeks, this is followed by a period of rest which occasionally is followed by one or more shorter flushes. The time of summer pruning is important.

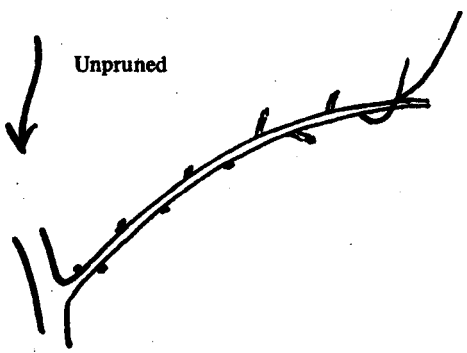
If trees are pruned before the first growth flush has finished it causes further compensatory growth which prolongs the total period of vegetative growth and flower-bud initiation is slightly reduced due to the extra effort the tree has to make up for the loss due to pruning.

If trees are pruned after shoot growth has finished a few buds may burst, but usually little further growth is made till next Spring. Because the amount of leaf surface is therefore reduced for a good part of the season the production of photosynthates is reduced and the treatment reduces the vigour of the tree.

Late summer pruning has a similar but smaller dwarfing effect since the amount of

time with fewer leaves is less. Both mid and late summer pruning may reduce flowering by reducing the number of buds, although the buds which are not removed are still capable of forming flowers.

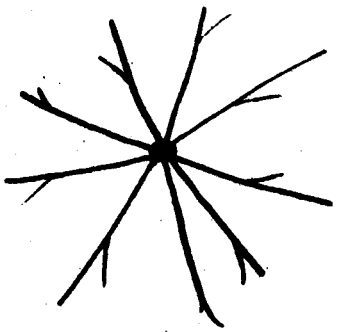




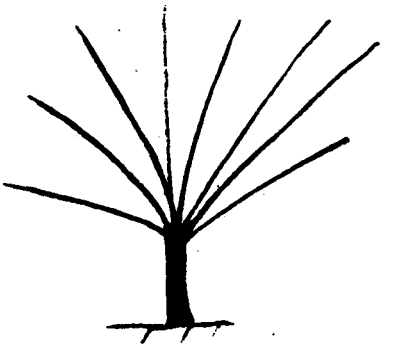
3. *Pruning Practices*
In the past considerable attention was paid to the pruning of each tree but nowadays, with the increase in the cost of labour and the realisation that a tree does not have to look neat and tidy to produce good crops, pruning is quite different. The old way was to treat most one-year-old laterals on main leaders in one of several ways; if they were required to produce spurs the following season (remember apples and pears fruit on two-year-old wood) they would be shortened back by ½ or ⅓ to encourage the spurs to form close to the leader. If further growth was required they would be pruned hard to discourage the formation of spurs and stimulate vegetative growth.
Nowadays pruning is generally less fussy. Large branches over the tree are left unpruned for several years and each year a proportion of these are cut back hard to gradually replace the old ones. This is known as the renewal system and is less demanding on labour.

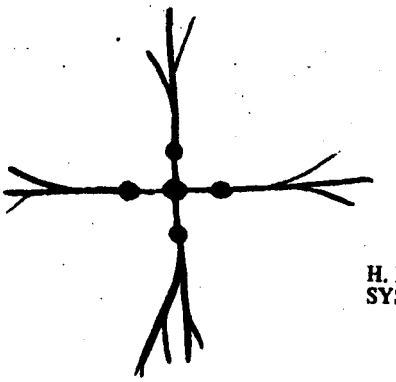
4. *Training Methods*
Apple branches which are horizontal are less likely to make vigorous growth than vertical ones, they are also more likely to initiate flower buds than vertical branches. Thus we have two ways of limiting growth on a tree, one is by pruning, the other is by encouraging horizontal branching. The latter, where applicable, is much the better way since it does not reduce leaf area and tree development and stimulates flower-bud initiation. You will see later how modern pruning methods rely on the training of branches horizontally to provide quicker and heavier yields.

There are many ways of training apple trees but the one which was almost universal in New Zealand until fairly recently was the vase system. This was replaced in Hawkes Bay by a method known as the Hawkes Bay System and later by the Centre-Leader method. Now also some trees are grown as hedgerows. These are shown diagrammatically below and you will hear and see how to train trees in this way during your course.

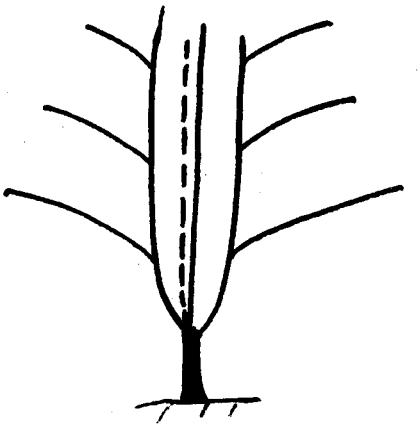


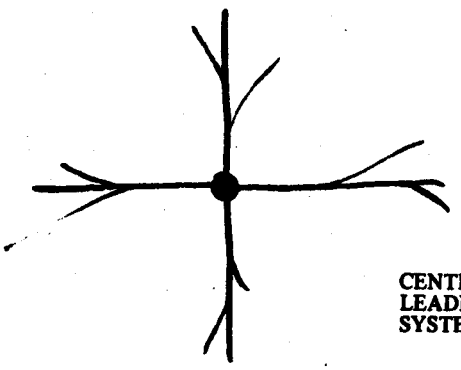
VASE SYSTEM



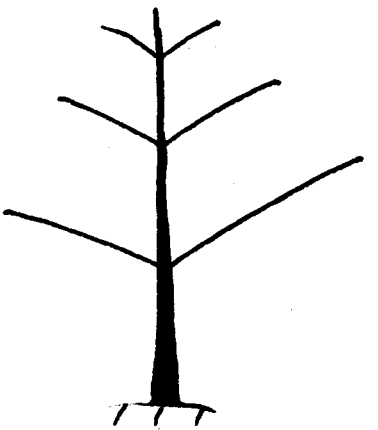


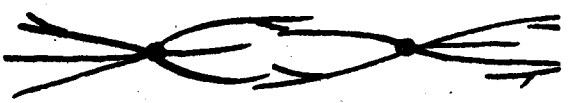
H. B. SYSTEM



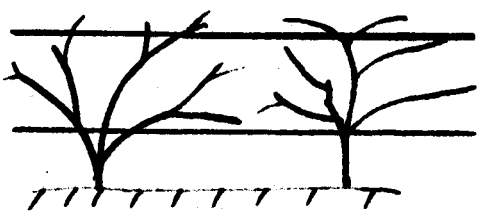


CENTRE LEADER SYSTEM





HEDGE SYSTEM



Other training methods are also being tried and we will see and discuss these during the year.

K. HARVESTING AND MARKETING

No formal lectures are given on this topic.

From your own experience and from the information you receive on field trips you should collect data on the following.

1. The Apple and Pear Marketing Board; history, organisation, function, advantages and disadvantages.
2. The harvesting operation; when to pick, how to pick, containers to use, mechanisation (tractors, fork lifts, bulk bins, graders, etc.), packing, apple grades, wraps, boxes or cartons, the use of labour.
3. Other avenues for marketing; gate sales, sales to processing firms, etc.
4. The importance of disease control to successful marketing.
5. Export and cool storage.
6. Likely trends; mechanisation, mechanical harvesting, packing houses, the future of the A. & P. Board, the modification of orchard practices to suit increased mechanisation.
7. The future of the industry.

L. STORAGE OF APPLES AND PEARS

See Padfield, C.A.S. 1969. The storage of apples and pears, N.Z. D.S.I.R. Bulletin 111 (Revised Edition).

Fruits are harvested over about four months but by judicious storage, marketing can be spread over ten or eleven months of the year.

Ripening and Respiration

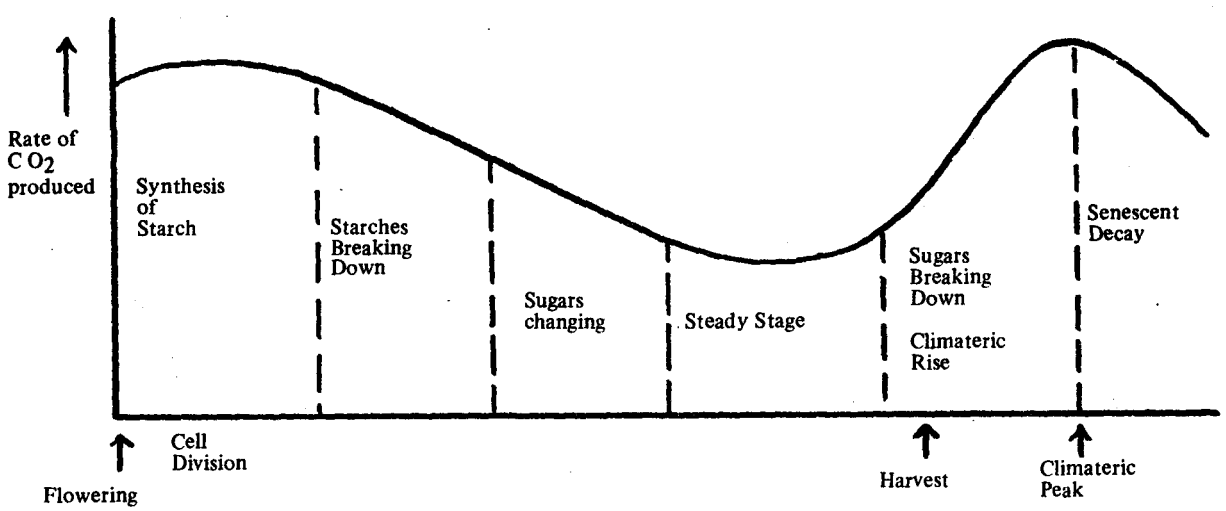
Apples, when detached from the tree, are still living, they may continue to ripen further before senility begins and death occurs. Ripening includes the change of starch into sugar and changes in acids and pectic substances. It involves the production of volatile substances and as esters, acetaldehyde, ethyl alcohol and ethylene. Respiration continues until the fruit is eaten or dies. During respiration oxygen is absorbed, carbohydrates disappear, energy is released, either as heat or for use in vital processes, and the end products, carbon dioxide and water are produced. The *rate* of respiration gives some idea of the changes taking place in an apple.

For maximum storage life and best eating quality the fruit must be picked at a stage after the climacteric rise has started but before the peak is reached. A storage operator's aim is to delay the climacteric for as long as possible.

The most effective way to reduce the rate of respiration is to reduce the temperature at which the fruits are stored. Rates of respiration doubles between 0°C and 10°C and between 10°C and 20°C, it almost doubles between 20°C and 30°C.

Factors governing the successful storage of fruit can be divided into three groups:—1. prestorage conditions; 2. conditions of storage; 3. post-storage conditions.

1. *Pre-storage conditions affecting longevity in store*
   (a) *Varieties.* Late-maturing varieties are generally used, the most common being Delicious, Golden Delicious, Sturmer, Granny Smith and Dougherty apples and Winter Cole, Winter Nelis, and P. Barry pears. Red sports do not generally keep as well as the parent variety, although this is not always the case: Richared



stores better than normal Delicious and the red strains of Dougherty store as well as the standard variety.

(b) *Rootstocks.* These probably have no direct effect on storage.

(c) *Soils.* Generally fruit store better from light sandy loams well supplied with plant foods. Some soils consistently produce apples with poor storage quality and fruit from these should always be segregated from the rest.

(d) *Fertilisers.* These can profoundly affect storage quality. The amount of fertilisers which produces best tree growth and high yields may not give the best-storing fruit. If fruits consistently store badly it is generally advisable to obtain a leaf analysis of the trees in the block to see if any element is lacking or over-abundant.

As a very general rule it can be said that nitrogen will tend to depress keeping quality if applied alone. If, however, it is combined with potassium and phosphorus as a balanced fertiliser the resultant apples may store as well as unfertilised ones. In New Zealand potassium and phosphorus alone have little effect on keep quality. In other words their role (particularly that of phosphorus) is to balance the effects of nitrogen. The form of the fertiliser is not thought to be important.

Any change in cultivation should be considered in relation to the effect on soil nutrient status:—cover crops of legumes will increase nitrogen, grassing down will lower the nutrients available to the tree.

(e) *Water.* Where there is lack of water, trees often produce small fruit of excellent keeping quality, where water is plentiful fruit is likely to be large, of poor colour and store badly.

(f) *Frost and Hail.* Damaged fruits should never be stored.

(g) *Fruit Size.* Large fruits seldom store as well as small fruits and for this reason any measures which promote excessive size, such as pruning or thinning, should not be overdone. Light crops and fruits from young trees should never be stored for long periods, and these fruits should always be separated from the rest.

(h) *Diseases and Pests.* A good spray programme will reduce the carry-over of diseases in store. During harvesting, however, much of the residue is removed and damage by bruising and puncturing should be kept as low as possible since it is through cracks and skin abrasions that much disease enters.

Glomerella and Ripe Spot/Lentical Spot complex

Where this is a problem Difolatan or Dithane may be used instead of the usual Black Spot programme after early December.

Black Spot (*Venturia inequalis*). Late infections on the tree can spread in the store and can provide points of entry for such rots as blue mould (*Penicillium expansum*).

Grey mould (*Botrytis cinerea*). On Granny Smith this can cause rotting around the stem cavity. On pears it can cause serious losses but may be prevented by wrapping in paper impregnated with copper sulphate. Orchard hygiene and careful picking are important.

Leaf-roller and codlin moth. Apples showing visible damage should be rejected.

Mealy bug. These can cause unsightly marks; in addition, honey dew and skin punctures produced by this insect provide points of entry and a good environment for moulds and rots.

(i) *Maturity.* It is important to pick at correct maturity but this is very hard to measure. Because blossom spread is so great in New Zealand it is unlikely that all fruits reach optimum maturity at the same time. Again, some disorders which develop in storage occur more commonly on early-picked fruit while others occur mainly on late-picked fruit. Thus, at best, the estimation of maturity is a compromise. In practice, the Ministry of Agriculture sets picking dates for fruits for storage and export.

Some guides to maturity:

1. Ease of separation of fruit from the spur.
2. Fruit colour; both the underlying ground colour and the degree of redness are used.
3. Seed colour; seeds change from white to brown.

4. Characteristics of the flesh such as resistance to pressure, tensile strength, and electrical resistance.
5. Size of fruit.
6. Number of days after full-bloom.
7. Heat units. These are the number of hours above a certain temperature during growth. When sufficient heat units have been accumulated the fruit is judged to be ready for picking. This method is not yet used in New Zealand. Why?

(j) *Delay between harvesting and storage.* This should be as short as possible. For pears it should not exceed 48 hours. With apples delays are often inevitable and they should then be kept in a cool place with adequate air movement. They should not be packed until just before cool storage.

(k) *Effect of cling sprays.* Fruits which have been kept on the tree with NAA sprays should still be picked at the normal time. Their rate of maturity is not reduced by these sprays and may even be advanced.

(l) *Blemishes on fruit.* Any damage is serious and every possible precaution should be taken.

(m) *Wrapping and other covering materials.* The simple white sulphite paper helps protect and cushion the fruit during transport. Nowadays, chemicals may be incorporated into the wrapping.

(i) Wraps with diphenylamine or mineral oils reduce scald. Diphenylamine and ethoxyquin are also used as post-harvest sprays or dips for scald.

(ii) Copper wraps for grey mould on pears.

(iii) Lining pads. Corrugated all-round pads are used to surround the fruit in the boxes and prevent bruising.

(iv) Waxed liners. These are sometimes placed on the inside of cases as well as corrugated liners to reduce wilting of Winter Nelis and Winter Cole pears and Sturmer apples.

(v) Polyethylene film bag liners. These are also used to reduce wilting. In addition the film tends to cause a retention of carbon dioxide and a reduction of oxygen and thus conditions similar to C.A. storage are created. Golden Delicious stores particularly well in film bags and Sturmer, P. Barry, and Winter Nelis are moderately successful. Polythene hoods are sometimes placed over pallets in cool store to reduce wilting and weight loss.

(vi) Oils and waxes as skin coatings. These might act to preserve moisture in much the same way as wax and plastic film. They are sometimes used to improve the appearance of fruits but not generally to improve storage.

2. *Conditions in the Store*

(a) *Shed Storage.* Well ventilated vermin-proof sheds are required, preferably on a bank with a southerly aspect or on the south side of a shelter belt. Shed storage is used to a considerable extent in Canterbury. The idea should be to keep the temperature as close as 36°F as possible while ensuring that the fruit does not freeze in frosty weather. Two months is about the maximum life that can be expected.

(b) *Cool Storage.* Cool stores must be capable of chilling fruit to the holding temperature within two or three days and thereafter maintaining a constant temperature and a humidity of 80-90%. Under ideal conditions there should be a pre-cooled chamber available to receive fruit immediately on arrival. Naturally fruit should be placed in cool store as soon as possible.

FLESH TEMPERATURES RECOMMENDED FOR LONG STORAGE OF NEW ZEALAND APPLES

–0.5 to + 0.5°C	0 to 1°C	1 to 2°C	2 – 3°C
Delicious	Dougherty	Cleopatra	Ballarat
Granny Smith	Golden Delicious	Firmley Beauty	Bledisloe Cox
			Cox's Orange
Red Delicious	Lord Wolseley	Rome Beauty	Gravenstein
Richared Delicious	Stayman Winesap	Worcester Pearmain	Jonathan
Democrat			Kidd's Orange Red
			Statesman
			Sturmer

Pears. Pears ripen very quickly at ordinary air temperatures, but are not susceptible to low temperature breakdown as are most apples. All varieties can be stored at -1 to 0°C. Freezing points are generally measured for all pear varieties at the beginning of each season since

these can vary from year to year. Winter Cole and Winter Nelis do not develop their best flavour unless they are cool stored. P. Barry is the only other variety commonly stored.

Fruit in cool storage should be inspected weekly and removed when it is considered that there are ten to fourteen days of "shelf" life left.

Effect of temperatures on storage disorders. In general, if apples are held above the optimum temperature for each variety, superficial scald, fungal rots, and bitter pit are liable to appear, while if held below this temperature they are likely to develop breakdown, coreflush, and deep scald. Freezing is always bad. Frozen apples are a complete write-off; frozen pears can sometimes be saved by expert handling.

Ventilation and Cleanliness. Opening and shutting of doors for loading and unloading normally provides sufficient ventilation to guard against the build-up of ethylene or carbon dioxide. However, if a very noticeable 'apple aroma' accumulates or if breathing in the chamber becomes difficult, extra ventilation should be given.

Cleanliness should be practised in cool stores but sterilisation of the stores is not required.

Mixing varieties. Where possible varieties should be kept in separate cool rooms, failing this varieties which require the same storage conditions can be stored in one chamber, providing maturities are approximately equal.

(c) *Controlled Atmosphere Storage (Gas Storage, C.A. Storage).*
In such stores the oxygen is maintained between 2 and 3% and carbon dioxide between 2 and 5%. This type of atmosphere is produced by the natural respiration of the fruit, excess carbon dioxide being reduced by chemical methods. Oxygen is replaced by ventilation if required. Carbon dioxide is absorbed by hydrated lime or by water scrubbing (CO_2 is more soluble in cold water than warm water). Controlled atmosphere storage enables apples to be available all year round and is beginning to be used commercially. The following varieties respond well to C.A. Storage:—
Dougherty (stores till December); Golden Delicious (December); Jonathan (June-September); Rome Beauty (December), Sturmer (December), William Bon Chretien pears store quite well in C.A.

3. *Physiological Disorders*
There are far too many disorders which can occur in stored apples to be considered in detail here. Rather, one or two of the most important disorders will be examined moderately closely. A physiological disorder is any disease that is not caused by a fungus, a bacterium, an insect, or a virus.

(a) *Bitter Pit (B.P.)* Small brown spots in the flesh which most commonly occur near the surface and may show through the skin as circular brown or greenish-brown depressions. If pitting develops while apples are still on the tree it is called "tree pit". Pit is most common in Cox's Orange but can occur in most varieties grown in New Zealand. Pitting is most severe on large apples, in fruit from trees carrying a light crop, in young trees and in trees making vigorous late vegetative growth. Immature fruit are generally more susceptible to B.P. Pit is due to localised deficiencies of the very immobile element calcium. It can be reduced by sprays of calcium nitrate or chloride but not by liming or applying calcium salts to the soil. These sprays of 5-6lb per 100 gal. are best applied at fortnightly intervals from petal fall until harvest, i.e. with normal cover sprays.

(b) *Core Flush (Brown Core).* This is essentially a low temperature disorder which first affects the flesh of the core area between the carpels and later extends throughout the apple. Common in Granny Smith, Dougherty, Cleopatra, Dunn's Favourite, and Statesman. It is more common on immature fruit and can be reduced by warming the fruit to 18°C after varying periods of cool storage. The cause of core flush is not known but it seems to have some relationship to the presence of seeds since if seeds are destroyed by irradiation core flush does not develop. (This method is not commercially succesful).

(c) *Internal Breakdown.* The first symptom of this disorder is a mealiness and brown discolouration of the flesh. Later the fruit becomes soft, is easily bruised, and assumes a dull water-logged appearance. Most varieties will develop breakdown except Delicious, which is very resistant. Low-temperature storage, over-mature fruit, excessive nitrogen fertilisers will increase breakdown. Delay between harvesting and storage increases breakdown susceptibility and large apples are more prone than small apples. Internal breakdown and core flush are generally indistinguishable once they are well developed but in the initial stages the two are quite distinct, C.F. develops from the centre and works outwards, I.B. is usually the reverse. Breakdown is perhaps the most serious disease limiting long storage of apples.

(d) *Superficial Scald.* The skin on infected apples becomes brown, grey-green or almost black. The surface may become slightly depressed or wrinkled but the underlying flesh is not normally affected. Immature fruit is more liable to get scald than mature fruit. Granny Smith, Sturmers, and Delicious are most susceptible. Oiled wraps used to be used to reduce scald on Granny Smiths but diphenylamine (D.P.A.) can now be used as wraps or as post-harvest dips and ethoxyquin ("Stop-Scald") can be used as dips but not in paper wraps. These are more successful than oiled wraps.

(e) *Wilt.* This of course can occur in any apple but Golden Delicious and Sturmer are most susceptible. It is accentuated by early picking, low humidity and high temperatures. Methods to reduce wilt have already been considered. On your visit to the Apple and Pear Marketing Board you should try to find out the normal length of storage of most of the common apple varieties.

M. PEST AND DISEASES

You have already studied, in another course, pests and diseases and their control. There will be no formal instruction in the fruit-growing course on this topic. You are expected to find out in field trips and laboratory classes the major pest and disease problems of apples and be familiar with current methods of control. This should include a knowledge of sprays, spray equipment, biological control and cultural practices required to reduce incidence.

12

Culture of Pears

THE PEAR (*Pyrus communis*) is probably a native of the region north of Persia and was introduced to Eastern Europe in prehistoric times. Annual world production is 7.4 million tonnes. The following countries produce annually over 250,000 tonnes; Italy (1,861,000); France (500,000); U.S.A. (665,000); Japan (470,000); West Germany (403,000); Australia produces 153,000 and New Zealand 20,000 (1971).

In 1972 New Zealand produced 18,400 tonnes. Production of pears has remained static for a number of years now. The main districts in order of importance are Hawkes Bay and Gisborne, Nelson and Marlborough, Auckland and Waikato, Central Otago, Canterbury.

A. BOTANY AND GROWTH

Botanically the pear differs very little from the apple. The chief difference is that the latter have their styles united at the base. Growth and development of the pear is similar to the apple.

B. CLIMATIC REQUIREMENTS

These are similar to the apple except pears are slightly more drought-resistant and more tolerant of waterlogging. They need almost as much winter chilling and have about the same degree of tolerance to frost.

C. SOILS AND FERTILISERS

Again the requirements are similar to apples with the exception that pears will tolerate heavier and wetter soils than apples.

D. VARIETIES IN NEW ZEALAND

Variety	Trees 1968		Harvesting Period	Main Areas
	0-5 yrs	Total		
William's Bon Chretien	17,359	87,558	Late Jan. - Feb.	Hawkes Bay Nelson
Packham's Triumph	6,036	24,078	Late Feb. - Mid April	Nelson /Hawkes Bay
Winter Cole	3,210	31,656	Early March-Apr.	Hawkes Bay /Nelson
Winter Nelis	2,843	20,325	Mid March-April	Hawkes Bay

Other varieties of lesser importance include Louise Bonne de Jersey (ripening in February), Beurre Bosc (Feb.-Mar.), Conference (Feb.-Mar.), Doyenne du Comice (March), Kieffer's Hybrid (March-April), P. Barry (April.) Most of these varieties except Conference, Beurre Bosc, W.B.C. and Kieffer's Hybrid store well and are exported. W.B.C. is the main canning variety although Conference and Kieffer's Hybrid are also suitable.

Most of the pear varieties grown are very old varieties. For example, W.B.C. originated in 1770, Doyenne du Comice 1840, Beurre Bosc 1807, Louise Bonne de Jersey 1788. Packham's Triumph and Winter Cole originated in Australia at the end of last century and the beginning of this. There are at the moment no promising new varieties.

F. ROOTSTOCKS

Pears are normally grown on seedlings from William's Bon Chretien and these produce trees comparable to the more vigorous apple rootstocks. Unlike apples there is no suitable range of size-controlling rootstocks; some selections of quince rootstocks are suitable but these are fairly heavily infected with various virus diseases. Virus-free stocks have been obtained by the D.S.I.R. and limited quantities of these are becoming available.

G. FRUIT SET

Most pears are partially or wholly self-sterile and pollinators are always recommended. Nevertheless natural parthenocarpy does occur in most varieties and can, to some extent, offset the lack of fertilisation (although non-fertilised fruits seldom have the even and attractive shape of fertilised fruits). Pears are one of the few tree fruits where application of hormones to aid set may have beneficial effects. Gibberellic acid sprayed at blossom has (a) overcome the effects of frost, (b) promoted fruit formation after poor setting conditions, and (c) stimulated early cropping of young trees. As yet these results have not been applied to New Zealand conditions.

Pollinators

William's Bon Chretien is effectively pollinated by W. Nelis.

Parkham's Triumph is effectively pollinated by W. Cole, W. Nelis.

Winter Nelis is effectively pollinated by William B. Chretien.

Winter Cole is effectively pollinated by W. Nelis.

As with apples the Ministry of Agriculture has full lists of suitable pollinators for all varieties grown in New Zealand.

H. BUD INITIATION

The process of bud initiation in pears is similar to that in apples. Biennial bearing is not common although under unfavourable conditions it can occur.

I. FRUIT THINNING

Under New Zealand conditions thinning is seldom necessary for pears.

J. PRUNING

Remarks under apples concerning pruning also apply with some modifications, which will be mentioned in lectures, to pears.

K. HARVESTING AND MARKETING

See notes under apples.

L. PESTS AND DISEASES

See notes under Apples.

13

Other Pome Fruits

A. QUINCE (*Cydonia oblonga*)

This is not extensively grown although quite a number of home gardens do have trees. The fruits are used for jams, jellies, and preserves. There is virtually no commercial outlet for quinces.

The quince requires similar conditions for culture as the pear, but it is more drought resistant and can withstand wet conditions better.

It can be propagated by layers, hardwood cuttings, stools or suckers or can be grafted on to Angers Quince or Common Quince.

Quince is subject to two leaf spots in addition to the normal run of apple and pear diseases. These are due to *Fabraea maculata* and *Sclerotinia cydoniae*.

B. MEDLAR (*Mespilus germanica*)

A fruit seldom seen in this country. It is unattractive and inedible at picking but after a few weeks storage and initial decay (called bletting) the fruit can be eaten raw, preserved, or made into jelly.

C. LOQUAT (*Eriobotrya japonica*)

Evergreen, blossoms about April and is subject to frost damage. Grown to some extent in the North Island.

14

Stone-Fruit Culture

INTRODUCTION

The origins of most stone fruits can be traced to the Caucasus-Persia region. However, about 2,000-2,500 years ago, they spread eastwards to eastern Asia and are sometimes regarded as natives of this area. Most stone fruits grown in Europe have been established there for over 1,000 years and, by selection, now differ considerably from their counterparts in Asia. A number of stone fruits are native to the American continent.

Stone fruits are spread throughout the world and are grown commercially in practically all regions of temperate to sub-tropical climate.

Pomology of the Group.

All stone fruits belong to the genus *Prunus*, a a member of the family Rosaceae.

The botanical classification of stone fruits is as follows:—

(a) Plums

Prunus cerasifera	Myrobalan or cherry plums
,, *spinosa*	Blackthorn or sloe plums
,, *domestica*	European plums and prunes
,, *institia*	Damsons
,, *salicina*	Japanese plums
,, *americana*	)
,, *nigra*	) Native American
,, *hortulana*	) plums
,, *Munsoniana*	)
,, *Besseyi*	)

A considerable number of hybrid plums exist. These are mainly crosses between *P. salicina* and native American plums.

(b) Apricots
Prunus armeniaca

(c) Almonds
Prunus amygdalus

(d) Peaches

Prunus persica	Peach
,, *persica var. nectarina*	Nectarine

(e) Cherries

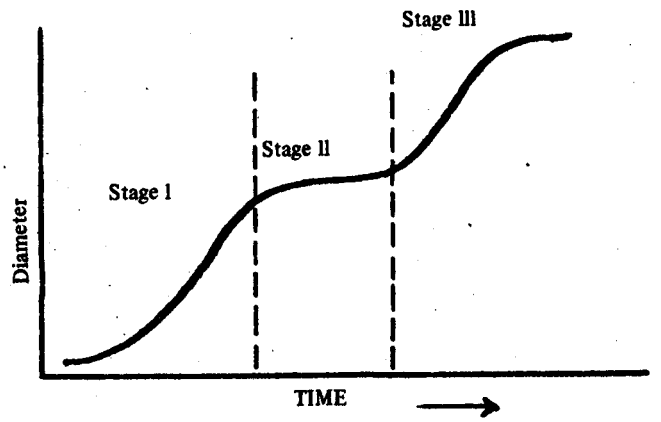
Prunus avium	Sweet cherry
,, *mahaleb*	Wild European species
,, *cerasus*	Sour cherries

The stone fruits are deciduous and their fruit buds are differentiated 9-10 months prior to flowering. Usually the fruit buds are borne laterally, either singly or in clusters of 2 or more, and contain flowers only. In the peach, lateral fruit buds are produced on long shoots, in the axils of leaves. One vegetative bud is normally surrounded by two flower buds. The Sweet Cherry and the domestica and institia groups of plums form their flower buds for the most part on spurs from lateral buds on the shoots formed in the preceding season. The almond, apricot, Japanese and American plums and the sour cherry, have a fruiting habit which is a combination of the peach and the sweet cherry. Fruit bud production on shoots gradually gives way to production on spurs as the trees grow older.

Flowers contain 5 petals, 5 sepals, a single carpel and numerous stamens.

The fruit is a drupe and consists of a seed surrounded by a hard shell or stone within a layer of soft flesh. The stone (endocarp) is formed from the inner part of the ovary wall and the soft flesh (mesocarp) from the outer part. During the first 2-4 weeks after fertilisation the ovary walls grow by cell division. After this time cell division ceases and growth is due to enlargement of existing cells. Up to the time the stone or endocarp begins to harden, enlargement is rapid, then, while the stone is hardening, growth is slow, followed by rapid enlargement of the flesh or mesocarp when stone hardening has ceased.

This produces the typical double-sigmoid
rowth curve shown in the figure. In the almond,
tage III of growth is absent since further expan-
on of the mesocarp does not occur.



Double-sigmoid growth curve of Apricot

14a

The Culture of Peaches and Nectarines

INTRODUCTION

World production of peaches and nectarines is 5.3 million tonnes. The following countries produce over 200,000 tonnes annually: U.S.A. 1,422,000; Italy 1,128,000; France 497,000; Argentina 235,000; Japan 279,000. Australia produces 116,000 and New Zealand 29,000 (1970).

New Zealand production in 1972 was 24,200 tonnes, 38% of which was processed. Districts in order of importance are Hawkes Bay and Gisborne, Central Otago, Auckland and Northland, Nelson and Blenheim.

Pomology

The peach fruit is the largest of the cultivated species of *Prunus*, the skin is furry and the flesh generally ranges from white to yellow. The outer surface of the stone (endocarp) is deeply indented and may be firmly (clingstone) or loosely (freestone) attached to the mesocarp. The former type is generally preferred for canning and the latter for dessert purposes. Nectarines are a smooth-skinned group of peaches having distinctive flavour and appearance. Apart from this they are indistinct in pomology and culture to the peach.

Flowers and fruits are sessile and are borne singly on lateral shoots.

Climatic Requirements

Peaches seem to grow well in most areas of New Zealand, although some varieties, such as Mayflower are not suitable for northern districts, possibly because of lack of winter chilling. Peaches in northern areas generally do not get the same amount of blossom as southern districts: however, the reduced danger from frosts more than compensates for this in most varieties. Dry conditions, especially during blossoming and ripening, will reduce the incidence of stone fruit blast and brown rot, and promote good setting of fruits.

In dry areas, like Central Otago, irrigation is essential. While in the past most orchards have used border-dyke irrigation ditches, the use of sprinklers, which can also be used for frost control, is increasing. In other areas the use of trickle irrigation will doubtless become more popular.

There is no doubt that lack of water, particularly in Stage III, can greatly reduce fruit size, however, excess water, especially if sprinklers are used, can increase the likelihood of brown rot.

Soils and Fertilisers

Peaches probably do best in well-drained light soils with ample supplies of nitrogen. Detailed fertiliser programmes cannot be recommended, but growers should seek advice from neighbours and their local Department of Agriculture for a guide in applying fertilisers. Soil analyses will help establish the general needs of the soil.

Varieties in New Zealand

The following tables show the varieties now recommended by the Ministry of Agriculture. Here again local knowledge should be sought to determine which varieties grow well in the district and this should be compared with market trends and consumer preferences, where these are known.

Rootstocks

Peaches are normally grown on peach seedling stocks although occasionally Myrobalan plum is used on heavy soils. Generally Golden Queen peach seeds from the canneries are used. (Myrobalan plums are propagated from cuttings or seedlings; the former is dangerous in that spread of virus, such as plum mosaic, is not controlled). These rootstocks form large trees of 15-20 feet which normally bear appreciable crops within three years of planting. Unfortunately there are no satisfactory dwarfing rootstocks for peaches.

Fruit Set and Fruit Thinning

Except for J. H. Hale all varieties are self fertile. Nevertheless fruit set may be improved if the bee population is high and is generally optimum during warm dry weather. Thinning is generally done by hand at or just before the beginning of pit-hardening. It is usually aimed to leave about 10cm between fruits. Chemical thinning with peaches and other stone fruit has not been too successful but recent trials with a chemical called dinoseb (D.N.B.P.) are quite encouraging.

Tree Training

Winter pruning is not now recommended for peaches in northern areas of New Zealand due to the likelihood of silver leaf infection at that time. If trees are pruned after harvesting little of the silver leaf pathogen will gain entry. Trials in Auckland have shown that light summer pruning gives higher yields than normal winter pruning. Orchardists who grow apples as well as peaches may, however, have difficulty finding time for summer pruning when harvesting of apples begins immediately after peaches, and some compromise may have to be made. Nevertheless in some areas of New Zealand up to 10% of orchardists' trees are commonly lost with silver leaf each year and even zero pruning may be preferable to winter pruning.

Traditionally, peaches have been pruned to an open vase shape (see section on Apples) and heavy pruning has been adopted. Growers pruned back, to a half or a third, approximately 50% of all laterals. It is somewhat debatable at the moment as to which training method will be used in future. Almost certainly heavy lateral pruning will be replaced by moderate corrective pruning but, until other methods such as centre-leader

RECOMMENDED PEACH VARIETIES

Variety	No of Trees 1972	% increase (+) or decrease (-) since 1968	Approx First Picking				Comments
			N.I.	Nelson Canty.	Otago	Main Areas	
Le Vainqueur	(1968) 6,147	?	5 Dec	15 Dec	–	H.Bay	Mainly N.I.
Mayflower	6,580	-12	–	18 Dec	22 Dec	C. Otago	No good in North
Briggs Red May	6,310	-22	–	26 Dec	1 Jan	Canty. C. Otago	Cool districts, may be supplemented by newer varities.
Swellengrebel	?	?	20 Dec	–	–	North	Good warm district var.
Dixired	14,200	+186	23 Dec	10 Jan	18 Jan	All Districts	High Value, popular variety
Redhaven	30,550	+150	8 Jan	20 Jan	1 Feb	All Districts	Good, popular variety
Fairhaven	3,210	+93	13 Jan	25 Jan	5 Feb	All Districts	Promising Variety
Southland	1,620	+200	20 Jan	28 Jan	10 Feb	H. Bay Nelson	Better colour in northern districts
Eclipse	4,790	+26	–	30 Jan	12 Feb	Nelson	Little grown outside Nelson
Mary's Choice	9,390	-20	28 Jan	15 Feb	28 Feb	Not Auckland	Popular with consumers
Paragon	39,580	+13	30 Jan	18 Feb	1 Mar	N.I.	Not popular in South
J. H. Hale	7,360	-6	5 Feb	20 Feb	10 Mar	All	Expected to be superseded.
Redskin	2,640	+164	8 Feb	22 Feb	12 Mar	All	Promising new variety
Paragon II	1,000	+490	15 Feb	–	–	Auck.	Good, new
Late Paragon	7,870	+23	22 Feb	1 Mar	–	N.I.	Reliable & Good
Kakamas	4,050	-30	26 Feb	8 Mar	–	H.B.	Not easy to grow – good canner.
Golden Queen	180,180	-7	1 Mar	12 Mar	–	H.B.	Main canner
Tatura Aurora	?	?	20 Mar	–	–	N.I.	Used to extend canning season

training ,hedgerow and palmette training have been adequately tested in this country, it is likely that the vase shape will still continue to be used as the basis for most trees.

Maturity, Harvesting and Marketing

As peaches mature the underlying greenness of the skin turns yellow. If fruits are to be sold shortly after picking, the orchardist can probably wait until almost all of the greenness has disappeared, however, when a delay is expected, a certain amount of greenness must be left. An overgreen fruit will not mature off the tree. Pressure testing using either the fingers or a more sophisticated Penetrometer is another useful guide to maturity.

In Hawkes Bay the canneries (Watties and Unilever) take about 85% of the total crop. At the beginning of each season a price is negotiated between representatives of the local growers and the canneries. Growers who produce under contract to the canneries will receive this price for all their crop. Contracts may be for several years and sometimes the cannery will supply the trees for an orchardist to plant.

Dessert peaches are generally packed in standard half-cases and sold by auction. Choice peaches are often packed in shallow trays in special exhibition packs. There are prospects for an export industry in dessert peaches. Already a number of choice peaches have been sent to the U.S.A., Noumea, Japan, Hong Kong and the U.K. If more yellow-fleshed peaches are grown, export could develop considerably. (Peaches will store for up to 3 weeks at 1-2°C and are sent by either air or sea.

RECOMMENDED NECTARINE VARIETIES

Variety	No of trees 1972	% Increase (+) or decrease (-) since 1968	Approx First Pickings				Comments
			N.I.	Nelson Canty.	Otago	Main Areas	
Early Lowe	3,230	+38	5 Jan	–	10 Jan	H.B.	Good dessert for H.B.
John Rivers	2,260 (1968)	?	–	10 Jan	10 Jan	Otago	Similar to Early Rivers
Earliblaze	5,920	No trees 1968	10 Jan	20 Jan	25 Jan	All	Very promising
Independence	2,330	"	15 Jan	22 Jan	1 Feb	H.B. Marl.	?
New Yorker	5,260	+137	20 Jan	28 Jan	10 Feb	All	Good dessert
Sunglo	6,400	No trees 1968	–	–	16 Feb	H.B. Otago	Good colour, fair flavour
Goldmine	21,310	+3	25 Jan	10 Feb	20 Feb	All	Major variety
Fillery	1,830	+250	28 Jan	15 Feb	25 Feb	Nelson Canty.	Suggested for limited planting
Murray	2,770	+61	12 Feb	–	6 Mar	H.B. Otago	Attractive
Deltur	4,380	+1890	8 Feb	–	4 Mar	H.B. C. Otago	Attractive & good quality
Redgold	8,850	No trees 1968	?	?	?	All	–

14b

The Culture of Apricots

Introduction

World production of apricots is 1.2 million tonnes p.a. The following are the world's chief producers:—Spain (151,000); U.S.A. (160,000); France (76,000); Turkey (118,000); Italy (170,000). Australia produces 48,000 tonnes and New Zealand 7,000 tones (1970).

The main apricot district in New Zealand is Central Otago which produces 90% of the total crop. Other areas are Canterbury 5% and Hawkes Bay 5%.

Pomology

The apricot is smooth skinned and the stone is smooth and easily separated from the flesh. Buds contain only one flower and these and the subsequent fruits are sessile.

Climatic Requirements

The apricot seems to grow best in areas with continental-type climates; dry and hot in the summer, cold in winter. It does well in Central Otago, moderately well in Canterbury but not exceptionally well in areas north of this. Like the peach it tends to shed flower buds after a warm winter. Also like the peach it prefers dry weather at blossoming and near maturity. Excess rain late in the season, will, in addition to helping the spread of brown rot, tend to cause cracking of the fruit. Remarks under Peach on irrigation apply equally well to apricots.

Soils and Fertilisers

Good deep soils with adequate nitrogen are best for apricots. Again, local conditions determine the type and amount of fertiliser to be used.

Varieties in New Zealand

The following table shows the varieties at present recommended by the Ministry of Agriculture.

Rootstocks

Apricots are normally grown on peach, Myrobalan plum, or apricot stocks. The propagation of apricot on apricot rootstocks is not common since unlike peaches, apricot seedlings may take two years to reach budding size and the 'take' of apricots on apricots is inferior to apricots on peach. Normally peach and apricot seedling stock are recommended for normal to light soils and plum for heavy soils. These rootstocks form large trees 4-5 m in height which produce reasonable crops within three years of planting. There are no dwarfing rootstocks for apricots.

Fruit Set and Fruit Thinning

All varieties of apricot are self-fertile, nevertheless the presence of bees may be beneficial and warm dry weather encourages good set. Thinning is normally done by hand at or before the beginning of pit-hardening, 8-10 cm being left between fruits. Like peaches chemical thinning with dinoseb at F.B. appears promising.

Tree Training

In Central Otago apricots tend to fruit on spurs whereas in areas north of this they are more inclined to fruit on laterals. Thus, pruning in Central Otago has been based on the apple system whereas in other areas they have tended to be pruned more like peaches. Summer pruning is sometimes practised in Central Otago to induce late lateral growth and therefore late blossoming and has advantages for frost control. (Growers sometimes maintain that fruits produced on laterals are inferior to those produced on spurs). Vase shaped trees are still recommended for apricots.

Maturity, Harvesting and Marketing

The maturity of apricots can be considerably advanced by spraying trees with hormone such as

2,4-D, at the commencement of stone hardening. This seems to act by reducing the length of the slow-growth period (Stage II). 2.4-D sprays may, in addition, increase fruit size and reduce fruit drop.

As fruits mature the green colour changes to the typical apricot colour of a ripe fruit. The flavour of the fruit develops to a peak when it is allowed to mature on the tree, however, such a fruit will only keep for a few days. If picked when the green has faded to a straw colour it will last from 1-2 weeks, but never develops satisfactory flavour. Cooling will prolong the life for only a few extra days.

Apricots from Central Otago are packed in half-cases and distributed throughout New Zealand. Others are canned or made into jam. Apricots produced in other areas are mainly sold for dessert purposes locally. Export seems unlikely.

Overseas a fairly large proportion of the apricot crop may be dried but this is not done commercially in New Zealand.

RECOMMENDED APRICOT VARIETIES

Variety	No of trees 1972	% increase (+) or decrease (-) since 1968	Approx. First Picking				Comments
			N.I.	Nelson Canty.	Otago	Main Areas	
Newcastle	14,020	+ 6	15 Dec	18 Dec	18 Dec	All	Well proven
Roxburgh Red	32,310	+49	-	-	15 Jan	Otago	Only good in C. Otago
Stevens Favourite	4,740	+48	-	-	17 Jan	Otago	Good quality
Dundonald	4,740	+17	-	20 Jan	20 Jan	Otago Canty.	Crops well
Moorpark	113,330	+33	14 Jan	22 Jan	20 Jan	Otago Canty	Major Variety
Bolton	7,480	+48	-	-	22 Jan	Otago	Not consistant outside Cental Otago
Tilton	2,470	+24	–	-	24 Jan	Otago	Good cropper and canner
Trevatt	16,920	+56	15 Jan	25 Jan	26 Jan	All	Warm climate apricot
Youngs Late	1,100	+57	-	-	7 Feb	Otago	Late Moorpark type

14c

Culture of Plums

Introduction

Annual world production of plums (and prunes) is 4.8 million tonnes. The following countries produce over 150,000 tonnes annually:—Rumania (697,000); U.S.A. 606,000, (of which 471,000 are dried, i.e. prunes); West Germany (541,000); Yugoslavia (896,000); Bulgaria (334,000). Australia produces 26,000 tonnes and New Zealand 4,000 tonnes (1970).

Most European plums are grown in Central Otago and 30% of these are processed. The districts for Japanese plums in decreasing order of importance are:—Auckland and Northland, Hawkes Bay and Gisborne, Central Otago and Canterbury. 7.5% are processed.

Pomology

Plums are all smooth-skinned and vary in the colour of their skin and flesh from yellow to dark red. The stone is smooth and is firmly attached to the flesh. Flowers and fruit are formed on pedicels of varying length and there are several flowers contained in each bud. The following are the major commercial groups of plums:—

(a) European plums (*Prunus domestica*)
Have been known in Europe for 2,000 years, having spread from Persia westward along the Mediterranean coast. They probably originated from a cross between *P. cerasifera* and *P. spinosa*. Prunes which are not grown in New Zealand belong to this group of plums.

(b) *Japanese plums* (*Prunus salicina*)
Originally a native of China and, more recently, of Japan.

(c) *Damsons* (*Prunus institia*)
This group includes damsons and bullaces which are tart or acrid plums and are seldom grown in New Zealand. They require similar conditions to European plums.

(d) Myrobalan or cherry plum (*Prunus cerasifera*)
This fruit also is little used commercially, although the stock is used extensively.

Climatic Requirements

The climatic requirements of each group differs. European plums are grown generally in the southern areas of New Zealand, as the table below shows. Since they flower after peaches and apricots they are less susceptible to frost damage. Japanese plums are grown in all areas of New Zealand. The remarks on irrigation under peaches apply equally well to plums.

Soils and Fertilisers

Plums (especially European) can generally stand heavier soils than other stone fruits. They require less nitrogen than peaches, apricots, or cherries.

Varieties in New Zealand

The following tables show the varieties at present recommended by the Ministry of Agriculture:

Rootstocks

Myrobalan is the normal rootstock used in New Zealand for all plums except greengages, which do best on greengage seedlings. Height of plum trees varies from 3.5-5.5m, depending on variety and district.

Fruit Set and Fruit Thinning

Not many plums are self-fertile and those that are generally benefit from cross-pollination. The Department of Agriculture has lists of suitable pollinators for commercial varieties. The problem with plums in New Zealand is lack of set rather than heavy set and therefore thinning is seldom required. Burbank, Santa Rosa and Sultan sometimes benefit from light thinning.

Tree Training

Plums are generally grown as vase-shaped trees, but apart from establishing the general framework of the tree, little training or pruning is undertaken. A certain amount of limb thinning is done most years and summer pruning may be advisable since plums are very susceptible to silver leaf.

Maturity, Harvesting and Marketing

Colour changes at maturity are not generally so marked as in apricots or peaches, especially when red pigmentation is present. As maturity approaches the underlying green colour turns to yellow and the flesh becomes noticeably softer.

Most plums are sold locally for the fresh-fruit market in standard half-cases. Many plums can be stored for 2-4 weeks at between 0-45°C.

RECOMMENDED EUROPEAN PLUM VARIETIES

Variety	No of trees 1968	% increase (+) or decrease (-) since 1968	Approx. First Picking				Comments
			N.I.	Nelson Canty.	Otago	Main Areas	
Angelina Burdett	443	?	20 Jan	22 Jan	25 Jan	Otago	Mainly grown as pollinator for Greengage
Diamond	675	?	22 Jan	25 Jan	30 Jan	Nelson	Culinary
Monarch	356	?	25 Jan	28 Jan	1 Feb	Otago	Consistent crop
Greengage	6,856	?	28 Jan	1 Feb	5 Feb	Otago	Most popular dessert & processing
Grand Duke	1,353	?	1 Feb	5 Feb	10 Feb	Otago	Crops well
Reine Claude de Bavay	250	?	5 Feb	10 Feb	15 Feb	H. B.	Crops consistently, medium quality
Coes Golden Drop	771	?	8 Feb	12 Feb	20 Feb	Otago	Excellent dessert
President	937	?	10 Feb	15 Feb	22 Feb	Otago	Dessert or canning
Total European Plums	14,508 (1972)	0					

RECOMMENDED JAPANESE PLUM VARIETIES

Variety	No of trees 1972	% increase (+) or decrease (-) since 1968	Approx. First Picking				Comments
			N.I.	Nelson Canty	Otago	Main Areas	
Wilson's Early	10.610	+ 7	15 Dec	20 Dec	26 Dec	Auck H. B.	Good crops, fair quality
Duff's Early Jewell	4,450 (1968)	?	18 Dec	24 Dec	30 Dec	H. B.	Reliable good cropper
Billington	6,680	+ 9	3 Jan	12 Jan	20 Jan	Canty	All purpose clingstone
Shiro	2,060	+48	-	-	23 Jan	Otago	Only Central Otago
Santa Rosa	4,823 (1968)	?	5 Jan	18 Jan	25 Jan	H. B.	Erratic cropper
Burbank	3,820	+19	10 Jan	20 Jan	30 Jan	Otago	Reliable cropper
Sultan	7,370	+ 9	10 Jan	20 Jan	30 Jan	Auck.	Reliable cropper
Black Doris	13,270	+38	26 Jan	5 Feb	15 Feb	H. B.	Good canner & dessert
Purple King	6,870	+ 7	28 Jan	8 Feb	18 Feb	H. B.	High quality dessert
Doris	8,770	+ 9	5 Feb	12 Feb	22 Feb	Auck.	Heavy cropper, good keeper
Late Burbank	238 (1968)	?	15 Feb	20 Feb	28 Feb	?	As Burbank but later
Geo Wilson (Omega)	30,590	+14	18 Feb	25 Feb	1 Mar	all	Pick good cropping strain
Victory	977 (1968)	?	20 Feb	28 Feb	5 Apr	H. B.	Quality fair crops fair

14d

The Culture of Cherries

Introduction

Annual world production of cherries is 1.7 million tonnes (1970). The following countries produce over 50,000 tonnes:—U.S.A. (228,000); Italy (210,000); West Germany (314,000); France (106,000). Australia produces 8,000 tonnes and New Zealand 500 tonnes.

The cherry-growing districts in New Zealand in order of decreasing importance are:—Central Otago, Nelson, Blenheim, Hawkes Bay and Gisborne, Canterbury.

More than 100 species and some 1,200 varieties of cherries are known. The cherry is indigenous in some form or other in all the countries of the Northern Hemisphere temperate zone, but the present commercial varieties probably originated from the Caucasus between the Black Sea and Caspian Sea. Records of cherries are found in the very earliest historical writings and almost all our present day cherries are chance seedling selections.

The two sorts, the sweet (*P. avium*) and sour (P. *cerasus*) are represented today by the variety Mazzard, parent of our sweet cherries, and the Kentish or pie cherry, progenitor of the sour cherries. Sour cherries are not grown in New Zealand.

Pomology

Cherries are the smallest stone fruits and the earliest to mature. Flower buds open to reveal three or more flowers and small or rudimentary leaves can sometimes be distinguished. Fruits are borne on long pedicels, they are smooth and the stone is firmly attached to the flesh. The skin and the flesh vary in colour from yellow to red.

Climatic Requirements

Cherries grow well in Hawkes Bay and most fruitgrowing areas south of this. They blossom early and are readily damaged by frost. Like all stone fruit they do best when the weather at blossoming and maturity is dry and warm. Rain or very hot weather during ripening will cause severe cracking. Early ripening means the the fruit is not on the tree at the driest part of the year, nevertheless irrigation may still be beneficial in certain areas.

Soils and Fertilisers

Cherries are the most particular of all stone fruits. They do best in good deep well-drained soils and, like most stone fruits, respond well to nitrogen.

Varieties in New Zealand

The following cherries are the varieties at present recommended by the Ministry of Agriculture.

Rootstocks

The main rootstock used in New Zealand is the wild sweet cherry or Mazzard (*P. avium*). Seed lings are used and trees vary from 3.5-5.5m. in height.

Fruit Set and Fruit Thinning

Sweet cherries are practically all self-sterile and pollinators, as prescribed by the Department of Agriculture, are necessary. Poor set is quite a problem and thinning is not required. Poor set contributes to the poor yields and high prices of cherries in New Zealand.

Tree Training

After formation of the desired framework little further pruning is required for cherries. Most are grown as vase-shaped trees.

Maturity, Harvesting and Marketing

Maturity of cherries is gauged by colour changes in the skin and flesh and by firmness and

sweetness. Fruits must be picked with pedicels attached otherwise infection may gain entry through the point where the pedicel was attached to the fruit. Cherries will store for up to three weeks at temperatures as low as 0°C.

The cherry is a luxury crop in New Zealand. Many are grown in expensive cages to protect them from the birds and therefore overheads are considerable. Most growers try to get crops before Christmas when prices are the highest. They are packed in flat cases, cardboard or wood, and the top layer is often placed by hand neatly in rows (called facing). The preference in New Zealand is for dark-fleshed varieties.

RECOMMENDED CHERRY VARIETIES

Variety	No of trees 1972	% increase (+) or decrease (-) since 1968	Approx. First Picking				Comments
			N.I.	Nelson Cant.	Otago	Main Areas	
Early Purple Guigne	462 (1968)	?	12 Nov	12 Nov	14 Nov	Otago	Good cropper
Burgsdorf Seedling	145 (1968)	?	15 Nov	15 Nov	-	H. B.	Good cropper
Chapman	428 (1968)	?	17 Nov	17 Nov	20 Nov	Canty	Only average in most respects
Early Rivers	1,674 (1968)	?	20 Nov	20 Nov	24 Nov	Marl.	Most grown early cherry
Merton Premier	?	?	28 Nov	26 Nov	4 Dec	?	Promising new variety
Black Bohemian	758 (1968)	?	2 Dec	4 Dec	8 Dec	Otago	Crisp and sweet
Bigarreau Pelissier	1,390	+32	-	-	9 Dec	Otago	Excellent quality
Dawson	15,080	+111	10 Dec	10 Dec	14 Dec	Otago	Large, sweet & firm
Florence	1,276 (1968)	?	16 Dec	16 Dec	20 Dec	Otago	Demand for processing
St Margaret	3,810	+18	18 Dec	18 Dec	24 Dec	Otago	Select good strain
Noble	1,190	+250	?	?	?	Marl	?
Paul	4,070	+402	?	?	?	Marl.	?
Van	570	No trees 1968	?	?	?	Marl.	?

14f

Frost and Frost Control

SINCE FROST DAMAGE is more serious on stone fruits (especially apricots) than other deciduous tree fruits, a separate section will now be devoted to this problem.

1. *Damage*

Frost is probably the most serious problem the stone fruit grower has to face. The danger of frost damage is greatest in September and October, although it can occur at times outside this period. Occasionally warm periods occur in August or even July, and, if buds have experienced sufficient chilling by that stage to have overcome dormancy, they may begin to swell. Once this occurs their resistance to cold is greatly reduced and subsequent frosts can kill them. Before swelling occurs buds are resistant to all temperatures likely to be experienced in New Zealand.

The following list shows the temperatures at which buds in different stages of development can be killed.

2. *Control*

The following methods have been used or suggested to combat the frost problem.

1. Selection of site. Plant on sloping ground and avoid low-lying 'frost-pockets'. Cold air, being heavier than warm air, always collects in these areas which are often several degrees colder than the surrounding country. Frosts occur mainly on clear nights when there is little wind. For this reason areas which are too sheltered are not suitable.
2. The use of late-flowering varieties.
3. The use of hormones to set fruit whose seeds have been damaged by frost. As mentioned earlier this holds some promise with pears but as yet it does not seem suitable for other tree fruits.
4. Sprays to delay blossoming. Theoretically inhibitors should prove useful in this respect but research has not as yet proved this method to be commercial feasible.
5. Pruning to delay blossoming. Summer pruning on apricots and possibly peaches causes late shoot growth. The buds on these shoots develop later in the season, remain dormant longer, and open 7-10 days later in the spring.
6. Mixing of cold and warm air by fans. Very often the air near the ground is below freezing while that several metres higher is above freezing. If the two layers of air can be mixed the resultant temperature might not be damaging. To this end large fans are sometimes used. Unfortunately they have not proved very suitable for New Zealand conditions although they are used quite successfully in citrus groves in California. They are useful in moderately light frosts where the height of the cold air (the "inversion ceiling") is not too great. One fan may raise the temperature about 1-2°C over one hectare.
7. Spraying with water. If a branch is continually covered by water in the process of freezing it is unlikely that the tissue of the branch will fall much below 0°C. This temperature is not generally damaging to blossoms, buds, and young fruits. This method is quite satisfactory and it is being used increasingly in New Zealand, since the investment serves two purposes—frost control and irrigation. It has the disadvantages that a heavy layer of ice can break branches and limbs and that unless the soil is well drained severe waterlogging may occur. The amounts of water required can be obtained from Ministry of Agriculture advisors in the district.

8. The burning of oil. Simple pots (called Lard Pails) are placed in the orchard at regular intervals and, when freezing occurs, are lit. The method is still widely used but it has several disadvantages. Firstly it is time-consuming and demoralising. A person who has been up most of the night will be little use the next day for other orchard activities. Secondly it is a dirty occupation and the smoke produced does not endear the orchardist to his neighbours. While it is cheap to establish (in contrast to wind machines or spraying equipment) it is costly to operate, both for oil and for labour.

FROST PROTECTION: CRITICAL TEMPERATURES (IN ^{0}C) *

– a summary of overseas and local research –

Kind	Stage of Development		
	Buds closed but showing colour	Full Bloom	Small Green Fruits
Apricots U. S. A.	-4	-2	-0.5
N. Z.	Pink -5		
	White tip -4.5 to -3.5	-2	-1
Cherry U. S. A.	-2	-2	-1
N. Z.			-1
Peach U. S. A.	-4	-3	-1
N. Z.		-3	-1
Plum U. S. A.	-4	-2	-1
N. Z.	-4	-2	-1
Prune U. S. A.	-5	-3	-1
		-3	-1
Almond U. S. A.	-4.5	-3	-1
Walnut U. S. A.	-1	-1	-1
Apple U. S. A.	-4	-2	-2
N. Z.		-2	-2
Pear U. S. A.	-4	-2	-1
N. Z.			-1
Grape U. S. A.	-1	-0.5	-0.5
N. Z.		-0.5	-0.5
Blackberry N. S. W.	-2	-2-	-2
Raspberry N. S. W.	-2	-2	-2
Strawberry N. S. W.	-2	-2	-2

* These are approximate temperatures when frost pots should be lit or sprinkling should begin. When trees are wet frost fighting should commence at a temperature one degree higher than those given.

15

Citrus Culture

A. INTRODUCTION

There are many species of Citrus which are important as commercial fruits, viz:—

C. sinensis	Sweet orange—The most important species
C. limonia	Lemon—next most important
C. paradisi	Grapefruit—increasing in importance
C. reticulata	Mandarin (Tangerine) — Increasing in importance
C. medica	Citron
C. aurantiifolia	Lime
C. grandis	Pummelo or Shaddock
C. aurantium	Sour orange (Seville)

Two closely related species are:

Fortunella sp.	Cumquats—Not grown much
Poncirus trifoliata	The trifoliate orange—Used as a rootstock

Sour oranges were introduced to Europe from South East Asia via some of the early trade routes but have, over the last 150 years, been largely superseded in commerce by the more palatable sweet orange, mandarin, lemon and grapefruit.

Interspecific hybrids are fairly common; their increasing number is making identification more difficult. Two such hybrids are: Tangelo, Tangerine x Pummelo and Citrange, Trifoliata x Sweet Orange.

Another interesting characteristic of many Citrus species (except shaddock) is that they produce polyembryonic seeds; in addition to the true sexual embryo each seed may contain several embryos formed adventitously from the nucellus. Hence the name nucellar seeds. Nucellar embryos, being produced from the female parent tissue asexually are of the same genotype as the female parent, hence are very important in the raising of stocks for propagation.

World production of oranges and mandarins is 30.5 million tonnes p.a. The following countries produce over 1 million tonnes:—U.S.A. (7.8); Brazil (3.4); Spain (2.2); Japan (3.0); Italy (1.8). Australia produces 295,000 and New Zealand 3,000 tonnes annually (1971).

World production of grapefruit is 3.1 million tonnes. U.S.A. produces 2,266,000 tonnes; Israel (300,000); Argentina (141,,000); and South Africa (82,000). Australia produces 10,000 tonnes and New Zealand 5,000 tonnes (1971).

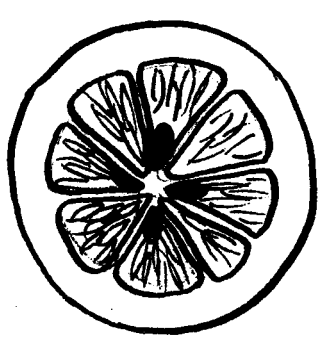
World production of lemons and other citrus fruit is 4.7 million tonnes. U.S.A. produces 765,000 tonnes; Italy (775,000); India (450,000); Mexico (195,000). Australia produces 20,000 tonnes and New Zealand 4,000 tonnes (1971).

B. BOTANY AND GROWTH

Revise the process of flower-bud initiation in Citrus (Chapter 7, A4).

Citrus species are characterised by aromatic oil in the leaves and other organs, a superior ovary on a raised disc and semi-transparent dots in the leaves. All are evergreen except *P. trifoliata* which is deciduous.

Flowers normally have five petals, five sepals, numerous stamens and a single compound pistil. The fruit has 8-15 locules each of which may



The cells in the locules become large and juice-filled and form the edible part of the fruit.

NO. OF TREES IN N.Z. (1968)

Type	Trees 1972	% Increase (+) or Decrease (-) since 1968	Blossom Period	Harvesting Period	Main Areas
N. Z. Grapefruit	156,000	+246	Late Spring (Oct.)	August - December	1. Bay of Plenty 2. Auckland 3. Kerikeri 4. Gisborne
Wheeny Grapefruit			Late Spring (Oct.)	November-March	1. Gisborne 2. Bay of Plenty 3. Kerikeri 4. Auckland
Standard Lemons	60,000	+76	Late Spring but also other times in lesser amounts	August-November or November-Feb.	1. Bay of Plenty 2. Bay of Plenty 3. Auckland 4. Kerikeri
Meyer Lemons			" "	June-November	1. Bay of Plenty 2. Kerikeri 3. Gisborne 4. Auckland
Mandarins	125,000	+ 81	Late Spring (Oct.)	June-December	1. Kerikeri 2. Bay of Plenty 3. Auckland 4. Gisborne
Oranges	222,000	+ 56	Late Spring (Oct.)	August-December	1. Kerikeri 2. Gisborne 3. Bay of Plenty 4. Auckland
Tangelos	119,000	+153	Late Spring (Oct.)	September-Dec.	1. Kerikeri 2. Bay of Plenty 3. Gisborne 4. Auckland

contain one or more seeds. The fruit is a *hesperidium* which is a specialised berry with a leathery rind.

The cells in the locules become large and juice-filled and form the edible part of the fruit.

C. CLIMATIC REQUIREMENTS

Citrus are a warm-weather crop and the growth of shoots, leaves and fruits is markedly influenced by temperature. Oranges have a minimum of 13°C and a maximum of about 40°C for growth. Lack of summer heat is usually reflected in slow growth, poor yields and unsatisfactory eating quality. Generally lack of summer warmth is as much a factor limiting growth of citrus in New Zealand as minimum winter temperatures. In fact, New Zealand summer temperatures are well below those considered essential overseas for successful citrus culture. Nevertheless with proper choice of site, rootstocks and variety citrus can be an economical crop in northern New Zealand.

Citrus are extremely susceptible to frost, especially the spring flush of shoot growth. Late frosts can also remove young fruits or damage mature fruits by lowering their juice content. Young trees are more prone to frost damage because of their longer growing period; also their small size places them where air is colder. Though they are evergreens, citrus are more resistant to cold during winter and can even withstand short spells of freezing.

Citrus require adequate moisture throughout the summer but high humidity tends to induce high incidence of insect and fungous blemishes. Unfortunately the citrus-growing districts generally have high humidity and a good spray programme and careful handling of fruit during and after picking are necessary.

Wind can damage citrus trees, reduce set and lower summer temperatures. For these reasons windy regions should be avoided and windbreaks may be essential in most other areas.

D. SOILS AND FERTILISERS

Because of a shallow rooting habit and the susceptibility of citrus to waterlogging or poor aeration, citrus must be planted on deep soils, preferably light and definitely well drained. A pH of 5.7 to 6.5 is good for citrus but they will grow quite well outside this range. Generally any very acid soils should be limed to bring the pH to about this level. Citrus respond to high levels of nitrogen.

E. VARIETIES IN NEW ZEALAND

1. *Lemons*. These, especially the Meyer lemon, have a lower summer temperature requirement than oranges and mandarins and therefore have a wider distribution in New Zealand. Main varieties are Lisbon, Eureka, Genoa, Villa Franca (called standard lemons) and Meyer (which is probably a hybrid between lemon and sweet orange). The Lisbon and Meyer have their main crop in winter and spring while the others are summer bearers.
2. *Grapefruit*. The New Zealand Grapefruit is probably a hybrid between the shaddock and sweet orange. Originally called Poorman's Orange, the best strains are Morrison's Seedless and Lippiatts. The Wheeny is more like the true grapefruit in appearance, but is also a hybrid, possibly between lemons or sour oranges and grapefruit. The true grapefruit do not grow well in New Zealand because of low summer temperatures.
3. *Oranges*. The Washington Navel or the strain Carter Navel are good early varieties ripening in August, mid season varieties such as Best Seedless, Ruby Blood, and late varieties as Valencia and Harwood Late can extend the harvesting season till December.
4. *Mandarins* (Tangerines). The Satsuma mandarins are well suited to our climate, they ripen during June and July. Other varieties in order of ripening are Clementine, Thorny, and Kara. The fruit Thorny is too small for commercial plantings.
5. *Tangelos*. These are hybrids between mandarin and either grapefruit or shaddock. Two varieties are recomemnded: Tiniura and Seminole.
6. *Kumquats* (Cumquats). Generally grown as ornamental shubs and for the colour rather than the eating quality of the fruit. They can, however, be used for marmalade or preserves.

F. ROOTSTOCKS

Three main rootstocks are used.

1. *Sweet orange*—good for lemons and grapefruit on sandy to medium loams where vigour is required. Susceptible to drought, rootrot and collar rot.
2. *Trifoliata*—suitable for oranges, mandarins, grapefruit and Lisbon lemons on most soils except alkaline ones. Produces small trees which come into bearing early and have heavy and reliable crops of good quality fruit. Highly resistant to collar and rootrot.
3. *Rough lemon* (or citronelle)—suitable only for lemon but seldom used now since it produces coarse fruit lacking in flavour and juice.

G. FRUIT SET, THINNING AND PRUNING

Pollination is no problem with citrus—some produce parthenocarpic fruit (e.g. Washington Navel) and all are self-fertile. Cross-pollination between varieties and between species readily occurs. Pruning should be very limited, branches close to the ground can be removed and any overcrowded areas can be thinned, otherwise the trees are best left alone. Pruning can be done at any time. Thinning likewise is not general.

H. HARVESTING AND MARKETING

This will be the subject of a separate lecture.

I. PESTS AND DISEASES

This will be the subject of a laboratory class.

16

The Culture of Grapes

Standard reference book is Winkler, A. J., General Viticulture (University of California Press, 1962). In N.Z. the best local publication is 'Viticulture' by F. Berrysmith (Ministry of Agriculture Bulletin 354).

A. GENERAL CONSIDERATIONS

Among the nearly 50 species of the genus *Vitis*, by far the most important is *Vitis vinifera*, commonly called the European grape.

There are many other species native to North America and Eastern Asia. *Vitis vinifera* appears to be the only species native to western Asia and Europe. It is not clear whether the cultivated form was derived from a wild subspecies (*V. vinifera silvestris*) which occurs throughout this area or from a special form typical of the Caucasian region.

Archaeological evidence suggests the grape was cultivated in prehistoric times south of the Caspian Sea in Asia Minor, and adjacent regions to the south. From here it spread in cultivation to Greece, Italy, and other areas bordering the Mediterranean. The Phoenicians carried it to France about 600 BC and the Romans planted grapes on the Rhine. As Europeans colonised new lands the grape was taken with them. Not until eastern North America was colonised were species other than *V. vinifera* of any importance. The imported European vines were not successful in Eastern U.S.A. and Canada due to their susceptibility to the indigenous Phylloxera insect, downy mildew and freezing. Nevertheless *vinifera* grapes are grown exclusively in California and with resistant rootstocks they are becoming popular in Eastern states.

Early American colonists turned their attention to the many native species of Vitis resistant to Phylloxera and other diseases. From selections of *Vitis labrusca* and hybrids a new and different grape industry developed. In the southern part of the United States varieties of *V. rotundifolia* are cultivated. These are muscadines with berries borne singly or in very small clusters maturing irregularly and dropping when ripe. However, the species is important for its hardiness under hot and humid conditions.

American grapes were introduced into Europe when they became available and their resistance to certain fungus diseases, notably *Oidium* (Powdery Mildew), was realised. However, with them were carried the insect Phylloxera and Downy Mildew. Phylloxera was discovered in hot-house vines in England in 1863 and in France in the same year. In the 20 years following its introduction into France most of the vineyards of that country were destroyed. It was necessary to seek resistant American species as root stocks on which to re-establish the industry. During this period Phylloxera was also carried to the then important European-grape areas of South Africa and Australia. In New Zealand Phylloxera is confined to two areas: Tauranga and all places north of Tauranga and the Hawkes Bay district.

In New Zealand 1970, there were 1470 hectares of grapes, almost four times as much as there were in 1970. The main areas are Auckland (658 ha.), Hawkes Bay (327 ha.), Gisborne (278 ha.), and Waikato (186 ha.). A large area of 500 hectares is currently being planted in Blenheim (1974).

Total world production of grapes is 54.8 million tonnes. The following table gives the production in the main grape-producing countries in 1971.

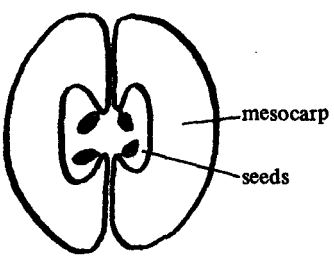
Country	Total Production	Grapes for Wine	Wine	Dried grapes (raisins, etc.)
	(1,000,000 tonnes)			(100 tonnes)
Italy	10.7	9.7	6.5	6
France	11.4	11.1	6.1	-
Spain	4.0	3.7	2.4	50
USSR	4.0	3.5	2.9	-
U. S. A.	3.0	1.6	1.4	2260
Turkey	3.8	-	-	3150
Argentina	2.4	2.2	2.1	50
Algeria	1.1	1.1	0.8	-
Portugal	1.6	1.5	0.8	1
Germany	1.3	1.3	0.5	-
	--- (tonnes) —			
Australia	758,000	341,000	275,000	589
New Zealand	17,000	17,000	21,000	–

B. BOTANY AND GROWTH

Revise Chapter 8, A3 — Buds and their Development.

Grapes flower 6-10 weeks after bud burst. The flower consists of 5 sepals (which shrivel and die soon after the bunches appear), 5 petals which are firmly united at the tip and are shed as a cap at blossom time), 5 stamens and an ovary which consists of 2 carpels and, normally, 4 seeds. The fruit is a berry.

Some American grape species are dioeceous: flowers may have rudimentary stamens (pistillate flowers) or rudimentary pistols (staminate flowers). European grapes are usually hermaphrodite.



C. CLIMATIC REQUIREMENTS

(a) Temperature:—Commercial grape cultivation is limited towards the poles by inadequate summer temperatures for maturation and winter killing, and towards the equator by winter chilling requirements. Most grape production occurs between latitude 35-40°, however, production in the highlands of tropical Asian areas is increasing.

Vines will grow very little if the temperature is below 10°C, and one way to gauge the suitability of a district for winemaking is to calculate the mean temperature for a month and multiply this by the number of days in the month. If we add the figures obtained over the growing period October to April inclusive we arrive at a new figure which is referred to as *Degree Days* (° days). Thus if the average temperature for December was 20°C the Degree Days for that month would be: (20-10) x 31 = 310.

Only in areas with heats units above 1950° days can grapes be successfully grown for dried fruit, for wine it is generally considered that 1100° days are required although some areas such as the Moselle and Rhine districts of Germany produce quality white wine with only 950° days. It is possibie, however, that by choosing a warm sheltered site 150-250 additional Degree Days may be added to the year's total. Degree Days in various districts are as follows: Davis, California (natural sweet and dessert wines, dried fruit) = 2206. Bordeaux (Claret) = 1333; Chalons-sur-Marne, France (Champagne) 1145; Trier, Germany (Moselle) 961; Henderson 1477; Gisborne 1363; Napier 1395; Blenheim 1133; Christchurch = 967; Alexandra = 897.

From the point of view of the winemaker the effect of temperature is most important for its effect on development of colour and flavour. Under relatively cool conditions ripening proceeds slowly favouring the production of good colour but retaining a high degree of acidity with most table-wine varieties; these conditions bring the aroma and flavour constituents to the highest degree of perfection. Some of the highest quality wine grapes are produced in the most northerly districts of Europe, e.g. Champagne and the Rhine.

Under hotter ripening conditions, sugars develop to a greater extent and acids are lower; hence the mature berries have a high ratio of sugar to acid. This is desirable for the production of dessert wines, for sherry and for distillation. High temperatures and dry conditions are necessary for the production of dried grapes.

(b) Rainfall: Rainfall during the growing period favours many fungal diseases and during fruit maturation causes fruit cracking and fungal breakdown. High rainfall during the critical grape-ripening period of February to April is the

most serious handicap to grape growing in the North Island, especially the Auckland area. Canterbury and Otago, having dry summers, would be very suitable for grape growing if suitable early varieties could be found which would mature under their relatively cool summers.

D. SOILS AND FERTILISERS

Vines are grown on a wide range of soil types, the main requirements being adequate drainage and an absence of root-impeding layers (vines are deep-rooting plants). There is considerable variation in wine quality with soil type, some of the better wines being produced on rocky soils high in lime, however, a pH of 5.5-6.0 is generally considered desirable.

Fertiliser needs will depend on the soil type but it should be remembered that soils which are too fertile or receive too much fertiliser will not produce the best quality wine. Certainly high nitrogen fertilisation should be avoided if qualtiy wine is required.

Grapes can be grown under clean cultivation, grass, or grass with weeds controlled under the plants, by Paraquat/diquat. Young plants may be planted through black plastic to assist with weed control in the early years. Clean cultivation is preferred when frosts and heat accumulation are problems. Night temperatures over grass may be as much as 4°C lower than over bare soil at night where frost is experienced, also, heat absorption under bare soil, especially if wet, is greater than under grass so that total heat units available to the crop may be increased. Hormones should never be used for weed control in or near the grape crop.

E. VARIETIES

On the basis of use, grapes may be classified as: — wine grapes, table grapes, sweet juice grapes, raisin or drying grapes, or canning grapes. About 94% of the grapes grown in New Zealand are used for wine, 4% for table use and 1% for juice. Many of the table grapes are grown under glass. The mature fruit of all named grape varieties (about 8,000) will ferment into a kind of wine when crushed and most can be eaten fresh or dried. However, only a limited number of varieties produce standard or higher quality wines; the raisins of commerce are produced from 3 main varieties; only about a dozen varieties are grown extensively as table grapes; for juice production and for canning only a few varieties are used.

There are two main sources of grapes: (a) the European grapes *Vitis vinifera*, and (b) hybrids between *V. vinifera* and *V. labrusca*, the native American species. The latter resulted from an attempt to combine the hardy, disease and pest resistance characters of the American varieties with the good wine and dessert qualities of the European varieties. In New Zealand there are about equal numbers of each grown. Recently a series of vinifera-rotundifolia hybrids have been bred in U.S.A. These are reputed to combine the rotundifolia genes for hardiness and disease and insect resistance with the quality of vinifera grapes.

The following list is taken from the grape survey of 1970.

Variety	Type	Area (Hectares)	Use
Palamino	Vinifera	235	Sherry and white wine
Baco 22A	Hybrid	211	" " " "
Riesling Sylvaner	Vinifera	188	White wine
Chasselas	Vinifera	125	White wine
Siebel 5455	Hybrid	107	Red wine
Albany Surprise	Hybrid	79	Red wine
Siebel 5437	Hybrid	64	Red wine
Pinotage	Vinifera	62	Red wine
Cabernet Sauvignon	Vinifera	40	Red Wine
Gamay Gloriod	Vinifera	34	White wine
Siebel 4643	Hybrid	32	Red wine
Pinot Chardonnay	Vinifera	31	White wine

The best white grapes grown in quantity at the moment are Riesling Sylaner and the Chasselas varieties. Unfortunately there are too few of the really top quality white grapes grown. Varieties such as White Riesling, Pinot Chardonnay, and Geweutz Traminer are unpopular because of poor yields even though the quality of wine is excellent. Likewise we grow too few of the quality red-wine grapes such as Cabernet Sauvignon, Pinot Noir, Gamay de Beaujolais.

The main varieties produced in glasshouses are Gros Colman, Barlinka, Black Hamburg and Pirovano 15.

Drying varieties such as Currants, Muscats, and Sultana (Thompsons Seedless, Sultanina) are essentially high sugar, seedless grapes—they are not grown in New Zealand.

F. ROOTSTOCKS

Most varieties of *V. vinifera* will strike readily from cuttings, however, in areas where Phylloxera is a problem resistant stocks must be used. Note also that no grape vine may be sent from a Phylloxera area to other parts of the country without first being sterilised under Department of Agriculture supervision.

Mourvedre x Rupestris 1202 is the most common stock in New Zealand. Cuttings strike easily and are easy to graft; they are vigorous on most soils, but, although resistant to Phylloxera, are susceptible to eelworm on moist sandy soils.

Riparia x Rupestris 3306. This is second in popularity, it is less vigorous than 1202 and may not produce such good crops. Nevertheless fruit is generally superior in colour, sweetness and set. Does well on a variety of soils.

Other stocks include *Berlandieri x Riparia* 420*A*, *Chasselas x Berlandieri* 41*B*, *Riparia x Rupestris* 3309, *Solanis x Riparia* 1616 (resistant to eelworm), *Aramon x Rupestris Ganzin No.* 1 (ARG 1).

Since in New Zealand one of the main problems is to get fruit mature before the advent of winter, stocks which induce earlier ripening are used. Those with a dominant Riparia or Rupestris character are generally suitable.

G. FRUIT SET

Most varieties are self-pollinated and self fruitful; insects do not seem to be involved in pollination, nevertheless spraying should be avoided during bloom. In most seeded varieties set seems to be dependent on the food supply to the clusters of flowers. Hence set is better the greater the number of illuminated leaves and poorer when the weather is cloudy during blossoming — rain during blossoming is the most important cause of poor set. Set can sometimes be improved by tipping the growing shoots so that more food is diverted to the berries. Tipping is done just before flower caps drop to improve set and a few weeks later if berry drop is a problem. Cincturing the canes at blossoming can improve set. If this is done later it will increase fruit size and hasten ripening. It consists of removing a small ring of bark up to 3mm wide around the trunk of the vine. Growth regulators such as PCPA (4CPA, 4-chlorophenoxyacetic acid) and gibberellic acid now tend to be used for similar effects. Albany Surprise is often cinctured when grown as a table grape.

H. THINNING

Thinning is normally practised on table grapes, more particularly those grown under glass. Sometimes whole bunches may be removed. Bunch thinning is done soon after set, it entails removing unfertilised berries, then moving to the bottom and selecting the berry which will form the point of the bunch. Thinning then should consist of removing parts so that when mature the fruits have good size and the bunch is well shaped. Fortunately grapes have only one major period of drop, which coincides with fertilisation, so that a good idea of the final appearance can be judged at thinning time.

Detailed thinning is justified for table grapes which bring very high prices. Pruning is the only effective means of regulating the crop in wine varieties.

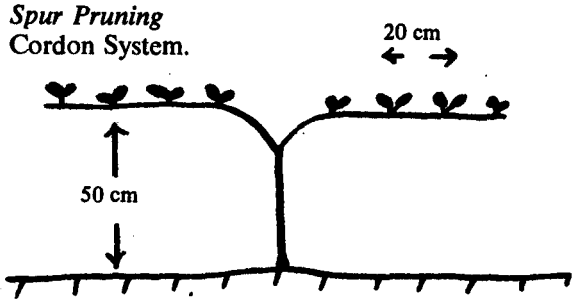
I. PRUNING

Grapes are very heavily pruned—up to 90% of last year's growth is sometimes removed. The fruiting wood on vines consists of one-year-old canes arising from two-year-old wood. One-year-old wood arising from older parts of the trunk or main arms (watershoots) does not fruit in the first season of growth: it usually is removed, although it may be used as replacement wood for old fruiting arms.

There are two types of pruning. Spur pruning can be used only on varieties which have fruitful basal buds. Rod pruning is used where buds near the base of the cane are unfruitful or with varieties producing small bunches and where many

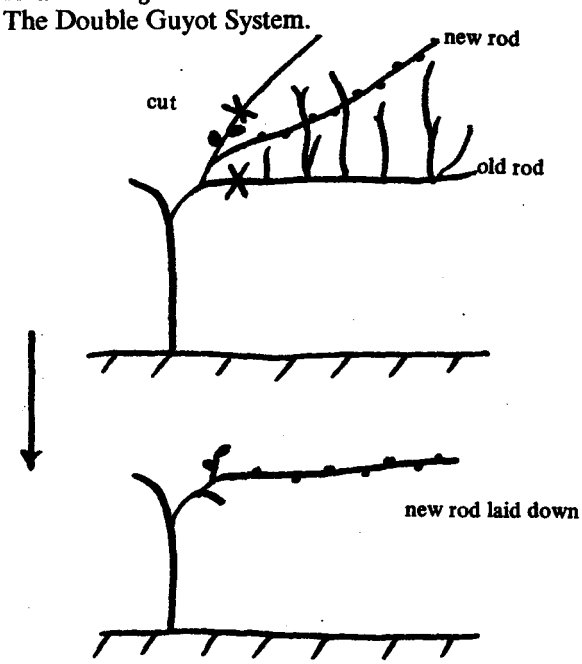
branches are required to produce a full crop. The number of spurs or rods left on a vine should vary with its size, the vigour of the year's growth and the fruitfulness of the buds.

Spur Pruning
Cordon System.



It is normal to leave 2-3 buds on each spur.

Rod Pruning
The Double Guyot System.



It is common practice in New Zealand to leave at least two rods on either side of the main trunk.

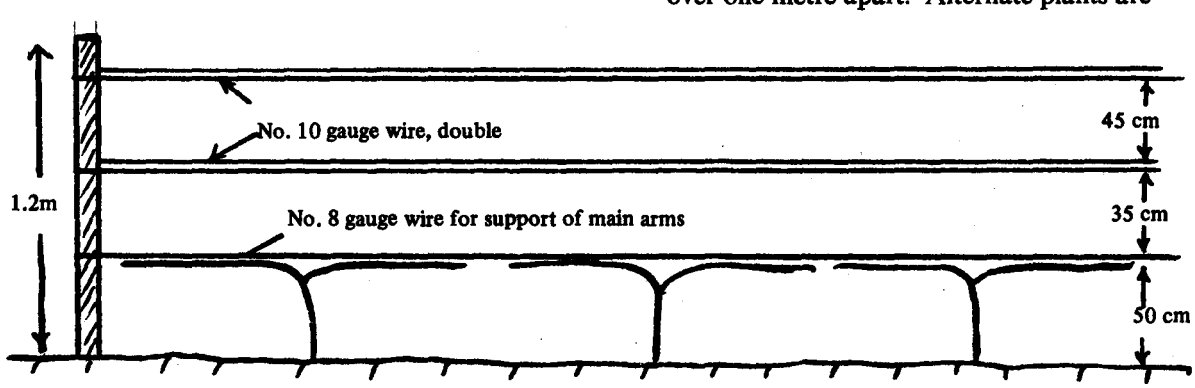
Where yield is important, cane pruning is generally the most successful method and in New Zealand it is the most common method adopted.

There are many alternative methods of pruning but we will not have time to describe these in this course. The interested student should consult Bulletin 854, "Viticulture", where other methods are described in detail.

Roots of vines extend a very long way and much of the feeding area becomes occupied by old non-feeding roots. To overcome this root pruning is often practised. Every 2-3 years deep ploughing on one side only of the vines is undertaken. This severs the roots and allows regeneration close to the vine. Two-three years later the operation is repeated on the opposite side of the rows.

J. TRELLISING OF VINES

1. *Low Trellis*
   This is the most common method and combines low cost with high yields. Most trellises are similar to the diagram below.
   Sometimes the top wires (which are double so that laterals may be trained between them) may be separated by cross pieces.
2. *High Trellis*
   In cooler districts with less vigorous varieties, high trellises of 1.5-2.0m are sometimes used; because of the increased height the danger of damage due to late ground frosts is reduced. At each spur shoots of up to ½ml are retained and allowed to hang down to form a sort of curtain. These are replaced each winter by the shoot which has formed closest to the main arm. Another alternative is to have a T-frame at the same height with wires running side by side just over one metre apart. Alternate plants are



trained on opposite wires so that a curtain of vines forms on both wires. This gives higher yields and is very adaptable to mechanical harvesting—it is called the Geneva Double Curtain.

3. *Pergolas*
   These are sometimes used for table wines, and, though they are more expensive to construct, give higher yields per acre. In the complete overhead pergola posts 2 m high are placed on 3 m squares and one vine is planted by each post. Wire connecting the tops of these posts support the vines as a horizontal canopy, 2 m high. Fruit hangs down and is picked from below. Other pergola systems, such as "Arched Pergola", are sometimes used.

We shall discuss training in more detail in lectures, and further information is available in Berrysmith's bulletin 'Viticulture'.

Grapes are normally placed 2.5 metres apart in the rows although weaker varieties may be planted as close as 2m. Distance between rows is usually 3 metres although this will be varied according to the width of machinery used.

K. DEVELOPMENT OF MATURITY IN RELATION TO WINE QUALITY

Ripening of grapes begins when the berries are almost full grown; during ripening the colour may change or the grapes may become translucent.

Chemical Composition of Grapes

1. *Sugars*—Primarily glucose and fructose; the former predominates before maturity while the proportion of fructose increases during ripening till, in *overmature* grapes, it is the main sugar.
2. *Acids*—Tartaric and malic account for 90% of the total acid content. Before ripening acid level is high but it decreases during the ripening process. This is due to the rise in acid salts at the expense of free acid. Malic acid disappears first. The unpleasant taste of unripe berries and the harsh sharpness of certain wines is generally due to excess malic acid. Nevertheless a certain amount of acidity is necessary for successful wine production.

   The pH of grape juice naturally is affected by presence of free acid. Low pH in "cleaner" fermentation which is less liable to infection by organisms other than yeasts. Grapes grown under high temperatures usually have a high pH.
3. *Colour constituents*—Colour in red and black grapes is revealed by loss of chlorophyll near maturity. High temperatures reduce colour development, probably via their effect on pH.
4. *Tannin*—Formation of tannin is accompanied by utilisation of sugars. In small quantities they provide astringency, stabilise colour and aid in fining. Too little tannin causes the wine to be dull or 'tired', too much results in bitterness.
5. *Odorous and taste constituents*—Flavour and aroma (bouquet) are a product of the above plus many other materials. Changes during maturation of wine include the chemical reaction between alcohol and acids to form esters.

As maturity approaches, the steady fall in total acidity will cease and sugar level will increase to a peak. Levels of acid and sugar can be measured and expressed as a ratio, the maturation index, this equals:

$$\frac{\text{Sugar content expressed as \% weight}}{\text{Total acidity in gm/litre tartaric acid}}$$

Time of optimum maturity is gauged when this ratio no longer increases dramatically from week to week.

The following factors tend to hasten maturity:

1. Light crops (leaf/fruit ratio is high)
2. Girdling
3. Withholding water and nitrogen.

New Zealand conditions are suitable for producing dry table wines. Natural sweet table wines require a minimum of 2,800 hours of bright sunshine and a heat summation of 2000° days. However, sweet wines may be produced by adding sugar or grapejuice in appropriate quantities.

Production of quality wine is determined by using the best varieties for the climate combined with good husbandry, determination of optimum maturity, good strains of yeast, proper care during fermentation and adequate maturation of the vine.

L. HARVESTING AND STORAGE OF GRAPES

Grapes should be handled with great care and all damaged or bruised berries removed. If grapes are to be placed in a cool store they should be cooled within 24 hours from picking. Packing material such as wood wool is often used. Grapes may be stored for up to 6 months depending on the variety used. Sulphur dioxide is sometimes used to kill micro-organisms and controlled atmosphere storage has been found suitable over

M. PESTS AND DISEASES (See notes on Apples)

17

Raspberries

A. GENERAL

World production of Raspberries is 141,200 tonnes. U.S.A. produces 31,000, Germany 24,000, U.K. 24,000, Hungary 14,000 and Yugoslavia 12,000 tonnes. Australia produces 1,500 and New Zealand 1,600 tonnes (1970).

Most plantings are small (1-4 ha.) and can yield over 12 t/ha. although the average will be lower than this. The raspberry is fairly easy to establish and produces marketable crops after 2 years and a full commercial return after 3 years. The main areas are Nelson/Blenheim and Canterbury, followed by Otago and Manawatu.

B. BOTANY AND GROWTH

The raspberry belongs to the family Roseceae. The ancestors of the garden variety *(Rubus idaeus)* still grow wild in parts of Europe and Northern Asia. Related species in America are *R. occidentalis* and *R. strigosus* and these have been used in the development of American varieties.

The raspberry has a perennial and subterranean rootstock. Shoots coming from the rootstock the previous summer provide the current year's fruiting wood. Fruit buds are borne laterally and unfold to produce a leafy shoot which terminates in an inflorescence. The inflorescence is a panicle (a compound raceme). Flowers are white with five sepals and petals and numerous stamens. The fruit is an aggregate drupe.

C. CLIMATIC REQUIREMENTS

Raspberry suits cool temperate regions. Areas which grow European plums and apricots seem to be suitable for raspberries. Few raspberries are grown north of Palmerston North and Levin. Raspberry buds burst late August and early September and flowers open late September to early October. After the buds are showing colour, temperatures of -2°C can cause damage. Early-flowering varieties such as Marcy are more frost-susceptible and a number of growers use sprinkler irrigation for frost control.

Summer rainfall is required and if this is inadequate irrigation may have to be installed.

D. SOILS AND FERTILISERS

Raspberries require good deep soil. They do best in soils which are slightly acid (pH 5.6-6.5) and are gross feeders.

Local advice should be sought to determine annual fertiliser needs.

E. HARVESTING IN NEW ZEALAND

Marcy is the most widely grown raspberry followed by Lloyd George. Taylor is popular in Canterbury and Red Antwerp (a late raspberry) in Nelson. Great American is used by a number of growers for jam making and some East Malling varieties are becoming quite widely planted. The results in the table are from a trial at Levin set out in June 1965 (hills 1.2m x 3m).

Fruit from 'Boyne' and 'Killarney' was considerably smaller than from the others.

A breeding programme is underway at Crop Research Division, Lincoln, to produce high yielding rich red types of good flavour. Marcy is being used as one parent and it is hoped to combine the good flavour of other varieties with the high yields of Marcy.

F. PROPOGATION

Raspberries can be freed from most viruses by growing plants for 2-3 weeks at 35°C. Fortunately, in New Zealand, which doesn't have the Raspberry Aphid, viruses are not a great problem. Nevertheless soil-borne viruses are possibly pre-

	Yield (tonnes/hectare)		Dates of Harvest (1970)	
Cultivator	1970/71	Mean Annual ('67/68-'70/71)	First Significant Pack	50% of crop picked
'Marcy'	17.3	16.0	24 November	7 December
'Lloyd George'	14.5	12.2	11 December	20 December
'M. Promise'	13.5	12.2	11 December	23 December
'Taylor'	11.0	9.0	11 December	23 December
'M. Exploit'	7.1	9.0	26 November	9 December
'Killarney'	10.3	8.8	11 December	26 December
'M. Enterprise'	10.1	8.5	11 December	28 December
'Norfolk Giant'	10.5	7.9	11 December	31 December
'M. Jewel'	9.9	7.8	11 December	27 December
'Boyne'	9.1	7.8	11 December	20 December

sent and Levin has released virus-free Lloyd George. Stock plants are set out in rows 2m apart with canes 0.6m apart in rows and each winter canes are cut to the ground. Suckers provide the basis for new plants and often the whole row will be removed and young plants selected.

G. PLANTING AND TRAINING

Raspberries produce reasonable crops for about 12 years after planting. The ground should be well-prepared and free of perennial weeds. Systems used:—

1. *Hedgerow System*
   Plants are usually placed 45cm apart in rows 1.5-2.0m apart. A fence 1.5m high is constructed. Posts are 10-12cm thick to spread the wires. The first pair of wires is strung 60cm from the ground and the second pair about 60cm above these. Canes are trained between these wires. This system gives best yields but requires more plants per hectare.
2. *Hill System*
   Clumps of 6-8 canes are planted on the square 2 x 2m. Canes are tied to a post about 1.75m high, fruiting laterals will then grow outwards from this.
3. *Hoop System*
   Planting is the same as in the Hill System but fruiting canes from adjacent hills are tied together to form hoops. New canes are tied to the post until winter when they in turn are tied to form next season's hoops.

What do you think are the advantages and disadvantages of each system?

Topping the plants to a certain height is often practised. This is usually done in August with the idea that removing tops of canes will stimulate the development of remaining buds. In the case of vigorous plants it may also help to keep the canes at a manageable height for picking. However, trials have shown that the higher the cane the higher the yield, thus one should only resort to topping for convenience of picking, not for increased yields.

After picking, fruiting canes are normally removed and remaining canes are reduced to 12 (hill or hoop) or 6 (hedgerow).

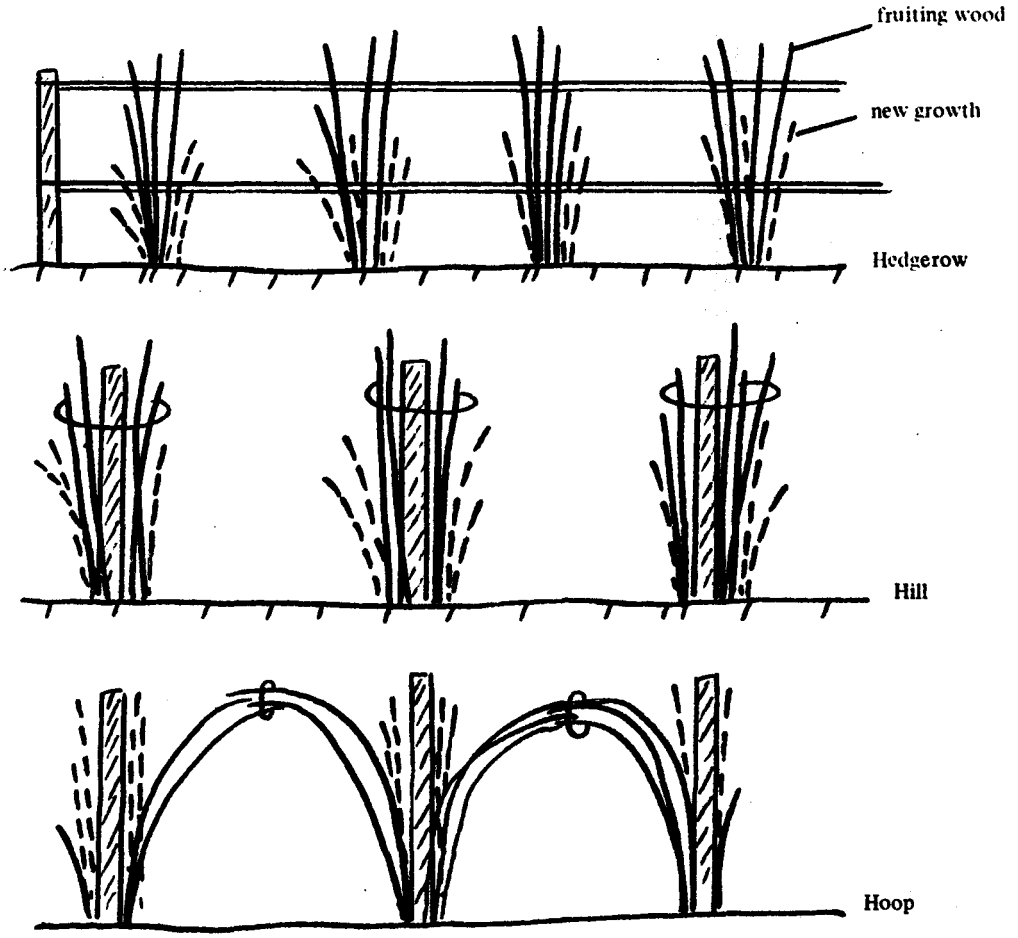
H. FRUIT SET AND FRUIT GROWTH

Raspberries, boysenberries, loganberries and blackberries are self-fertile and cross pollination is not required. Nevertheless the presence of bees will sometimes help improve fruit set. Fruit growth of raspberry is double sigmoid.

I. CULTIVATION

The following methods are used:—

1. Clean cultivation with or without chemical weed control.
2. Clean cultivation with cover crop sown in March (rarely used now).
3. Mulching with sawdust.
4. Mown sward.
5. Mown sward with control of weeds in rows using paraquat and simazine.



Method 2 seems to give best yields but it may not be most convenient; method 5 is probably the most widely used now.

These are three Raspberry Marketing Committees in the South Island. One in Canterbury, one in Nelson and one in Central Otago. Nelson is the only committee which controls marketing to approximately the same degree as the Apple and Pear Board, although growers can sell an unlimited quantity privately. The other committees act as advisory bodies for marketing, although they will actually fix quotas for processing firms and may make arrangements for transport to the North Island. North Island raspberries come under the jurisdiction of the Berryfruit Growers' Federation. This does not undertake marketing but acts as an advisory body. The Nelson committee now organises exports and the other marketing committees have agreed to act thrugh the Nelson Committee.

J. HARVESTING AND MARKETING

First crops come in late November in the North Island and mid December in the South Island. These are fruits borne on last year's canes. The crop lasts for 3-4 weeks and picking is done every 3rd or 4th day. A second crop is usually borne on the tops of the present season's growth and this is harvested late in the season (about March). Fruit is picked into punnets or tins for marketing fresh (dessert or jam). When supplied for processing (jam, quick freeze or icecream) containers as arranged by the marketing authorities are used.

Most of the non-dessert raspberries are made into jam, frozen or used as flavouring for icecream. Canning of the fruit and preparation of raspberry juice or wine are not widely practiced in New Zealand but are popular in some other countries.

18

Boysenberries and Loganberries

A. GENERAL

These are hybrid berries which originated in U.S.A.

Botanically they are similar to raspberry except that the berries are larger, the receptacle does not come away when the berry is picked and the shoots are longer and are trailing.

The boysenberry yields heavy crops—12 tonnes /hectare or more—and plants will last up to 20 years. The main areas in New Zealand are Nelson/Blenheim, Hamilton/Tauranga followed by Hastings/Gisborne.

B. CLIMATIC REQUIREMENTS

These fruits can be grown in most areas of New Zealand and can withstand drier conditions than can the raspberry. Windy areas, however, are not very successful because of damage to vines and flowers.

C. SOILS AND FERTILISERS

Similar to raspberry.

D. VARIETIES IN NEW ZEALAND

Most of these fruits have originated from seedlings and there are no named varieties. Levin has, however, selected several promising strains and these can now be obtained as 'Levin Selected Strains'.

E. PROPAGATION

The most common method used is tip layering. This is done when the tip becomes 'snaky' and leaves are reduced in size (February-March). The tips are pegged down or buried in a small trench. The young plants are replanted in spring. Serpentine layering—a modification of tip layering—will give a greater number of plants.

F. PLANTING AND TRAINING

Plants are normally spaced about 3m apart in rows which are 2-2.5m apart. Posts are 1.5m high with three wires, the bottom of which is about 50 cm above the ground. About 5 shoots are then trained horizontally along each wire. In winter the old canes are cut to the ground and burnt, current season's growth is then tied to the wires. Summer pruning can be adopted if the growth of the new canes is too vigorous: surplus canes are removed as they appear by cutting to ground level. This process, however, should not continue beyond early December.

G. CULTIVATION

Similar to raspberries.

H. HARVESTING AND MARKETING

Harvesting of boysenberries occurs from about Christmas to early February. Boysenberries are not under the control of Raspberry Marketing Committees, but contracts are often arranged with local processing firms.

19

Blackcurrants

A. GENERAL

The blackcurrant is easy and cheap to establish. It crops reasonably well in its third year and is in full production in four years. The economic life of a planting is about 12 years and yields of up to 12 tonnes/hectare are possible. The main areas are Canterbury, Otago and Manawatu.

B. BOTANY AND GROWTH

Currants and gooseberry belong to the family Saxifragaceae. Blackcurrants (*Ribes nigrum*) are found wild in Europe, Russia, and Central Asia.

Fruit buds are formed laterally and contain one or two leaves below a terminal raceme of about 10 berries. The apical bud is vegetative and continues the growth of the stem. Buds and other parts of the plant contain yellow glands which give off the characteristic odour of blackcurrants.

Flowers are greenish white and inconspicuous. All flower parts are in fives. Growth of the fruit is double-sigmoid. Flower-bud initiation occurs in response to short days.

C. CLIMATIC REQUIREMENTS

Like raspberries the black currant does not grow well in areas north of Palmerston North and Levin. Blackcurrants like plenty of moisture in the summer and can be grown in situations which might be considered too cool for other fruits. Late frosts can kill the blossoms which open early October. Blossoms can be damaged by strong winds and shelter at the time is sometimes necessary.

D. SOILS AND FERTILISERS

Deep well-drained soils which retain the moisture in summer are best. Nevertheless blackcurrants are more tolerant of wet soil than red or white currants and most other fruit trees. A pH of 5.8-6.0 is considered ideal. Suitable fertilisers are usually applied in Autumn or Spring.

E. VARIETIES IN NEW ZEALAND

The following three varieties, in order of preference, make up the bulk of planting in New Zealand: (1) Magnus, (2) Cotwold Cross, (3) Goliath.

F. PROPAGATION

Currants are normally propagated by hardwood cuttings 20-30cm long. For blackcurrants the previous year's growth is used and all buds are retained. With red and white currants older wood can be used and lower buds removed.

G. PLANTING AND TRAINING

Planting normally takes place in autumn, plants are spaced from 1-1.5m apart in rows 2-2.5 m apart. Bushes usually yield in the 2nd year and produce economic crops in third year. Pruning consists of thinning out the bushes and retaining young canes which originate as close to the ground as possible. A new system of short-term cropping has recently been introduced. Cuttings are planted 15cm apart in the rows, usually through plastic, and are left for 3-4 years without pruning. After this the bushes are either severely pruned, cut to the ground, or the area is replanted. The following trial at Levin showed same remarkable differences:

Conventional—1.2 x 2.5m—average yield over first 4 years: 4.2 tonnes/hectare.

Short-term cropping—.15 x 2m—average yield over first 4 years: 7.2 tonnes/hectare.

To guard against blackcurrant eelworm it is wise to dip cuttings or plants in 2500 ppm parthion.

H. FRUIT SET AND FRUIT GROWTH

The blackcurrant is self-fertile but cross pollination may improve set. Growth of fruits is double-sigmoid.

I. CULTIVATION

Blackcurrants are now often grown through black polythene. The rows can then be cultivated, kept weed-free with chemicals or grassed down.

J. HARVESTING AND MARKETING

Blackcurrants ripen from about the middle of December until early February depending on variety. Blackcurrants can be adapted to mechanical harvesting and for this the variety Magnus would seem to be best. A machine has been developed by the Agricultural Engineering Institute at Lincoln College in conjunction with the Horticultural Research Station at Levin. You will probably have an opportunity of seeing this during the year.

20

Red and White Currants

A. GENERAL

These are seldom grown commercially in New Zealand. Only where growth or culture differs from blackcurrant will details be given below.

2. BOTANY

These are types of the species *Ribes rubrum*, the white currant is sometimes referred to as *R. rubrum album*. Flowers are small, whitish-green and borne on racemes on old wood.

C. CLIMATIC REQUIREMENTS

A warmer position is required for these fruits than for blackcurrants.

D. VARIETIES IN NEW ZEALAND

Red currants—Fay's Prolific and Versailles.

White currants—White Dutch and White Transparent.

E. PLANTING AND TRAINING

Bushes are usually planted at 1.2m intervals in rows 2-2.5m apart. They can be grown on standards 30cm or more in height. A framework is usually provided with about six main leaders. Laterals are usually cut back in winter to 3 or 4 buds to encourage the production of spurs. Since production from spurs over 3 years old is reduced, a number of main leaders are cut back each year and are replaced by strong new shoots.

21

Gooseberries

OF THE BERRY FRUITS GROWN commercially gooseberry is the least common. Nevertheless the possible use of standard bushes and the advent of mechanical harvesting may encourage the production of this crop. Gooseberries usually yield over 15 tonnes/hectare. The biggest area is in the Manawatu.

A. BOTANY AND GROWTH

The gooseberry (*Ribes grossularia*) is a native to central and southern Europe, North Africa and Western Asia. Growth of the bush and the initiation of flowers resembles red and white currant and pruning and training are often similar. Flowers are borne laterally either singly or in twos and threes.

B. CLIMATIC REQUIREMENTS

Like currants and raspberries, gooseberries do not do well in the northern parts of New Zealand. They require reasonably sheltered conditions and can be damaged by late frosts at or near flowering which occurs in early September (Levin Early flowers first).

C. SOILS AND FERTILISERS

Gooseberries, red and white currants will not tolerate conditions as wet as can be withstood by blackcurrants. A silty loam, pH 5.8, is supposed to be ideal for gooseberries.

D. VARIETIES IN NEW ZEALAND

The following table shows yields of gooseberries obtained in experiments at Levin.

Results are from a trial set out in July 1964.

E. PROPAGATION

Gooseberries are propagated using hardwood cuttings taken in early winter. The length of the cutting is dependent on whether the plant is to be grown as a standard or not. Buds should not be removed from the base of the cuttings until they have rooted.

Cultivator	Mean Annual Yield, tonnes/hectare 1966/67 to 1970/71	Single Pick Harvest Date 1970/71
'Green Overall'	15.8	24 November
'Gregory's Perfection'	14.4	23 November
'Yorkshire Champion'	14.0	24 November
'Crown Bob'	12.1	4 December
'Farmer's Glory' No 6	10.5	26 November
" " No 5	8.6	1 December
'Billy Dean'	8.6	1 December
'Levin Early'	8.1	11 November
'Roaring Lion'	6.1	26 November

F. PLANTING AND TRAINING

Plants are spaced at 20-30cm intervals in rows 1.75-2.00m apart. Pruning, whether on standards or otherwise, is towards a framework of 7-8 branches. During pruning laterals are thinned out and some of the old laterals and spurs are cut back hard to encourage new growth. Branches and laterals trailing on the ground are removed. Pendulous types, such as Farmers Glory, are pruned as near as possible to an upright habit.

G. FRUIT SET AND FRUIT GROWTH

Gooseberries are self-fertile and fruit growth is double-sigmoid.

H. CULTIVATION

Similar to blackcurrants.

I. HARVESTING AND MARKETING

They are the earliest of berryfruit harvested (see table) coming in at about the start of the strawberry season. Gooseberries could probably be adapted to mechanical harvesting now the machinery for blackcurrants has been perfected. To this end plants at Levin are being grown through polythene at 15cm intervals, yields suggest that this is likely to be economical.

22

Strawberries

A. GENERAL

World production of strawberries is 1,041,400 tonnes. U.S.A. produces 224,000, Japan 133,000, Mexico 110,000, Poland 94,000 and Italy 94,000 tonnes. Australia produces 40,000 and New Zealand 50,000 tonnes (1970).

Strawberries are easy to establish and produce marketable crops in the first year.

Yields of strawberries can be as high as 60 tonnes/hectare. Biggest areas are Auckland, Canterbury and Manawatu.

B. BOTANY AND GROWTH

Wild strawberries are found in north and south America, in northern and central Europe and in Asia from Siberia to north Syria. The Old World wild strawberry, *Fragaria vesca*, is small and the modern varieties of strawberries are mostly due to the introduction into Europe of the American species *F. virginiana* and *F. chiloensis*. The name strawberry originated from the Anglo-saxon streawberige and is not related to the practices of laying straw beneath the fruits.

Strawberries belong to the order Rosaceae. There are five petals, five sepals, numerous stamens and numerous one-seeded carpels (chenes) situated on a fleshy receptacle. The main stem of the strawberry, the crown, is greatly reduced due to extremely short internodes. At the nodes a leaf subtends an axillary bud which can form a stolon, or axillary crown or even inflorescences. Stolons are produced during long days and are stopped when short days induce the apex to become reproductive. At this time branch crowns may be developed. Certain varieties of strawberry such as Red Gauntlet are not so dependent on day length as others. These 'perpetual fruiting' strawberries can initiate flowers under longer days and produce more than one crop a year.

C. CLIMATIC REQUIREMENTS

Most areas of New Zealand can produce strawberries. Early strawberries usually gain maximum prices and so northerly slopes are usually sought. Protection from strong winds is desirable and adequate summer moisture required. Strawberries flower late in September-early October and frost control is often necessary.

D. SOILS AND FERTILISERS

Moderately well-drained soils suitable. Acidity down to 5.5 satisfactory.

E. VARIETIES IN NEW ZEALAND

Red Gauntlet accounts for 70% of the present planting in New Zealand. Cambridge Favourite is a popular early strawberry especially in Auckland while Tioga is a new American variety which holds considerable promise. It gives yields which are almost as high as Red Gauntlet and crops about one week earlier.

The following table shows yields of certain varieties planted in two systems (see later).

F. PROPAGATION

Two viruses, yellow-edge and crinkle, can be troublesome and must not be propagated. Virus can be inactivated by growing at 38°C for 3 weeks. Ideally strawberry plants are propagated in areas where the strawberry aphis cannot survive (high altitudes). In U.K. the research stations produce virus-free stocks which are distributed to nuclear stock growers who grow it for a year and sell to selected growers who sell it as 'elite' stock. In New Zealand Levin Experimental Station supplies 'mother' stock which can be used for propagation. The majority are grown by Turners and Growers in Auckland who have their nurseries away from other planations, cover the plants with insect-proof netting and use systemic insecticides

Plants of the four cultivars ex cold store were set on 20 February 1969 and compared with freshly lifted plants set on 22 April 1969. Yields were as follows:

Treat No.	Cultivator	Month Set	Total Yields tonnes/hectare			
			1969/70		1970/71	
			Nov-Dec	Nov-Feb	Nov–Dec	Nov–Jan
1.	'Red Gauntlet'	Feb.	25.2	46.5	31.3	55.5
2	"	April	21.0	33.3	27.5	49.0
3.	'Tioga'	Feb.	46.6	61.3	61.3	82.9
4	"	April	15.4	16.0	50.0	75.1
5	'C. Favourite	Feb.	37.7	53.4	52.5	70.8
6	"	April	18.4	20.8	50.0	67.4
7	'Shasta'	Feb.	29.0	44.5	32.5	48.2
8	"	April	11.5	12.6	28.8	42.8

such as metasystox to eliminate any predators. However, unlike the U.K., we have no legislation on this matter and anyone can sell strawberry plants. Plants are normally spaced 1.2m apart and runners from each yield up to 100 daughter plants.

PLANTING AND TRAINING

Conventionally Autumn is the normal time for planting strawberries. February-March planting is now gaining in popularity and can give up to 3-fold increases in the first year (see table). Runners are lifted in June and July and stored in polythene bags with tops folded over (not sealed) at -1°C (limit of variation -2° to 0°C). After planting in February it is essential to see that the young plants receive adequate water. Nowadays most strawberries are planted through black polythene. The soil between the rows is usually kept weed-free by using Simazine (1lb/acre) and Paraquat or Diquat may be used as additional sprays if full control has not been achieved.

Distances

In Auckland strawberries are grown as an annual crop and spaced about 12cm apart in rows 1m apart. This means about 95,000 plants are needed per hectare. Occasionally they are double planted in rows and 125,000 plants are required. In the South Island where plants are usually kept for three years they are usually spaced 24cm apart in rows 1 m apart (47,000 plants/hectare). Plants can be derunnered using Paraquat or Diquat.

G. FRUIT SET AND FRUIT GROWTH

Strawberries are self fertile. Fruit has a sigmoid growth curve. Flowering occurs in early September and the first fruits mature in mid November onwards (October in Auckland).

H. HARVESTING AND MARKETING

Strawberries are picked in punnets or cans for dessert or jam (or processing). After picking the early crop, fields are often opened up for 'pick your own'.

Some are exported to Australia. A number of processed products are made. They can be frozen (free flow or slab), canned, made into jam or used for flavouring. Juice and wine manufacture is quite common overseas. Overseas they also freeze and drum-dry strawberries.

23

The Culture of Chinese Gooseberries

Reference—Ministry of Agriculture Bull. 349
"Growing Chinese Gooseberries".

A. INTRODUCTION

The Chinese gooseberry, Kiwi berry or Kiwi fruit (*Actinidia chinensis*) is a native of China and was first introduced into New Zealand at about the turn of the century. However, the commercial potential was not realised until about 1940 when several small plantings came into production in the Bay of Plenty. Nowhere else in the world has the Chinese gooseberry attained the commercial development and general acceptance that it has in New Zealand.

By 1972 there were over 525 hectares planted in New Zealand and average plantings of over 40 hectares/year are expected for the next few years. Because of the high rate of planting yields, which are now (1972) 2300 tonnes/year, are expected to increase about four-fold by 1980. About half the crop is exported and marketed as 'Kiwi berry' or 'Kiwi fruit'. Main plantings are in the Bay of Plenty with smaller areas in Kerikeri, Auckland and Gisborne.

The Chinese gooseberry commences bearing about four years from planting and reaches full production in about nine years. The produce up to 20 tonnes/hectare when in full production.

B. BOTANY AND GROWTH

Actinidia chinensis is a member of the family Actinidaceae which is indigenous to Eastern Asia. It is a deciduous fruiting vine growing to a height of 9m in its natural habitat. Leaves are cordate up to 20cm long and branches covered with small reddish hairs. It is dioecious and produces flowers on one-year-old wood in much the same way as the grape. Flowers are 3-4cm across, white-buff yellow borne in small clusters in the axils of leaves. The fruit is a juicy berry bearing many small seeds.

C. CLIMATIC REQUIREMENTS

While dormant the deciduous vine can stand relatively hard winter frosts but spring growth in September-October is very tender and easily injured by light frosts. Although being confined commercially to subtropical areas the vine is slightly more hardy than citrus, tamarillos or passionfruit. The Chinese gooseberry is less susceptible to wind damage than other citrus or subtropicals grown in New Zealand—nevertheless strong winds will break young branches and branch rub can severely damage fruits, especially of the Haywood variety. Irrigation is not generally used in the high rainfall areas where the vines are grown but there is evidence that in some seasons inadequate soil water has adversely affected fruit size and crop returns.

D. SOIL AND FERTILISERS

They will grow in a wide range of soils provided they are well drained. Deep friable sandy loams are best and heavy wet soils are generally unsuitable. Chinese gooseberries are gross feeders and heavy dressing of artificial fertilisers are often used. They are applied in two dressings, half to two-thirds in late August-September and the balance after fruit set in December.

E. VARIETIES

The late-flowering Hayward is the most popular variety in New Zealand because of its superior flavour and keeping quality, about 90% of new plantings are with this variety. Other varieties are Bruno (largest), Abbott, Allison and Monty.

F. PROPAGATION AND PLANTING

The most common way of propagating vines is by budding or grafting desired varieties on seed-

ling stock. Cuttings are also used but seedlings are too variable for satisfactory use.

Seedlings sown in late July can usually be T-budded in March at the end of the first growing season or grafted at the end of July or August using the whip and tongue or cleft graft. They can also be propagated using soft-wood and root cuttings.

Plants are usually grown on trellises which are 4-4.5m apart and plants are spaced 7.5-9m apart in the rows (6m for Hayward). Planting is best done in late winter.

G. FRUIT SET AND FRUIT THINNING

Flowering takes place in spring after the young shoots have begun to elongate. Pollination is mainly by insects and it is necessary to have a male clone which blossoms at the same time as the female. If, in every third row, every third plant is a male, adequate pollination should occur. Male scions are sometimes grated on to female plants so that one in every 9 horizontal branches is male. Male plants or laterals are not allowed to become too vigorous. Inadequate pollination results in reduced fruit numbers and size.

Thinning is not required for Chinese gooseberries.

H. PRUNING AND TRAINING

Vines may be grown on fences or pegolas. The former is cheaper and is more common for commercial production. Posts are placed about 6m apart and each is about 1.8m high. A wire is run along the top and a second may be placed about ½m below. Training is illustrated below:—

The temporary arms are cut out after 2-3 years. Vines may be spur pruned in much the same way as grapes and for this method 3-4 wires are used and one permanent arm is run along each wire.

Fruit normally develops on the first 3-6 buds on the current season's growth and the vigorous growth at the end of the shoot is usually removed during the summer to reduce the vigour and allow light and air to gain entry to the fruit. Cut back between buds 8-9 after the last fruit which has been formed on the lateral. Further growth will then occur probably from buds 7 and 8. Later in the season cut back between buds 6-7 on the same lateral and repeat if necessary making sure to leave at least two dormant buds after the last fruit (these will flower next year).

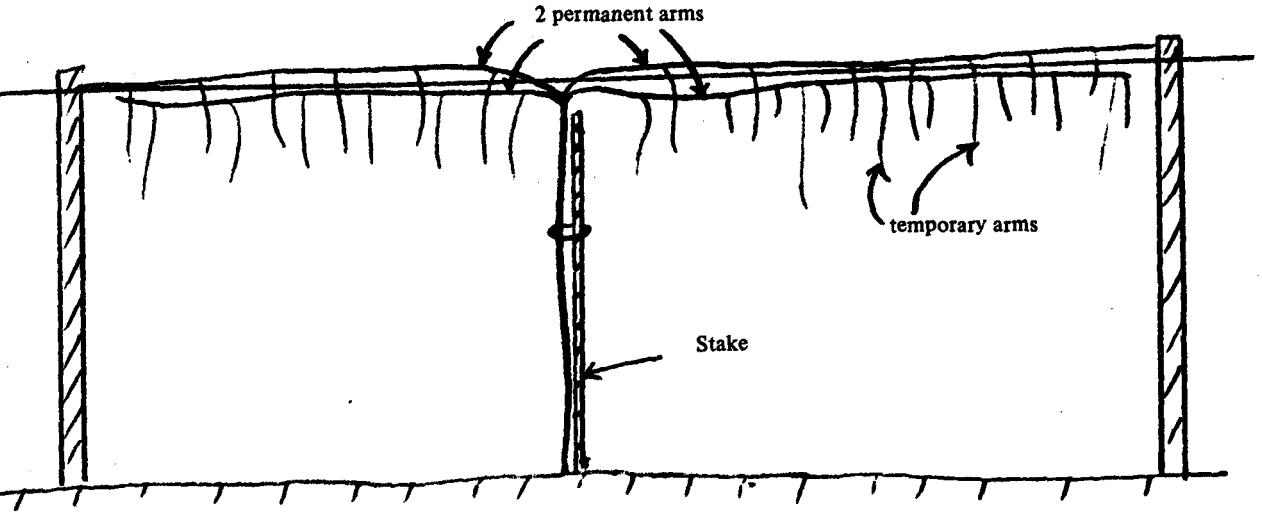
If laterals stop growing on their own account do not prune again until winter. Trials have shown that Alar sprayed on the vines in the summer will reduce the amount of summer pruning. Winter pruning begins in July after the crop has been harvested when the vines are dormant. It consists mainly of removing one-third of the main fruiting arms and cutting back other laterals to two buds after the last fruit, if this was not accomplished by summer pruning).

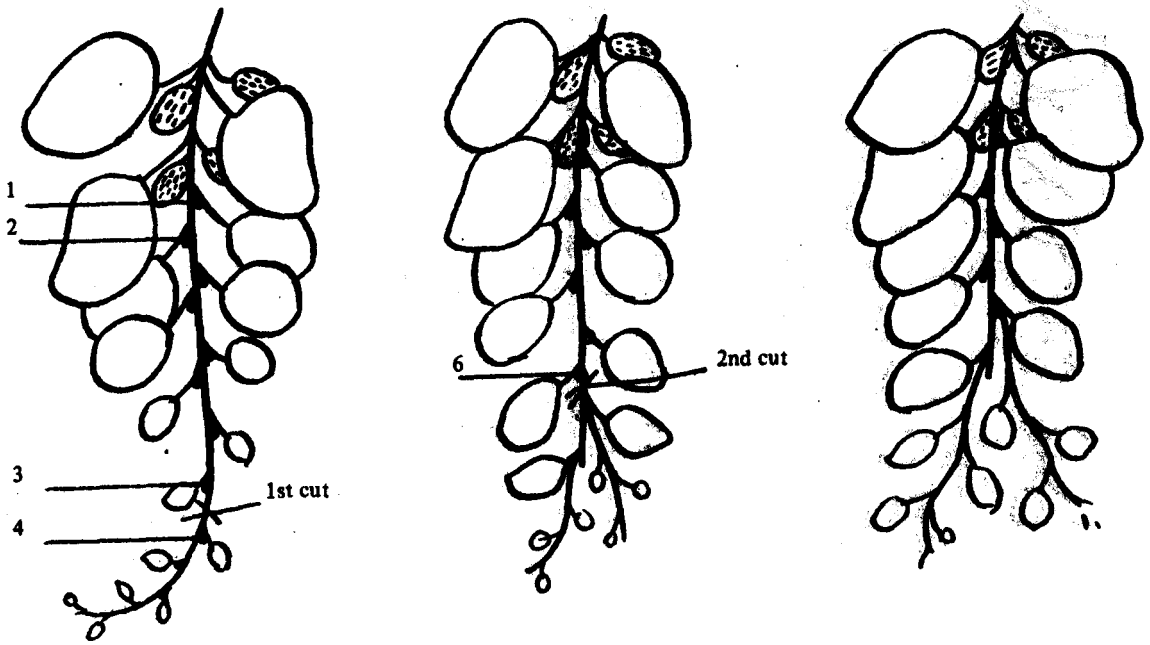
I. CULTIVATION

Most growers now maintain their vines in a permanent sward, which should be predominantly clover, and use herbicides to control growth in the rows.

J. HARVESTING AND MARKETING

The first fruits of the season are normally ready for picking at the beginning of May and harvesting continues till about July when winter





pruning of the vines must begin. Berries are harvested when still hard and allowed to soften off the vine before eating. Several pickings need to be made.

Fruit have excellent keeping qualities and may be kept in a cool draught-free place for up to 8 weeks. They will keep 4-6 months in cool storage at -1 to 0°C and 90% R.H. and polythene box liners are often used to maintain the humidity.

Fruit are packed in various ways—from single layers to jumble packs in ¾ sized cases. Special attention should be paid to export fruit to ensure that a good presentation is achieved.

K. PESTS AND DISEASES

There are few pests and disease of serious concern for the Chinese Gooseberry grower. Among those sometimes causing problems are: leaf roller catepillar, greedy scale, thrips, root-knot eelworm and botrytis rot.

24

The Culture of Tamarillos

Reference — Ministry of Agriculture Bull. 306
"Tree Tomato Growing"

A. INTRODUCTION

The tamarillo or tree tomato (*Cyphomandra betacea*) is a sub-tropical shrub and native of Brazil and Peru. It was introduced into New Zealand in the 1890's but only since the last war has it been produced extensively in N.Z. Although it is now grown in a number of countries it seems that only in N.Z. has its commercial potential been exploited.

Bushes commence bearing with 18 months from planting out and they produce up to 30kg per annum after 3-4 years. An average yield is 3 tonnes/hectare. The plant is generally short-lived.

Yields in N.Z. could reach 2,500 tonnes by 1973 at which stage the local fresh-fruit market could be becoming saturated. In 1971 there were 220 hectares planted in tamarillos. Largest plantings are in Bay of Plenty and Kerikeri, followed by Auckland with a much smaller number growing in Gisborne.

B. BOTANY AND GROWTH

Cyphomandra betacea is a member of the Solanaceae family. It is a shrub growing to 3-4 metres with large leaves, brittle branches and shallow roots. It produces fruit on one-year-old wood. Flowers are in long pendulous racemes, purple in the bud becoming greenish pink. Fruit is a two-celled berry with many seeds. There are two common strains grown in N.Z., the yellow and the red of which the red is the more popular.

C. CLIMATIC REQUIREMENTS

Tamarillos are sub-tropical shrubs and aré considerably more frost tender than lemons, consequently they are grown only in the warmer areas of the North Island where frosts are infrequent and slight.

Due to the brittle nature of the shrub and the shallow rooting habit adequate wind protection is required.

D. SOILS AND FERTILISERS

Light fertile well-drained soils are best for successful establishment, plants cannot tolerate waterlogging or periods of drought so that drainage and irrigation may need to be provided. Being heavy bearers regular fertiliser applications may be necessary. Fertiliser is best applied in two dressings — early September and November-December, amounts will depend on soil types and soil reserves.

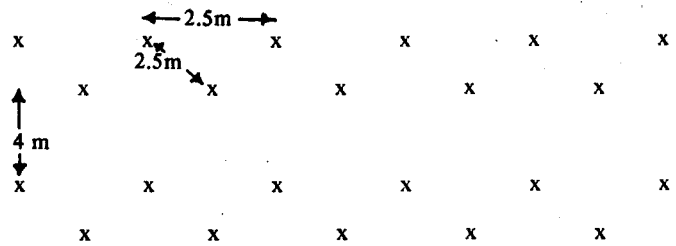
E. VARIETIES

There are no recognised named varieties but plants should be obtained from recognised healthy and heavy-bearing stocks. Although the red strain is most commonly used commercially yellow strains are often considered to be more palatable.

F. PROPAGATION AND PLANTING

Plants are obtained from seeds or cuttings. Seedlings tend to be more upright having a stem of about 2 metres before branching occurs. Cuttings are lower and more bushy. The former is generally preferred for commercial production.

Plants are often set out in double rows with 2½m within and between double rows while the double rows are placed 4 metres apart.



G. FRUIT SET AND FRUIT THINNING

Flowering occurs in late spring and early summer, set is not usually a problem and thinning is not required.

H. PRUNING

Seedling plants are usually cut back to about 1m to encourage branching and each branch may be subsequently pinched back at 45cm to further encourage branching. Maintenance pruning consists of removing dead wood, thinning to prevent overcrowding and cutting back laterals to encourage new growth (remember it fruits on one-year-old wood). Pruning is normally done after harvest. Time of pruning influences time of maturity; early spring pruning induces early maturity while late spring pruning (October-November) results in a late crop (November). Thus to spread harvest different parts of the plantation may be pruned at different times.

I. CULTIVATION

The normal method is to keep the area within the double rows clean with herbicides and to grass down the area between the double rows. If mechanical cultivation is adopted it should be shallow to prevent damage to the roots.

J. HARVESTING AND MARKETING

The harvesting period is from April until November—not all fruits mature at the same time on a bush and so numerous pickings are required. The stalk must be retained and the fruits are normally packed in shallow packs—little size grading is necessary.

Storage is not usually considered since the fruit is picked over a long period. However, hot water treatment at 50°C for 10 minutes, followed by waxing and storage at 3.5-4.5°C will enable the fruit to be stored from 12-14 weeks.

K. PESTS AND DISEASES

The main problems are caused by powdery mildew, ascochyta, blast, white flies and green vegetable bugs. Fortunately all these, except blast, are easily controlled using sulphur, Bordeaux and Gusathion.

25

The Culture of Passionfruit

Reference—Ministry of Agriculture Bull. 135
"Passionfruit Growing"

A. INTRODUCTION

The purple passionfruit or granadillo (*Passiflora edulis*) is a subtropical climber which is a native of tropical South America. The banana passionfruit (*Passiflora mollissima* or *Tacsonia mollissima*) is more hardy but its quality is inferior.

Passion vines commence bearing fruit within 15 months of planting and reach full production after 2 years, but due to heavy costs, for trellising especially, it is usually sometime before a payable return is obtained.

There are about 40 hectares (1973) of purple passionfruit in New Zealand with a production of about 100 tonnes/annum. Most are grown within the Auckland Province. Outlets for this crop on the local market are limited and although there has been some interest in exporting passionfruit, especially as pulp, disease control problems and high costs of production are likely to limit any substantial development for this purpose in the foreseeable future.

B. BOTANY AND GROWTH

Passiflora edulis is a member of the Passifloraceae family. It is a climber which produces fruit on one-year-old wood. Flowers are large (5cm across) usually solitary, white in the inside, and green on the outside, and the fruit is a many-seeded berry.

C. CLIMATIC REQUIREMENTS

Passion vines tolerate only slight frosts and need warm, moist conditions to survive. Good shelter and aspect to provide the warmest possible conditions are important. Irrigation is not needed in most passionfruit areas.

D. SOILS AND FERTILISERS

All soils except heavy clays can be used for passionfruit. A deep well-drained friable sandy loam with good drainage is the best. Fertilisers should be applied on the same basis as for tamarillos.

E. VARIETIES

No established varieties are available but material taken for propagation should be from carefully-selected plants.

F. PROPAGATION AND PLANTING

The usual method of propagation is to raise plants by seed, but they can also be raised vegetatively by grafting or from cuttings. Cuttings are not often used because of the danger of transmission of viruses. Grafting on the other hand may have advantages in that resistance to crown canker, die back and black root rot may be obtained. The banana passionfruit would seem to be the most suitable rootstock.

Planting distances of 3m between rows and 5m in the row are usually adopted. A trellis with two wires at 1 and 2m above the ground should be provided before planting.

G. FRUIT SET AND THINNING

Flowering occurs in late spring (November), fruit set is not a problem and thinning is not required.

H. TRAINING AND PRUNING

When the young vine starts to grow choose the four strongest shoots and direct two to each wire, allow 2-3 branches from each leader to grow

along the wires as shown in the diagram below, tie the leaders, do not twist around wire as this means replacement will be difficult. From here on pruning is similar to the cordon (spur) system of training grapes.

Vines are pruned annually in September or early October when the plants are commencing vigorous growth. Laterals arising from the leaders are cut back to 2 or 3 buds. As one-year-old leaders produce the greatest number of fruiting laterals it is desirable each year to remove some of the oldest leaders and replace them with vigorous young shoots.

I. CULTIVATION

Weeds in the rows are commonly controlled by chemicals and the inter-row area may be either cultivated (not deeply) or sown in to grass.

J. HARVESTING AND MARKETING

The main crop is harvested from February to May while an off-season crop ripens September and October. The main crop should be harvested daily by shaking the vines and collecting fallen fruit. At other times of the year weekly harvesting is adequate: the fruit are picked off the ground and fully-coloured fruit of the vine are picked. Fruits are normally packed in standard half cases.

K. PESTS AND DISEASES

Three diseases are of major significance in the industry and are one of the major barriers to passionfruit culture.

1. *Grease Spot and Blast* (bacterial) troublesome mainly in winter and spring and also in summer in humid weather.
2. *Brown Spot* (fungus) Spring and early summer
   Septoria Blotch (fungus) Summer and Autumn *Crown Canker and Die Back* (fungus)
   All of the above except crown canker need spraying at monthly intervals or less during rapid growth. Bordeaux will control all four but restricts vegetative growth and leaves blemishes on fruit. Maneb and Zineb do not control grease spot and blast. Bordeaux can be used relatively safely till November. Crown canker cannot be controlled and is an important factor limiting production of passionfruit.
3. *Woodiness* (Virus)
   No known control—use virus-free stocks and remove and replace infected vines.