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The cause and control of bitter pit... 5th report.

BITTER PIT INVESTIGATION.

THE CAUSE AND CONTROL OF BITTER PIT,

WITH

THE RESULTS OF EXPERIMENTAL INVESTIGATION.

(WITH 73 FIGURES AND COLOURED FRONTISPIECE.)

BY D. McALPINE,

APPOINTED BY THE COMMONWEALTH AND STATE GOVERNMENTS OF AUSTRALIA.

FIFTH REPORT.

1915-16.

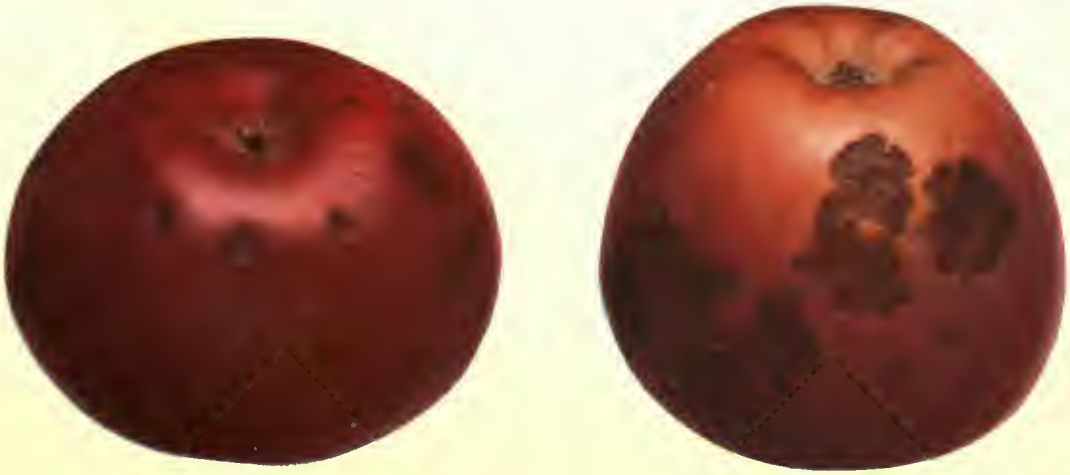
By Authority:
ALBERT J. MULLETT, GOVERNMENT PRINTER, MELBOURNE.

C.700.

FRONTISPIECE.

LONDON PIPPIN.

ROME BEAUTY.



JONATHAN.

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CONTENTS.

CONTENTS—*Continued.*

INTRODUCTION.

The investigation has now reached a stage where much that was formerly obscure is now cleared up, and where the conditions under which the disease occurs are so well known as to suggest measures for directing and controlling them.

Owing to the exceptionally dry season of 1914-15, many of the experiments were barren of results. But where the apple crop was a failure during that season, as in the pruning experiments at Deepdene, the manurial experiments at Box Hill, and the experiments generally at Blackwood, the succeeding crop promised remarkably well and turned out the best of the whole series. Hence it became necessary to continue the experiments, since they form the basis from which practical conclusions are drawn, and to allow for the variations of the seasons, which often interfere with the continuity of the work.

It has already been pointed out that everything which concerns the life of the tree has a possible bearing upon Bitter Pit. But we have to select those factors which are most important for our purpose and which promise the most immediate practical results. I have therefore paid special attention to pruning in an experimental way, since it can divert the nourishment into proper channels, and distribute it where most wanted, so that the fruit is well and evenly developed and less liable to those fluctuations which encourage Bitter Pit. The blossom- or fruit-buds are also specially studied, since they are the foundation of fruit bearing, and on them depend the quality and the quantity of the fruit. The past season with its prolific crop and generally under-sized fruit where irrigation had not been practised, might have been expected to offer the most favourable conditions for resisting the disease. But Bitter Pit has been very prevalent in some districts notwithstanding. The dry conditions which prevailed during the late spring and early summer, which is the critical season for the proper growth of the apple, followed in Victoria by the heavy rains in February, supplied those conditions which are most favourable to the development of Pit, especially where the trees were heavily pruned. The sudden change from dry to wet conditions induced an abnormal flow of sap, and the over-pressure exerted in the conducting vessels of the fruit and the adjoining pulp-cells, brought about a rupture and collapse in the latter, the well-known symptoms of Bitter Pit.

The bio-chemical researches on Bitter Pit have not been continued, owing to the lamented death of Dr. Rothera, which occurred in August of last year. He rendered me valuable assistance in the investigation, as may be seen from his last contribution in Report IV. He had intended following up various lines of investigation, particularly the early detection of Pit by micro-chemical methods, before the browning stage has been reached. By the death of Dr. Rothera, bio-chemical science has lost one of its most promising workers, and I have been deprived of the wise counsel and co-operation of a highly esteemed colleague.

In a recent review of my previous Reports in *Phytopathology*, the official organ of the American Phytopathological Society, it is stated that: "The series of publications furnished by far the most elaborate treatment ever given this subject, and is probably the most voluminous report that has ever been made upon any single plant disease."

As a justification for this exhaustive treatment, I have pointed out from the very inception of this investigation, that it involves not merely the fruit, which is the final outcome of all the vital activities of the tree, but the conditions and results of the functional activity of every organ, at least during the fruit-bearing stage. It therefore concerns itself with the proper action of the roots in supplying the necessary nutriment from the soil, with the conducting tissues of the stem in conveying the

"crude sap" to its destination, with the healthy action of the leaves in supplying the "elaborated sap" in due proportion to blend with the materials derived from the soil, and finally with the flower, which is the necessary antecedent to the formation of the healthy and normal fruit, by means of proper pollination. That this wide view is necessary for a proper understanding of the subject is seen in the great variety of contributing factors which have been brought forward to account for the disease, and most of them more or less applicable to different phases of it.

Thus the late Dr. Rothera in his bio-chemical researches, in conjunction with myself, arrived at the conclusion, after very elaborate experiment, that "starch metabolism and Pit are evidently closely associated." Wherever metabolism is concerned, or the process of nutrition with the various chemical changes involved in the process, then a wide field is opened up for exploration as to the cause of the disordered nutrition.

Again, it is said to be a disease of the vascular or conducting system, and no doubt the vessels of the apple are involved in it. The disease begins in the neighbourhood of the vessels, which also become discoloured, as well as the surrounding pulp-cells.

But when it is said to be a constitutional disease, then the vast scope of the enquiry becomes manifest. The real root of the matter lies in the weakening of the constitution of the apple, by the efforts of successive generations of men to produce an enlarged, succulent, and palatable fruit. This is gained at the expense of the vascular system (which is such an important feature of the fruit) and a consequent softening of the fibre. When it is considered that all our cultivated apples are derived from the small and sour Wild Crab, the improvement is a matter for congratulation, but at the same time calls for the highest skill in remedying the defects arising from this interference with the inherent vigour of the wild stock.

The following Report consists largely of the results of continuous experiments, conducted during a period of five years, and while the investigation is academic in the sense that it deals with principles, it is also practical in the sense that it deals not only with the cause of the disease, but suggests measures for preventing it in the oversea shipments of fruit and for minimizing it in the fruit while growing on the tree.

The great lesson taught by this investigation, as a whole, is that if progress is to be made, knowledge increased, and the products of the soil brought to their highest perfection, it is by the experimental method that such results are to be secured.

I.—AMONG THE ORCHARDS—THE ABUNDANT YIELD IN RELATION TO PIT.

The yield of apples for season 1915-16 has been phenomenal in the State of Victoria. This is largely accounted for by the fact that the crop was very light the previous season, and in some instances there was no crop at all. The yield is a record one, as shown by statistics (Appendix I.), being about six times as large as the crop of the preceding year, and although many of the apples were rather small, yet, on the whole, there was a good marketable product.

I have taken advantage of this to illustrate the well-laden trees in some of the orchards within convenient distance of Melbourne. In these orchards, on account of the generally small size of the fruit, the relative proportion of Pit was not large, but the worst cases occurred where the fruit was extra large and in very susceptible varieties.

BOX HILL.

At Mr. Hatfield's orchard, Box Hill, where the manurial experiments were conducted, the yield far exceeded any previous records, and a few striking examples have been selected for illustration.

An avenue of Rymer apple trees is shown in Fig. 1, about 16 years old, and without any artificial watering. The trees, as may be seen, were loaded with fruit and formed an imposing picture, yielding on an average 5 to 6 bushel cases.

As showing the effect of watering on the yield, I have represented two varieties of apple trees, which were artificially watered three times.

The Stone Pippin (Fig. 2), 18 years old, yielded about 15 bushel cases of fruit when picked in May. The watering kept the trees going, and prevented the leaves from falling too early. The fruit was generally sound, and the large leaves effectually protected it.

The Statesman (Fig. 3), about 16 years old, yielded 10 bushel cases, and the fruit was well distributed over the tree. There was very little Pit in the orchard this season, the few Cleopatras grown being the worst. The Esopus Spitzenberg apples were relatively small and free from Pit, but the large ones were badly affected. The Jonathans were small but good, on the whole, and free from Pit.

DEEPDENE.

I have also selected some typical examples from the orchard of Mr. Smith, at Deepdene, where the pruning experiments were conducted. It is not only individual trees which bore well, but a high standard was maintained throughout the orchard, and avenues of trees are shown all equally loaded with fruit.

In Fig. 4 is represented an avenue of Statesman apple trees, about 12 years old, the average yield of which was 8 bushel cases.

In another portion of the orchard is shown a Rome Beauty apple tree (Fig. 5), about 10 years old, which yielded 5 bushel cases. There was only a very slight proportion of Pit throughout this orchard, but in the experimental Cleopatra trees, where severe pruning was adopted, as much as 32 per cent. occurred in individual trees. With light pruning there was only from 4 to 6 per cent. of Pit, and the influence of the method of pruning on the development of Pit will be subsequently shown in a detailed account of the experiment.

GREENSBOROUGH.

A Record Yield.

I am indebted to Mr. Wallis, Orchard Supervisor for the district, for bringing under my notice a Rymer apple tree, with the largest yield yet recorded, to my knowledge, and at the same time practically free from Bitter Pit.

The largest yield hitherto recorded was that from a Stone Pippin in the Harcourt district, 35 years of age, which bore a crop of 45 bushel cases, with over 17 cwt. of good, average-sized fruit. The tree had been very lightly pruned and was practically free from Bitter Pit (see Report III., Figs. 34-37).

The history of this Greensborough Rymer tree will throw some light on the phenomenal yield, favoured, of course, by the season and its position in the orchard.

It is about 26 years old, and the stock is said to have been a sucker, on which the Rymer was grafted. For the first twenty years it never bore a full crop, and it was only on every other year afterwards that it did so.

Meanwhile it grew luxuriantly, being situated alongside an open drain. When the photograph was taken in May, 1916, it had a height of 25 feet, a spread of 33 feet, and a girth of 3 feet 1½ inches, one foot from the ground. Add to this that the previous season it bore no crop and the heavy yield is largely accounted for.

The fruit was well distributed over the tree, as may be seen from Fig. 6, and the fruit-bearing wood was well matured, there being very little young wood. The lateral system of pruning was adopted, and the laterals, which were three to four years old, were shortened where necessary in order to secure a normal as opposed to an abnormal growth.

No manure was applied. The tree was sprayed twice with arsenate of lead for Codlin Moth, but no Woolly Aphis was present.

The fruit was picked on 4th May, and Fig. 7 shows a total of 40½ cases, 17¼ of which were windfalls. Sixteen cases of windfalls had been previously removed, as the picking had been unduly delayed, so that there were 56½ cases in all. The average weight of fruit in each case was 40 lbs., so that *one ton of apples* was produced by this one tree. With such an excessive crop of average-sized fruit there was no Bitter Pit to speak of, only two apples being found among the windfalls with slight traces of it.

In this well-established orchard, there are six other old Rymer trees, which are also free from Pit, and it is interesting to note the treatment of them in the orchardist's own words: "I prune very little, only cut a bit out here and there if inclined to get too thick; most of the fruit laterals and spurs are many years old and well distributed over the tree; hence no Pit."

The ground in this orchard is on a river flat, and consists of an alluvial soil, so that the roots of the trees can readily enter and spread freely, and the trees continue to bear to a good old age.

Old Apple Tree.

An old apple tree in the same orchard, planted about 1838, shows that different varieties growing on the same stock may be differently affected as regards Pit. The girth of this tree at a height of one foot from the ground was 5 feet 9 inches. It was re-worked to Rymer in 1891, and Rome Beauty was grafted on to a limb which had been broken with the weight of the fruit in 1912 (Fig. 8).

Rome Beauty was free from Pit, while Rymer was affected to the extent of about 40 per cent., thus showing that in this instance the scion, rather than the stock, was the determining factor.

BURNLEY HORTICULTURAL GARDENS.

There are some varieties of apple which are so constitutionally liable to Pit that they are affected continuously year after year, notwithstanding the varying seasons. The list of varieties given in Report IV., Appendix II., showing the relative amount of Pit for four years in succession, bears this out. While some varieties are invariably free, others are invariably badly pitted, and among the latter stand out prominently Annie Elizabeth, Garden Royal, Lord Wolseley, Northern Spy, Shockley, and Lord Suffield.

It is sometimes observed that a variety may be badly affected while still young and growing vigorously, and that it may grow out of it, as it were, when it reaches a mature age. But there are instances where a variety is just as badly affected in its old age as in its youth. A striking illustration of this is seen in Lord Suffield. In these gardens there is an old tree of this variety, now 37 years

of age, which is bad with Pit every season. For comparison this variety was grafted on to Northern Spy roots in September, 1913, and in January, 1915, it bore four apples, all of which were badly pitted (see Report IV., Fig. 27). During the past season it made good growth and bore 18 apples, all of which were pitted on the tree.

A cluster of Crab Fairy apples is shown in Figs. 9 and 10, taken from a tree about 22 years old, on Northern Spy stock. Both pitted and crinkled apples occur in the same cluster, but the main object of the illustration is to show the unusual feature of six apples blended into one continuous mass, with a distinct "eye" representing each. It is not at all unusual to find a twin apple, as in Jonathan (Fig. 11), but it is certainly unique to have six of them run together into one (Fig. 10).

In extreme cases of pitting, such as that of Lord Suffield, the orchardist seems justified in cutting back such trees, in order to re-graft them with some other variety less liable to the disease. But in the Deepdene orchard, where the Cleopatra trees were being thus treated, on account of their being so badly pitted as to be valueless, I was able to prove experimentally that even such hopelessly pitted trees, could produce a marketable crop, when a particular system of pruning was adopted. The orchardist is therefore recommended to give this system of pruning a fair trial, and if the commercial results are not profitable, then he can re-work his trees, that is, graft another variety on the old stock.

The Age of the Tree in Relation to Pit.

When a Pit-liable tree is young and vigorous and making rapid growth, it is generally agreed that at that stage it is very subject to pitting, and the first few crops are often very bad. The conditions are such as to favour rapid transpiration, and the excessive growth will tend to interfere with the regular development of the vascular network. It might seem, however, at first sight, as if the young and vigorous tree which transpires freely would be less subject to Pit than the older tree, which is more slow and steady in growth and transpires relatively less. The greater transpiration of the younger tree might be supposed to lower the water pressure and thereby prevent the development of Pit.

On the other hand, the relatively fewer fruits of the younger trees would be more liberally supplied with water, and the rank and rapid growth would encourage those conditions which favour Pit. It is the rapidity of growth of the fruit at certain seasons which renders possible the influx of water from the root, being greater than that given off in the form of watery vapour at the surface of the fruit. Hence the rapidly growing fruit in young and vigorous trees is liable to have the balance disturbed between the incoming and outgoing water, so that the expanding pulp-cells, in the outer layer to begin with, become over-gorged and over-pressure results. The nutritive network between the pulp and the skin becomes ruptured and the adjoining pulp-cells collapse.

Cleopatra at Burnley Gardens.

At the initiation of this investigation wherever fruit-bearing Cleopatra trees were available they were invariably used for experimental purposes, because the fruit was particularly susceptible to Bitter Pit; and it was at the same time a valuable export apple. It is recognized as one of the worst affected in each of the six States of the Commonwealth (see Report I., p. 31), and in Western Australia it is regarded as the most liable of all the varieties grown.

Although such a well-known and widely grown apple, the origin of the name has never been distinctly traced, and even the Pomological Committee of Australia, at their last meeting in April, 1916, had to acknowledge that "The committee have been unable to ascertain the source of the name Cleopatra."

There is a tree growing in the Burnley Gardens under the name of Ortley, imported from America, and it is undoubtedly the same as Cleopatra, but how the latter name came to be introduced is the point at issue.

With the assistance of Mr. C. T. Cole, an officer of the Agricultural Department, I have been able to trace the name as far back as May, 1869, when his late father, Mr. J. C. Cole, of Richmond, recorded it in his Catalogue of Fruit Trees. It fruited in 1871, when it was found to be identical with Ortley. It appears in Mr. Cole's catalogue of fruits for 1872 as available for planting.

II.—"CRINKLE," A CONFLUENT FORM OF BITTER PIT.

In the Frontispiece several varieties of apples are figured, showing both Pit and "crinkle," and they are thus brought together in order to emphasize the fact that the two are but different phases of the same disease. I have already called attention to this, but there are some orchardists who have not, in their limited experience, met with the necessary data for forming an opinion, and it is for such that the illustrations are mainly intended.

He is said to be a public benefactor who makes two blades of grass grow where only one grew before, and it may be assumed with equal justice that he also is a benefactor who merges two apparently distinct diseases into one.

"Crinkle" was the name given by myself in 1901 to a disease of the apple in which the surface towards the "eye" end is thrown into a series of folds and wrinkles, elevations and depressions, so that the apple often assumes a grotesque appearance. It is also called Pig-face and Monkey-face from the odd shapes given to it.

If a section is made of the affected part, the skin is seen to be intact, and it is the pulp-cells beneath the skin which are brown and spongy, sometimes for considerable stretches. It is evident that the disease is internal, and that it is the pulp-cells which shrink and bring about the external corrugated appearance.

The London Pippin or Five Crown apple (Fig. 12) is one of the varieties most liable to "crinkle," and so constant is this that in some orchards the ordinary form of Bitter Pit has not been observed. But if observation is extended, all gradations will be found, from the solitary pit to a few run together and then confluent over considerable areas of the skin. On the tree from which the pitted specimens of London Pippin were taken (Figs. 13, 14, 15) it was difficult to find any trace of "crinkle," but when one has closely observed numerous specimens in different seasons, partly pitted and partly crinkled (Fig. 15), there is no reasonable doubt of "crinkle" being a confluent form of Pit.

The violent vicissitudes of the weather produce wholesale rupture of the pulp-cells beneath the skin, and the effect is seen in the distorted surface, owing to the extensive shrinking.

I have brought together a number of specimens of different varieties, mainly to show that "crinkle" is not confined to just a few varieties, and that it may occur on the same tree with pitted apples, and even the same apple may exhibit both forms. In the Annie Elizabeth apple tree, in which 58 clusters of apples were enclosed in white calico bags as soon as the fruit had set, in order to protect it from insects, Pit and "crinkle" combined were very noticeable in the apples enclosed in the bags (see Report I., Fig. 111).

A typical form of "crinkle" is shown in Esopus Spitzenberg (Figs. 16, 17), although it is unusual in that variety, and both Pit and "crinkle" are shown in the same apple in Rome Beauty (Fig. 18), Sturmer (Figs. 19, 20), and Jonathan (Figs. 21, 22), as well as in London Pippin.

There are two exceptional cases of "crinkle," occurring in Yates and Jonathan, which are worthy of special mention on account of their rarity.

In an orchard at Greensborough, which had been rather neglected, a Yates apple tree about 15 years old was found bearing very small fruit and badly affected with "crinkle" (Figs. 23, 24). Hitherto only occasional apples had been found crinkled, but in this instance it was general. This seemed all the more peculiar, seeing that in another portion of the orchard, Yates apples were growing up to 2¼ to 2½ inches in diameter, instead of 1¼ to 1½ inches, and yet they were unaffected. The larger apples are usually the worst affected, but in this instance it was just the reverse. There was no apparent difference in the soil or situation to account for it, and we must regard this as one of those exceptional cases where even with the smaller fruit there were considerable fluctuations in growth.

The Jonathan apple (Fig. 22) is also shown in the Frontispiece, so that it will not be necessary to describe its appearance in detail. A large black blotch with roughened surface covers the greater

portion of one side of the apple, but when closely looked into it is interspersed with green patches. On removal of the skin (Fig. 22) the flesh beneath was found affected in isolated patches and in large brown irregular masses.

The conditions under which this specimen was found throw light upon its occurrence. Among the numerous Jonathan trees (800) in Mr. Hatfield's orchard it was very hard to find a specimen of Pit or "crinkle." But as there was one tree in the collection, which had been severely cut back on account of the poor growth it had been making, in an undrained portion of the orchard, I went straight to it with the expectation of finding what I wanted, and was not disappointed. This is undoubtedly the worst example of "crinkle" observed in the Jonathan apple.

III.—DISEASES SUPERFICIALLY RESEMBLING BITTER PIT.

There are quite a number of spot diseases of the apple, and some of them have been confounded with Bitter Pit. Only two need be mentioned, as having attracted the attention of orchardists and likely to cause confusion in Australia.

One of these has been rather prevalent in some districts during the past season, and has been termed "surface Pit." It has been found only on the Jonathan apple in Australia, but in America the same disease occurs on other varieties as well, although it is so common on Jonathan that it has received the name of "Jonathan Spot."

The other consists of spots caused by the decay set up where insects have pierced the fruit, and has been called Stigmonose.

JONATHAN SPOT.

This is the name given to very shallow black or brown spots in the skin of the apple. The spots may be small and isolated and slightly depressed, but generally they form superficial dark blotches which run together into patches of varying size. The blotches usually extend all over the calyx end and middle of the fruit, while the stem end is comparatively free.

If the discoloured skin is carefully removed from the underlying flesh, it is seen to be purely a skin disease, since there is no browning of the pulp-cells immediately beneath, or any change in their texture. The disease is thus seen to be quite distinct from that of Bitter Pit, which is an internal disease, first affecting the pulp-cells beneath the skin and causing their discoloration (Fig. 30).

NAME OF THE DISEASE.

There are so many "spot diseases" of the apple, that it is no wonder they are often confused, and this confusion is often the cause of remedies being applied, where the nature of the disease does not warrant them. There is "Black Spot," or "Scab," and "Fruit Spot," both due to well-known fungi, and capable of being controlled by spraying with fungicides. But in some parts of the United States orchardists have sprayed extensively for "Bitter Pit," following the directions for "Fruit Spot," although the latter is a different disease altogether.

"Jonathan Spot" is the name generally applied to this disease in America, but since this particular variety of fruit is not the only one subject to it, the name is to some extent misleading. The term "Freckles" has also been suggested, but it has not met with general acceptance.

In Australia, it is often referred to as "Surface Pit," but, being confined to the skin, there is no scientific justification for the name. It is also called "Cool Store Spot," but, as shown below, it is not confined to cold storage conditions.

While it would be very desirable to get away altogether from the use of the term "spot," it is not easy to suggest a better, and so, with all its imperfections, it may be retained.

OCCURRENCE.

The disease occurred under the most varied conditions. It was only distinctly observed after ripening, and the riper the apples became the disease developed all the more. It was also noticed that the disease is more common in the small apples than in the large ones, and this was observed both on the tree and in the apples after being picked. The longer the apples are left on the tree the worse affected they become.

It is sometimes spoken of as "Cool Store Spot," as if it only occurred under these conditions, but it may appear on the tree or develop after the fruit is picked. It appears also in windfalls, and in fruit kept under ordinary storage as well as in cool store. In one instance, the worst specimens were found in a case left exposed in the orchard for about a month, and the apples towards the top seemed to be more affected than those lower down.

There was a striking instance of perfectly clean fruit from one orchard in which the fruit had been picked a month before the others in the district, and placed in cool store on 23rd March. It is generally found that the latest fruit brought in to the cool store develops the worst, so that it is not advisable to delay picking too long.

WEATHER CONDITIONS.

During the past season, the apples were slow in ripening in the district investigated, and some of the fruit was left on the trees rather long. This is generally considered to favour the disease when the fruit is afterwards placed in cold storage.

As regards the weather, there was an exceptional amount of rain towards the beginning of the year, and wind was very prevalent.

The following table gives the monthly rainfall for the past five years and for the half of the present year :—

TABLE I.

RAINFALL AT TYABB, VICTORIA.

	1910. Inches.	1911. Inches.	1912. Inches.	1913. Inches.	1914. Inches.	1915. Inches.	1916. Inches
January ..		·46	·50	·29	1·01	1·78	5·82
February ..		2·46	·81	·70	·13	·20	1·54
March ..		4·47	·55	7·01	1·08	·68	·48
April ..		1·19	2·37	1·23	1·56	2·80	2·61
May		4·10	1·43	3·40	2·76	4·56	2·10
June ..		4·15	2·16	1·41	·76	3·38	3·38
		16·83	7·82	14·04	7·30	13·40	15·93
July		2·75	2·43	2·22	3·84	1·80	
August ..		1·01	2·42	2·86	·64	2·46	
September		2·92	3·00	1·90	1·49	3·32	
October ..		·86	1·57	1·75	·50	3·31	
November ..		·65	4·32	3·03	1·75	1·21	
December ..		3·94	3·46	1·63	3·67	·58	
Totals ..	29·93	28·96	25·02	27·43	19·19	26·08	

It will be observed that in the months of January and February, 1916, there was an exceptionally heavy rainfall, compared with the previous years, and in the month of March it was comparatively light. Those apples picked and placed in cold storage in March were comparatively free from spot, while those picked and stored in April were badly affected.

CHEMICAL ANALYSIS OF JONATHAN APPLE.

A chemical analysis of the Jonathan apple from a district in which "spotting" occurred was made by P. R. Scott, Chemist for Agriculture. The apple was first taken as a whole, and the principal contents determined. Then, as the skin was only concerned in the spotting, the ash contents of the whole apple and of the skin separately were determined in normal and affected apples, so that a comparison might be made between the two.

The following are the analyses :—

1.—Jonathan Apple. Sample small, very ripe, with watery taste.

Quantity taken	1,000 grms.
Juice expressed	830 ccs.=866·5 grms.
Gallons per ton of expressed juice	185·51
Weight of pulp	98·3000 grms.
Moisture of pulp	66·684 grms. (=67·84% of pulp)
Per cent. of juice in pulp (corrected)	70·82% by weight
Per cent. of dry matter in pulp (corrected)	29·18% ,,
Per cent. of dry matter in whole apple	2·868% ,,
Per cent. of juice in whole apple	97·132% ,,

Specific gravity of juice	1.044 @ 15°C.	
Freezing point	−·77	
Total solids	12·25% by volume.	11·73% by weight of juice.
Ash	0·212% ,,	0·203% ,, ,,
Total acids (as malic)	0·258% ,,	0·247% ,, ,,
Cane sugar	—	1·29% ,, ,,
Reducing sugars (as dextrose) ..	8·69% ,,	8·33% ,, ,,
Tannin	0·002% ,,	0·0019% ,, ,,
Nitrogen { Juice		0·010%
Nitrogen { Whole apple (slice through centre) ..		0·0203%

2.—Percentage of dry material—of ash content of whole apple and skins separately, of affected and normal apples.

	Normal Apple. Whole Apple. %	Normal Apple. Skin. %	Affected Apple. Whole Apple. %	Affected Apple. Skin. %
Ash	2·176	2·608	1·452	2·870
Containing—				
Fe_2O_3 Al_2O_3 ..	0·045	0·068	0·071	0·049
Mn_3O_4	0·005	—	0·004	—
CaO	0·109	0·260	0·071	0·185
MgO	0·092	0·316	0·090	0·455
K_2O	0·746	1·006	0·591	1·141
SO_3	0·125	0·577	0·047	0·178
P_2O_5	0·195	0·250	0·127	0·290
Nitrogen	0·529	1·092	0·339	0·861
Tannin	—	0·050	—	0·120
Sugars (as dextrose) ..	—	3·50	—	3·80

The most striking differences between the normal and the affected skin of the apple lie in the proportions of sulphuric anhydride, nitrogen, and tannin respectively.

The salts in the form of sulphates are only about one-third that of the normal. The nitrogen is considerably less than the normal, while the tannin is fully twice as much as the normal. In all these chemical relations there is no evident clue to the discoloration of the skin of the Jonathan apple, except that an excess of tannin might be supposed to favour it.

CAUSE OF THE DISEASE.

There are various fruit spots of the apple undoubtedly due to fungi, but the one we are now considering is non-parasitic and external in its origin. It is therefore quite distinct from the fruit spot due to *Cylindrosporium pomi* (Brooks) on the one hand, and from an internal physiological disease such as Bitter Pit on the other.

Norton (9) has shown that typical spots may be produced by the action of gases, and he has suggested the possibility of ammonia from the cooling apparatus in cold storage being a common cause of "Jonathan Spot." But, as he points out, the spot may appear on the fruit while still on the tree, and therefore there must be other causes.

It has sometimes been attributed to injury from an arsenical spray, but that theory was disproved by extensive spraying experiments carried out by the United States Department of Agriculture.

One of the most probable causes is that of sudden chilling of the fruit, and this may account for the appearance of the spots, both while the fruit is on the tree and in store. When the fruit is fully ripe and the weather moist, the rapid drying of the fruit by a cold wind would tend to produce "spotting." The same result would happen if the moisture on the tough skin of the Jonathan were to evaporate rapidly. If the apples are picked when wet, and placed in that condition in cold storage without allowing the moisture to evaporate, then there is a danger of the spot appearing.

PREVENTIVE MEASURES.

This is only a side issue to the Bitter Pit investigation, and no direct experiments have been carried out in connection with it.

In the United States of America, where this disease is very prevalent, there are no definite measures recommended for its prevention, and in the absence of unanimity as to the cause this is not to be wondered at.

From the conditions under which it occurs here the following suggestions may be offered :—To pick the fruit, as far as possible, in dry weather ; to see that it is not too ripe at time of picking ; and any moisture on the fruit should be allowed to evaporate before placing in cool store.

STIGMONOSE.

"Jonathan Spot" is clearly distinguished from Bitter Pit, because there is no browning of the tissue beneath the skin, and it is purely a skin disease. In Stigmonose, on the other hand, due to the punctures of insects, not only is there a "spotting" of the fruit, but a browning of the tissue beneath the skin, and to that extent it resembles Bitter Pit.

About the beginning of the twentieth century the theory of insect punctures and the injection of a poison as a cause of disease in plants was established on a scientific basis. In 1900 Woods (10) found a "spotting" of the leaves of carnations to be due to this cause, and on making a section of the leaf the sucking apparatus of the insect was found in the tissues. The spots were mostly produced by Aphides and Thrips, and the name of "Stigmonose" was given to the disease. In 1901, by a curious coincidence, both Professor Mangin, in France, and Dr. Cobb, in Australia, attributed the disease now known as "Bitter Pit" in apples to the punctures of insects. Dr. Cobb at first attributed the disease to the Harlequin Bug, but afterwards discarded it, while in France the insect theory of the disease is still maintained. Insects may puncture the fruit and produce "spotting," but this is so distinct from the genuine Bitter Pit that there need be no confusion between the two (Figs. 31, 33).

Further, it has been clearly shown that Bitter Pit may be developed under conditions in which insects are excluded, apart altogether from the different symptoms.

In my first Report an apple tree is shown in which 58 clusters of fruit are enclosed in white calico bags (Report 1., Fig. 111). The fruit was enclosed as soon as it had set, and thus the access of insects as well as the possibility of an arsenical spray reaching it was guarded against. The fruit enclosed in

the bags grew to the normal size, but deficient in colour, and out of the 136 Annie Elizabeth apples 75 were pitted and 61 clean, 5 of the pitted apples being also "crinkled" (Report I., Figs. 42, 43).

It is absolutely certain, therefore, that Pit and "crinkle" are developed in the absence of insects, and it remains to be seen how far the results of insect punctures agree with the genuine forms of Pit.

The presumed effects of insect punctures on the apple fruit have been recently described in France and America, and examples will be given of the piercing of fruit by insects actually observed in Australia.

AUSTRALIA.

In Mr. French's *Handbook of the Destructive Insects of Victoria,* Part I., published in 1904, there is a coloured illustration of the apple being punctured by the Harlequin Fruit Bug. Where the insect has pierced the fruit there are decayed spots shown on the surface, and this decay also extends beneath the skin. In the early stages of attack there was no distinct evidence of puncture, and certainly there was no depression. But after a considerable time dark blotches appeared under the skin, surrounding each particular spot where the puncture had been made. The beak of the insect penetrated the skin of the fruit and extracted the juice, thereby causing the decayed spots. These "spots" are irregular in outline, small, brown, and very slightly depressed. There is no risk of confusion between the punctures of such insects and Bitter Pit, as may be seen from the faithful drawings made by Mr. C. C. Brittlebank, Vegetable Pathologist, and here reproduced (Figs. 31-33).

FRANCE.

In France the first reference to this disease was in 1901, when Professor Mangin referred to it as "La Graisse ou Maladie des Taches des Pommes" (The Grease or Spot disease of the Apple). Then, in 1908, Delacroix described it under the name of "Points brun de la chair des pommes" (Brown spots of the flesh of the apple). Finally, in 1915, M. Bois (1), in the *Bull. Soc. Nationale d'Acclimatation de France,* gives the latest information concerning this disease under the name applied to it by Professor Mangin. His brief description of the disease is as follows :—"This name is given to an affection of the apple, of which the causes are not yet absolutely certain, which depreciates considerably the fruits of several varieties of apples classed among the very best, such as Reinette du Canada, Calville, etc. The alteration is characterized by the small masses of spongy tissue, brownish, scattered beneath the skin of the fruit and penetrating to a depth which may reach up to a centimetre. They correspond generally to the spots which form upon the skin of the fruit—small depressions of a greyish colour, from 1 to 5 millimetres in diameter."

As early as 1901 Professor Mangin (8), in a note appearing in the *Revue Horticole,* attributes the disease to the punctures of insects, which had injected into the wound produced a liquid capable of irritating and mortifying the tissues.

This view is accepted by M. Bois as the correct one, and accordingly he recommends various measures for the destruction of the insects, such as whitewashing, spraying, fumigation, etc.

It is evident that the insect theory of the disease, like the poison theory, has been arrived at without sufficient data to establish it as generally applicable. While insect punctures may produce decayed "spots," there are depressed spots with the underlying diseased tissue which cannot be thus accounted for.

AMERICA.

In America Charles Brooks and D. F. Fisher (2), of the United States Department of Agriculture, have been recently investigating various "spot diseases" of the apple which might be confounded with Bitter Pit, and refer specially in one article to "Jonathan Spot, Bitter Pit, and Stigmonose." Another article, appearing in *Better Fruit* for February, 1916, bears the expressive title of "Spot Diseases of the Apple causing much general confusion."

It appears that in America there is not the same clear-cut distinction as there is with us between the effects produced by insect punctures and a non-parasitic disease such as Bitter Pit is acknowledged to be. It becomes necessary, therefore, to clearly define the disease we are dealing with, and endeavour to carefully exclude whatever other diseases might be mistaken for or confounded with it. This has been done by the above-named authors in the following description of Stigmonose of the apple:—"Stigmonose is used to refer to responses to insect attacks. In certain cases the effects on apples can scarcely be distinguished from Bitter Pit. The development of some form of this trouble seems to be closely associated with the occurrence of the Rosy Aphis [not known in Australia]. It differs from Bitter Pit in that it develops earlier in the season, that it occurs on the fruit that is in the middle of the tree rather than that on the exposed limbs, that it is often followed by cracking of the fruit and premature ripening, is often accompanied by a corrugated gnarled appearance of the apple, that the spots are not typically at the ends of the vasculars, that the brown tissue beneath has more definite margins, is more nearly spherical in shape, and is firm rather than spongy."

In Australia there is no comparison or chance of confusion between the punctures of insects and Bitter Pit, as shown in Figs. 31, 33. In America the two are often confounded, although the genuine Bitter Pit is acknowledged to be prevalent. In France, as we have seen, there is a tendency to attribute all such symptoms as are exhibited by Bitter Pit to sucking insects.

BITTER PIT CONFOUNDED WITH BITTER ROT.

References to Bitter Pit in horticultural literature are sometimes rather startling, because the nature of the disease is evidently misunderstood, and it is confounded with some other disease with a name somewhat resembling it.

Thus in *The Sweet Pea Annual* for 1916, edited by J. S. Brunton, F.R.H.S., it is stated:—"Now what connection have the fruit trees with disease? Anthracnose is the self-same disease that causes 'Bitter Pit' in apples. The disease can be transferred from apples to sweet peas or *vice versa*." A leading orchardist brought this statement under my notice, and it was very easily disposed of. Anthracnose or "Bitter Rot" of the apple is due to the fungus *Glomerella rufo-maculans* (B.) Sp., and since there is a sweet pea anthracnose due to the same fungus, the same disease is common to both, only "Bitter Rot" has been mistaken for Bitter Pit, and hence the mistake.

The disease of Bitter Pit is now regarded by all the investigators who have made a special study of it as non-parasitic in its nature, being due neither to insects nor fungi, and the foregoing account shows how indispensable it is to determine the proper cause of a disease before attempting to prescribe remedies or recommend preventive measures.

IV.—THE FRUIT-BUDS OF THE APPLE TREE.

THEIR POSITION, ORIGIN, PERIOD OF FORMATION, AND TREATMENT.

The seed and the bud are the two organs which either originate the tree as a whole or portions of it. The bud is an undeveloped or incipient shoot, and may either give rise to the ordinary leafy branch or to flowers. The buds which develop into leafy shoots are known as *leaf-buds*, or *wood-buds* as they are often called, because they produce the new wood. The buds which develop into flowers only are known as *blossom-buds*, but the orchardist speaks of them as *fruit-buds*, because it is from them the fruit is obtained, in contradistinction to the *wood-buds* which provide new wood for future fruit bearing.

We will confine our attention to the buds which produce flowers, or the fruit-buds, and they are recognized as being larger, plumper, and blunter than the wood-buds.

THEIR POSITION.

The bud may be developed at the tip of the shoot, when it is terminal, and such buds are well seen in Jonathan, borne on one-year-old wood. Or it may be formed in the inner angle between the branch and the leaf, where it is conveniently situated for a supply of food-materials, and such buds are known as axillary. But a large number of fruit-buds are borne on spurs, which are just very short and condensed branches. There are thus three classes of fruit-buds, according to the position in which they occur, viz., terminal, axillary, and buds borne on spurs.

THEIR ORIGIN.

In the case of terminal buds they are naturally formed on one-year-old wood, and when the end of the axis is terminated by a flower growth in length ceases. A flower may grow out of another flower, but that is an unusual occurrence.

There is a growing point at the tip of the shoot, and this first manifests itself as a swelling. At this stage either a leaf-bud or a fruit-bud may be formed, and it depends on the proper conditions which of the two it is going to be. Klebs, in his Croonian lecture on "Alterations in the Development and Form of Plants as a result of Environment" (1910), clearly shows that it is the nature and amount of the raw and elaborated food materials available at the time which determines the formation of the vegetative or reproductive tissues. If the organic substances are in excess the formation of reproductive bodies is favoured, and if there is a strong supply of root-sap vegetative growth is stimulated.

Fruit-buds are usually formed on one-, two-, or three-year-old wood, and when finally determined they show calyx leaves, corolla leaves, and stamens distinctly.

PERIOD OF FORMATION.

It has long been generally known that fruit-bud formation on the apple occurs in the summer previous to flowering, although the exact details of the process have only been recently investigated. Professor Kraus (7) has remarked that "changes take place within a bud and determine whether it will become a leaf- or fruit-bud in the apple or pear as early as the latter part of June, and proceed throughout the summer and autumn. The very beginnings of fruit-buds are also visible as late as the latter part of August, so that apparently there is actual differentiation of buds occurring throughout the summer." With us the blossom-buds begin to appear towards the end of the year, and their formation is continued throughout the summer months of December, January, and February. The blossom-buds are thus laid down, while the coming crop is rapidly growing and developing. Both require to be nourished simultaneously, and if the nutritive materials required by the growing fruit are limited, then the supplies for the blossom-buds may be deficient. The effect of one season is carried on to the next, and determines to a certain extent the abundance or scarcity of bloom.

Thus while the crop is still on the trees the nature of next season's crop is being determined, and the quality and amount of fruit settled by the development of the fruit-buds. Nature looks ahead, and while the one fruit is maturing, its successor is being prepared to take its place. It will be evident from this brief sketch what a critical time the tree passes through during the summer months, and while the soil and climate, heat and moisture all influence the conditions, an important part is also played by pruning, which regulates the number of buds retained, their distribution on the tree, and the access of air and light to stimulate them. Even the picking of the fruit is now seen in a new light, for if carelessly done, the fruit-buds for next season are torn from the tree along with the ripe fruit. In the case of a tree inclined to shy bearing, this loss of fruit-buds is serious, since it not only causes loss of crop, but may disturb the balance between the reproductive and vegetative processes, and thus favour the occurrence of Bitter Pit.

THEIR TREATMENT.

Their proper treatment may be deduced from a few general considerations offered as to the best methods of encouraging their growth and development.

The first and most general consideration is to maintain the proper balance or relation between the vegetative growth and reproduction. There may be an excessive growth of wood at the expense of fruit bearing, or the abundance of bloom may be so great as to weaken the energies of the tree, so that only a poor quality of fruit is produced. It is not advisable to allow the tree to produce a crop too early, otherwise the fruit-producing wood may not be old enough and properly matured. When a young tree is forced by drought into premature bearing, the tree is in danger of becoming stunted. Then, when the proper bearing stage has been reached, it will be the object of pruning to produce the maximum number of fruit-buds, consistent with the general vigour and carrying capacity of the tree.

The next general consideration is that the lateral branches of medium length, or laterals as they are briefly called, should not be interfered with too much. These laterals, with their terminal fruit-buds, are specially adapted for fruit bearing, and when allowed to remain they generally develop fruit-buds all along their length. But if headed back and the terminal-buds removed, the orchardist usually gets what he expressively calls "dead ends." Of course, when the lateral is too long and too exposed to the wind it may be desirable to head it back, and in those cases where the laterals grow inwardly instead of outwardly they may be cut back or removed altogether.

A final consideration is the general effects of heavy and light pruning—of severe heading back and removing a large amount of wood, and light heading back so that the growth of the tree is but slightly interfered with.

When a one-year-old branch is severely pruned, the result is that the portion left produces lateral branches, and not fruit-buds. Whereas, if the pruning is light, fruit-buds are usually produced, at least adjoining the position of the cut. All dead wood, of course, must be removed, as well as all branches which cross and interfere with others, and if otherwise superfluous branches are likewise removed, including laterals, the remaining fruit-buds will be most favourably situated for their proper development.

In conclusion, attention may be drawn to the occasional development of an apparently small apple fruit from the bud without blossoming. During the winter months minute "apples," generally about the size of a pea, may be met with in some seasons, showing no trace of an "eye," and when cut lengthwise shown to be without a "core." This coreless, bloomless apple is of no commercial value, but it emphasizes the fact that the fleshy portion of the apple, arises independently of the essential organs of the flower, such as the carpels which constitute the core and the stamens which produce pollen. Fig. 34 represents a stalked, green Cleopatra "apple" which only consists of the fleshy portion, and the fibro-vascular bundles from the stalk end are seen to be continued right through. It need hardly be pointed out that this is entirely different from the seedless apple which created such a stir early in 1905, when the first specimens reached England from America. This coreless apple arises from a disorganized bud, in which the petals are represented by a cluster of green leaves, and the calyx still forms the "eye," while the stamens produce a small percentage of pollen.

V.—PRUNING EXPERIMENTS WITH JONATHAN, LONDON PIPPIN, AND KING DAVID APPLE TREES GROWN IN POTS.

When apple trees are grown in pots, it is possible to follow in detail the effects of removing certain portions of the tree in pruning, a method which would hardly be practicable with large trees grown in the orchard. On this account such an experiment enables us to confine our attention to a limited area and determine exactly how the tree itself is affected as regards growth and how the yield is controlled by the treatment given to each individual branch.

Although the conditions of a pot experiment are necessarily different from those found in the orchard, yet the results obtained indicate the effect of certain measures under such conditions. When these results are compared with others obtained under natural orchard conditions, they will be found to supplement each other and suggest fresh lines of research.

For the purposes of this experiment I have selected three varieties in their third year, grown in 12-inch pots at Burnley Horticultural Gardens. Two of them are extensively grown in Victoria, viz., Jonathan and London Pippin or Five Crown. As usually treated these two varieties represent two different types of pruning which are in vogue. In the case of Jonathan the growth of laterals is encouraged, because it is on these that the crop is chiefly borne, more so than on the main limbs. Whereas on the London Pippin the laterals are almost entirely suppressed, because the bulk of the fruit is said to be produced along the main limbs.

Such is the traditional view of the proper mode of pruning these two typical varieties. But when pruning experiments with London Pippin were continued over a period of five years in succession it was found that the lightly pruned trees in which the laterals were allowed to grow freely produced slightly larger crops than the trees in which the laterals were severely pruned, and the amount of Bitter Pit was a negligible quantity.

The following descriptions and tabulated details refer to the trees after pruning :—

JONATHAN.

This tree, budded on the Northern Spy, is three years old. It was cut back hard last year, and was severely pruned this year on 12th July. Its height is 4 feet 4 inches, its spread of branches 3 feet 1 inch, and its girth round the stem immediately above the union is $2\frac{7}{8}$ inches.

It consists of a main stem with five leaders or primary branches. The main stem reaches a height of 19 inches from the ground, and the five leaders are described in order from below upwards. Each individual leader is minutely described, and the one-, two-, and three-year-old wood is distinguished with their respective growths and the various laterals, spurs, buds, flowers, and fruits arising from each.

In pruning, the same weight of wood was practically removed from each leader, with the exception of the topmost one, where the prunings weighed one ounce instead of one-eighth of an ounce as in the others.

Last season (1915-16) the tree bore 23 apples, all of which were free from Pit (Figs. 35, 38).

LONDON PIPPIN OR FIVE CROWN.

This tree is also three years old, and budded on the Northern Spy. It was severely pruned on the same date as Jonathan. It has a height of $4\frac{1}{4}$ feet, a spread of branches of 5 feet 1 inch, and the girth of stem above the union is $2\frac{3}{4}$ inches.

It consists of a main stem with five leaders, as in Jonathan, and the details are given in the table.

The tree bore 22 apples last season. Of the 20 apples on the tree only one was pitted, and this pitting (not crinkling) is distinctly seen in the topmost apple. There were two windfalls, one of which was pitted, so that the amount of Pit was 9 per cent. (Figs. 36, 37).

KING DAVID.

This is a comparatively recent introduction, and has not been tested sufficiently to enable definite conclusions to be drawn as to its commercial value. It is supposed to be a cross between Jonathan and Arkansas Black, and originated more than twenty years ago in Arkansas.

Like the others, it is a three-year-old tree on Northern Spy stock. It consists of a main stem with six leaders, and the fruit is chiefly borne on the laterals. There were 20 apples altogether, and four of these were borne on long spurs. The fruit was clean, although it is reported to be very seriously affected with Pit in America. This tree did not bloom, and consequently no fruit set.

PERIOD OF BLOOM.

The time of flowering, as compared with trees of the same variety grown under natural conditions, is shown in the following table.

The first bloom, as the name indicates, is the period when the first flower has fully opened. Full bloom is when all the blossoms have opened, and as this state of full bloom may continue for several days the last date is given when it is still full. The final bloom is when the petals have all fallen and the fruit is beginning to set.

TABLE II.

BLOOMING PERIOD OF VARIETIES IN POTS AND THE SAME VARIETIES IN THE ORCHARD.

Variety.	Date of First Bloom.		Date of Full Bloom.		Date of Final Bloom.	
	In Pots.	Orchard.	In Pots.	Orchard.	In Pots.	Orchard.
Jonathan ..	Sept. 30	Sept. 28	Oct. 7	Oct. 7	Oct. 10	Oct. 10
London Pippin	Oct. 24	Oct. 17	Oct. 26	Oct. 28	Oct. 28	Nov. 4
King David ..	—	—				

The yield, together with the percentage of Pit, will be observed for the coming season, and recorded. It would be preferable to record the results at the end of the fruit season, but for official reasons the report is required at the end of the year.

TABLE III.

JONATHAN APPLE TREE IN POT.

Main stem, 30 inches high ; leaders, 5 ; laterals, 10. Weight, with pot, 63½ lbs.

	3-year-old wood.	2-year-old wood.	1-year-old wood.	BUDS. Axillary.	BUDS. Terminal.	Spurs.	Length of Leader. Inches.
Leader No. 1—	,,			3 (dormant)		1 (elongated)	6¼
Lateral (1)		,,	,,	9		5	
,, (2)		,,	,,	2		2	
Do.		,,		4		3	7½
Do.			,,	4	1		2½
,, (3)			,,	4	1		
Leader No. 2—	,,			1			3
Lateral (4)		,,	,,	4		3 (1 terminal)	
Do.		,,		2		4 (2 elongated)	6
Do.			,,	3	1		4
Leader No. 3—	,,			2		1 (elongated)	7½
Lateral (5)		,,	,,	7 (6 dorm't)	1		
Do.		,,		4			4
Do.			,,	6	1		7

TABLE III.—JONATHAN APPLE TREE IN POT, ETC.—*continued.*

	3-year-old wood.	2-year old wood.	1-year-old wood.	BUDS. Axillary.	BUDS. Terminal.	Spurs.	Length of Leader. Inches.
Leader No. 4	,,			3 (dormant)			5
Lateral (6)		,,	,,	6		5	
Sub-lateral			,,	6	1		
Lateral (7)		,,	,,	13	1	4 (prob'bly dead)	
Do.		,,		3			$2\frac{7}{8}$
,, (8)			,,	4	1		
Do.			,,	7	1		$7\frac{3}{4}$
Leader No. 5—	,,			4			6
Lateral (9)			,,	4	1	1	
Do.		,,		4			3
,, (10)			,,	2	1		
Do.			,,	4	1		$3\frac{7}{8}$

TABLE IV.

LONDON PIPPIN APPLE TREE IN POT.

Main stem, 33 inches high ; leaders, 5 ; laterals, 12. Weight, with pot, $58\frac{1}{4}$ lbs.

	3-year-old wood	2-year-old wood.	1-year-old wood.	BUDS. Axillary.	BUDS. Terminal.	Spurs.	Length of Leader. Inches.
Leader No. 1—	,,			8		3 (1 elongated)	$7\frac{1}{2}$
Lateral (1)			,,	5	1		
Sub-lateral			,,	7	1		
Do.		,,		1		2 (1 elongated)	3
Lateral (2)			,,	7 (5 dormant)	1		
Do.			,,	4	1		$3\frac{1}{2}$
Leader No. 2—	,,			8		2	$12\frac{3}{4}$
Lateral (3)		,,	,,	7		3	
,, (4)		,,	,,	1	1	2	
Do.		,,		3		7 (3 elongated)	9
Do.			,,	4	1		$2\frac{1}{2}$
Leader No. 3—	,,			4 (dormant)		6 (1 elongated)	8
Do.		,,		1		10 (3 elongated)	$10\frac{3}{4}$
Do.			,,	7	1		$5\frac{1}{2}$
Leader No. 4 —	,,			7		4	15
Lateral (5)		,,	,,	11	1	5 (2 elongated)	
,, (6)		,,	,,	4	1		
Do.		,,		4		8 (3 elongated)	$10\frac{1}{2}$
Do.			,,	7	1		4
Leader No. 5—	,,			2		1 (elongated)	4
Lateral (7)		,,	,,	3		5	
Do.		,,		5		3	$6\frac{1}{4}$
,, (8)				5	1	1 (elongated)	
Do.			,,	7	1		$4\frac{7}{8}$
Main Stem—	,,					10	
Lateral (9)			,,	9	1		
,, (10)			,,	9	1		
,, (11)			,,	4	-	1	
,, (12)			,,	8	1	2	

TABLE V.

KING DAVID APPLE TREE IN POT.

Main stem, 28½ inches ; leaders, 6 ; laterals, 11. Weight, with pot, 58 lbs.

	3-year-old wood.	2-year-old wood.	1-year-old wood.	BUDS. Axillary.	BUDS. Terminal.	Spurs.	Length of Leader. Inches.
Leader No. 1—	,,			2 (dormant)			4
Lateral (1)		,,	,,	9	1		
Do.		,,		1 (dormant)			2½
,, (2)			,,	2	1		
Do.			,,	7	1		3¾
Leader No. 2—	,,			5		1	9
Lateral (3)			,,	3	1		
,, (4)			,,	2		2 (1 elongated)	
Sub-lateral				6	1		
Do.		,,				5 (1 elongated)	6½
Do.			,,	5	1		5¼
Leader No. 3—	,,			3		4 (1 elongated)	13
Lateral (5)			,,	3		1	
,, (6)			,,	3		2	
Do.		,,				2 (1 elongated)	1½
Do.			,,	5	1		4¾
Leader No. 4—	,,			4		1 (elongated)	6½
Do.		,,				2	3¼
Lateral (7)			,,	4		1	
Do.			,,	7	1		6¼
Leader No. 5—	..			3 (dormant)		3	5¼
Lateral (8)			,,	2		1 (terminal)	
,, (9)			,,	5		1 (terminal)	
,, (10)			,,	4		1 (terminal)	
Do.		,,		2			1½
Do.			,,	8	1		8
Leader No. 6—	,,					5	7
Lateral (11)		,,	,,	5		1	
Do.		,,		2			3
Do.			,,	7	1		7¼
Main stem	,,					2 (elongated)	

The object in view in recording the minute details of the age and position of the various portions of the tree, is to be able to show exactly where the fruit is afterwards produced. Also whether Bitter Pit is more liable to be developed on the older or younger wood. The length of each leader is also recorded, in order that its growth may be noted in subsequent years.

VI.—RINGING AND CONSTRICTING THE BRANCHES OF APPLE AND PEAR TREE.

It is now four years since this experiment was begun in order to test the effect of ringing the branches on the fruit produced. Six different branches of one tree were severely rung by removing one inch of bark right round at different dates, commencing on 28th June. The ringing of the branches does not seem to have affected their vigour, only they shed their leaves much earlier than the rest of the tree. The fruit was picked on 23rd March, with the following results :—

TABLE VI.

RESULTS OF RING-BARKING THE BRANCHES OF ANNIE ELIZABETH.

Date of Ringing.	Clean. lbs.	Pitted. lbs.	Total. lbs.	Per cent. Pitted.	Shedding of Leaves.	First Bloom.	Full Bloom.	Final Bloom.
28th June, 1912	$1\frac{1}{4}$	$\frac{5}{8}$	$1\frac{7}{8}$		9th May	26·10	4·11	7·11
30th July, 1912	16	$2\frac{1}{2}$	$18\frac{1}{2}$	14	14th June	21·10	2·11	4·11
29th August, 1912 ..	$2\frac{1}{2}$	$\frac{1}{8}$	$2\frac{5}{8}$		23rd June	24·10	28·10	2·11
30th September, 1912 ..	$3\frac{1}{2}$	$\frac{5}{8}$	$4\frac{1}{8}$		1st June	21·10	28·10	4·11
30th October, 1912 ..	$5\frac{1}{2}$	$\frac{1}{8}$	$5\frac{5}{8}$	14	1st June	21·10	28·10	2·11
6th November, 1912 ..	$6\frac{1}{2}$	$1\frac{3}{4}$	$8\frac{1}{4}$		1st June	10·10	28·10	2·11
Total for ringed branches	$35\frac{1}{4}$	$5\frac{3}{4}$	41	14				
Remainder of tree ..	$41\frac{1}{2}$	14	$55\frac{1}{2}$	25	1st August			
Windfalls	13	$11\frac{1}{4}$	$24\frac{1}{4}$	46				
	$54\frac{1}{2}$	$25\frac{1}{4}$	$79\frac{3}{4}$	32				
Entire tree	$89\frac{3}{4}$	31	$120\frac{3}{4}$	25				
Check tree	$44\frac{1}{2}$	$8\frac{1}{2}$	53	16	1st August			
Windfalls	$9\frac{1}{2}$	$5\frac{1}{4}$	$14\frac{3}{4}$	35				
	54	$13\frac{3}{4}$	$67\frac{3}{4}$	20				

As a rule there was less Pit when the cinctures were made in the spring than in the winter months, but during the past season there was no difference.

If the fruit gathered from the ringed branches is compared with that from the remainder of the tree, it is found that 14 per cent. by weight were pitted in the former and 25 per cent. in the latter.

There was thus less pitted fruit on the ringed branches than on the ordinary branches of the same tree, and this holds good throughout for the branches ringed in the spring months, with the exception of the first year.

The windfalls are not taken into account in this estimate, for the simple reason that they could not be assigned to their proper source.

The wound has not completely healed in any of the ringed branches. The callus from the upper and lower margins has not met at all in any of the ringed branches, with the exception of the branch ringed in August, where there is a meeting just at one small spot.

CONSTRICTION OF BRANCH OF BEURRÉ DE CAPIAUMONT PEAR TREE BY WIRE OF LABEL.

This is the fourth year in which the result of constricting the limb has been observed. The constricted limb has not made as much growth as the rest of the tree, but the fruit is similar in size and ripeness, so that it did not mature earlier. The wound, however, has now healed over, and no difference is observable in the shedding of the leaves. When examined on 1st June the upper two-thirds of the tree as a whole was bare of leaves, while the leaves still adhered to the lower one-third. By 14th June the leaves had completely dropped.

The fruit was perfectly clean throughout, and was gathered on 8th March. The pears off the constricted limb numbered 203, and off the remainder of the tree 1,152, consisting of five branches. Thus the yield was less, on an average, from the limb constricted by the wire.

VII.—EXPERIMENTS CONDUCTED UNDER NATURAL CONDITIONS WITH A VIEW TO CONTROLLING THE DISEASE.

A.—MANURIAL EXPERIMENTS.

The experiments with manures have been conducted for five years, under varying conditions of soil and climate, and the results are necessarily of a mixed character. But a few general conclusions may be drawn with regard to the yield and the amount of Pit in relation to the kind of manure.

The highest yield was obtained in each State from the use of a complete manure, such as superphosphate, sulphate of potash, and sulphate of ammonia. When potash was omitted from this manure the yield was lowest, and when nitrogen only was omitted the yield was intermediate.

As regards the Pit, the unmanured plots were least affected, so that manure by itself does not tend to reduce the amount of Pit.

There is one substance which merits further trial in this connection, and which has been found in some instances both to increase the yield and reduce the Pit, viz., sulphate of iron.

A number of fertilizers were tested, and their influence upon the crop would be affected by the nature of the soil and the amount of rainfall. A chemical and mechanical analysis of the soil is therefore given for each experiment station, along with the monthly rainfall. While the results of the experiments are given in detail, in each case the percentage of Pit in relation to yield and manure is clearly shown in a separate table.

In the strictly technical sense, the term manure is applied to natural products used for increasing the fertility of the soil, such as farmyard manure, while the term fertilizer is applied to artificial products used for the same purpose, such as superphosphate. But it is customary to make a distinction between manures and fertilizers, and to regard a fertilizer as simply supplying plant food, and a manure as, in addition, acting beneficially on those constituents already present in the soil. However, we will use manure as a general term to include both natural and artificial products.

1.—At H. H. Hatfield's Orchard, Box Hill, near Melbourne.

This is the fifth year of the manurial experiments. In the previous season (1914-15) there was no crop, so that the manures then applied were not repeated for the past season. The manure was thus applied four years in succession, and in the fifth year it might reasonably be expected to show its full effect upon the crop.

The trees were about 14 years old at the start, so that they are now 19 years of age, and were treated alike in every respect, with the exception of the manure applied. The yield was far above any previous record, and it will be interesting to compare the rainfall at the critical time when apples show the greatest amount of growth, viz., November, December, and January, together with the yield, from the beginning of the experiment.

	1910-11.	1911-12.	1912-13.	1913-14.	1914-15.	1915-16.
	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
November ..	3·26	·49	2·96	2·96	1·72	·49
December ..	3·23	3·54	4·15	1·25	3·18	·36
January ..	·64	1·57	·40	1·57	2·13	·24 (up to 27th)
	7·13	5·60	7·51	5·78	7·03	1·09
		Lbs.	Lbs.	Lbs.		Lbs.
Yield of 9 plots ..	—	6835	2359	5954	—	11,695

Taking the rainfall for these three months in each season for five successive years, and comparing it with the past season, it is found that six times as much rain fell, on an average, during the five preceding seasons as during the past season.

Unless where the trees were irrigated, the apples were below the normal size, and this may be accounted for by the relatively low rainfall during November, December, and January. Most of the rain in January fell towards the end of the month, beginning on the 28th, so that there was continuous dry weather for the space of three months. The fruit never really recovered from the check it received during these dry months, so that the apples, although abundant, were smaller in size.

The fruit was picked on 10th April, with the result shown in the following table :—

TABLE VII.

MANURIAL EXPERIMENTS WITH ESOPUS SPITZENBERG AT BOX HILL. VICTORIA—1915-16.

Plot No.	Manure.	Per Tree.	No. of Trees.	Total Yield.	CLEAN. On Trees.	CLEAN. Wind-falls.	PITTED. On Trees.	PITTED. Wind-falls.	Per cent. Pitted.	Remarks.
		lbs.		lbs.	lbs.	lbs.	lbs.	lbs.		
1	Sulphate of ammonia ..	½	8	1600	1054	500	26	20	2·87	
	Ordinary superphosphate ..	1½								
	Sulphate of potash	½								
		2½								
2	Sulphate of ammonia ..	½	8	1503	1067	410	13	13	1·73	
	Special bonedust	½								
	Ordinary superphosphate ..	1								
	Sulphate of potash	½								
		2½								
3	Sulphate of ammonia ..	½	8	1590	1154	360	46	30	4·78	
	Ordinary superphosphate ..	1½								
	Kainit	2								
		4								
4	Ordinary superphosphate ..	1½	8	1393	1050	293	30	20	3·59	Green manuring, 1913.
	Sulphate of potash	½								
		2								
5	Check—no manure	—	8	1410	1079	280	41	10	3·61	
6	Ground limestone		8	1533	1079	400	41	13	3·52	Green manuring, 1912 & 1914
	Green manuring with dun peas									
	Bonedust	½								
	Ordinary superphosphate ..	½								
		1								
7	Ordinary superphosphate ..	1½	8	1090	862	180	38	10	4·40	
	Sulphate of potash	½								
		2								
8	Ordinary superphosphate ..	1½	8	556	382	126	18	30	8·63	
	Sulphate of ammonia ..	½								
		2								
9	Sulphate of iron	1	6	1020	809	170	31	10	4·00	

TABLE VIII.

PERCENTAGE OF PIT IN RELATION TO YIELD AND MANURE.

Manure.	Yield. lbs.	Percentage of Pit.
No manure	1410	3·61
Sulphate of iron	1020	4·00
Superphosphate + Sulphate of potash	1090	4·40
Do. + Sulphate of ammonia	556	8·63
Do. + Do. + Sulphate of potash	1600	2·87
Do. + Do. + Do. + Special Bonedust	1503	1·73
Do. + Do. + Kainit	1590	4·78
Green manuring + Ground limestone	1533	3·52
Do. + Superphosphate + Sulphate of potash	1393	3·59

The highest yield was obtained with a complete manure—superphosphate, sulphate of potash, and sulphate of ammonia—and practically the same when kainit replaced sulphate of potash. The lowest yield was obtained with superphosphate and sulphate of ammonia, and also the highest percentage of Pit. The smallest amount of Pit occurred when bonedust was added to a complete manure, but there was very little difference between this and the complete manure by itself. The unmanured plot gave a good yield, and the percentage of Pit was only 3·61.

The general effect of manuring on the yield was that a general mixture or complete manure, consisting of phosphoric acid, potash, and nitrogen, gave the best results, while the omission of potash from the complete manure produced the lowest yield.

In this particular variety the amount of Pit was so relatively small, and the fruit so slightly affected, that no definite distinction could be made between the effect of different manures, with the exception of superphosphate and sulphate of ammonia, which produced practically double the amount of any of the other plots.

2.—AT GOVERNMENT FARM, BATHURST, NEW SOUTH WALES.

It is now five years since the commencement of these manurial experiments, and during the past season no manure was applied. The results will therefore give the action of the residue of the manure on the crop.

The trees were all 20 years old, and therefore of an age favourable for showing average results.

The manager of the Experiment Farm informs me that the rainfall for the year was 18·80 inches, one of the main features being a dry November. A hailstorm was experienced on 4th December, 1915, which marked a percentage of the fruit, and it was difficult to differentiate in all cases when selecting for Pit.

In the previous Report it will be noted that the rainfall for 1914 was 22½ inches, and early frosts occurred.

The fruit was picked from 29th March to 3rd April, just a little later than the previous season.

TABLE IX.

MANURIAL EXPERIMENTS WITH CLEOPATRA AT BATHURST EXPERIMENT FARM, NEW SOUTH WALES—1915-16.

Plot No.	Manure—applied 28/7/14.	Tree No.	Yield. lbs.	Clean Fruit. lbs.	Pitted Fruit. lbs.	Per cent. Pitted.
1	Check—no manure	1	91	72	19	20·88
		2	42	21	21	50·
		3	155	136	19	12·25
		4	119	109	10	8·40
		5	172	147	25	14·53
		6	83	67	16	19·27
		Total	662	552	110	
		Average	110·33	92	18·33	16·61

TABLE IX.—MANURIAL EXPERIMENTS WITH CLEOPATRA, ETC.—*continued.*

Plot No.	Manure—applied 28/7/14.	Tree No.	Yield. lbs.	Clean Fruit. lbs.	Pitted Fruit. lbs.	Per cent. Pitted.
2	Ordinary superphosphate .. Sulphate of potash	1	17	16	1	5·88
		2	276	266	10	3·62
		3	167	161	6	3·59
		4	74	54	20	27·02
		5	129	117	12	9·30
		6	113¼	112	1¼	1·10
		Total	776¼	726	50¼	
		Average	129·37	121	8·37	6·47
3	Ordinary superphosphate .. Sulphate of ammonia	1	147¾	145	2¾	1·86
		2	149	149	—	—
		3	142	142	—	—
		4	137	125	12	8·75
		5	114¼	113	1¼	1·09
		6	245	244	1	0·40
		Total	935	918	17	
		Average	155·83	153	2·83	1·81
4	Check—no manure	1	136	135	1	0·73
		2	131	130	1	0·76
		3	194½	192	2½	1·28
		4	178½	175	3½	1·96
		5	74½	71	3½	4·69
		6	98	98	—	—
		Total	812½	801	11½	
		Average	135·41	133·5	1·91	1·41
5	Ordinary superphosphate .. Sulphate of potash .. .. Ground limestone	1	209	208½	½	0·23
		2	230¾	228	2¾	1·19
		3	129¼	129	¼	0·19
		4	149	149	—	—
		5	142½	142	½	0·35
		6	189¾	189	¾	0·39
		Total	1050¼	1045½	4¾	
		Average	175·04	174·25	0·79	0·45
6	Sulphate of potash .. .. Sulphate of ammonia .. .. Ground limestone	1	74	74	—	—
		2	143	142	1	0·69
		3	119¼	113	6¼	5·24
		4	153	145	8	5·22
		5	114½	107	7½	6·55
		6	131	114	17	12·97
		Total	734¾	695	39¾	
		Average	122·45	115·83	6·62	5·41

TABLE IX.—MANURIAL EXPERIMENTS WITH CLEOPATRA, ETC.—*continued.*

Plot No.	Manure—applied 28/7/14.	Tree No.	Yield. lbs.	Clean Fruit. lbs.	Pitted Fruit. lbs.	Per cent. Pitted.
7	Check—no manure	1	187¼	187	¼	0·13
		2	151¼	151	¼	0·16
		3	193	192	1	0·51
		4	58½	58	½	0·85
		5	166	161	5	3·01
		6	221	221	—	—
		Total	977	970	7	
		Average	162·83	161·66	1·16	0·71
8	Sulphate of potash .. .. / Sulphate of ammonia .. .. / Special bonedust	1	242	241	1	0·41
		2	161	160	1	0·62
		3	80	79	1	1·25
		4	127¾	127	¾	0·57
		5	159¾	159	¾	0·46
		6	212	208	4	1·88
		Total	982½	974	8½	
		Average	163·75	162·33	1·42	0·86
9	Ordinary superphosphate .. / Sulphate of potash .. .. / Sulphate of ammonia	1	113½	112	1½	1·32
		2	172	164½	7½	4·36
		3	135	121	14	10·37
		4	112	105	7	6·25
		5	186½	174	12½	6·70
		6	123½	111½	12	9·71
		Total	842½	788	54½	
		Average	140·42	131·33	9·08	6·57

TABLE X.

PERCENTAGE OF PIT IN RELATION TO YIELD AND MANURE.

Manure.	Yield. lbs.	Percentage of Pit.
No manure—3 plots .. .. Average per plot	817	5·24
Superphosphate + Sulphate of potash	776	6·47
Do. + Sulphate of ammonia	935	1·81
Do. + Do. + Sulphate of potash	842	6·57
Do. + Sulphate of potash + Ground limestone	1050	0·45
Sulphate of potash + Sulphate of ammonia + Do.	734	5·41
Do. + Do. + Special bonedust	982	0·86

On glancing over the results obtained from the individual plots, the most striking feature is that the highest and lowest yields are associated with the least and greatest percentages of Pit. The highest yield was obtained from plot 5, with 1,050 lbs. of fruit, and manured with superphosphate, sulphate of potash, and ground limestone; and the lowest yield from plot 1, with 662 lbs. of fruit and no manure.

The greatest percentage of Pit was in plot 1, unmanured, and the least percentage in plot 5, manured, as above. So that the highest yield and the smallest percentage of Pit were associated in

one plot, and the lowest yield and the greatest percentage of Pit in another. This relation held even in individual trees, and it will be observed that in those plots where the percentage of Pit was high, it was usually mainly owing to individual trees with light crops. Thus in plot 1 a tree with the lowest yield of 42 lbs. of fruit had 50 per cent. of Pit, and in plot 2 a tree with 74 lbs. of fruit had 27 per cent. of Pit.

In the unmanured plots the average yield per tree was 136 lbs., while in the manured plots it was 147 lbs.

On the whole, the past season was not a bad one for Pit, but to show how variable it is in its occurrence, plot 5, with the least percentage of Pit in 1916, had the greatest percentage in 1915.

EFFECT OF SULPHATE OF IRON ON PIT.

A solitary Cleopatra tree which had been consistently badly pitted year after year was selected for testing the effect of sulphate of iron. It was lightly pruned throughout the five years of the experiment, and gave the following results :—

TABLE XI.

EFFECT OF SULPHATE OF IRON ON PIT.

Season.	Manure.	Total Yield. lbs.	Sound Fruit. lbs.	Pitted Fruit. lbs.	Per cent. Pitted.
1911-12	No manure	169	139	30	17·75
1912-13	Sulphate of iron—2 lbs.	291½	287	4½	1·54
1913-14	,, ,,	229	215	14	6·11
1914-15	,, 1 lb.	424	404	20	4·71
1915-16	No manure	37½	24	13½	36

It will be seen from the above that whenever sulphate of iron was applied the yield was increased and the amount of Pit considerably reduced.

If a comparison is made with individual trees in the manurial plots, the application of sulphate of iron gave the highest yield in every instance, and in season 1914-15, when the yield was 424 lbs., the highest yield approaching it was 254 lbs. Sulphate of iron, when applied in proper quantities, seems to have a decided effect in reducing Bitter Pit, and it is worthy of being tried on a large scale and for a sufficient number of seasons.

3.—AT MR. ROESSLER'S ORCHARD, STANTHORPE, QUEENSLAND.

There is, unfortunately, no report for these manurial experiments, since the very severe drought experienced, together with the ravages of the parrots by day and the flying foxes by night, has left very few apples on the trees.

The Orchard Inspector, Mr. J. Henderson, informed me that the cultivation and spraying had been attended to, but the trees had made practically no growth, owing to the drought. As regards Pit, he remarked : "The fruit showed very little Pit on any of the plots ; in fact, so far as Pit was concerned, there appeared to be no difference between the manured trees and the 'buffer' trees."

4.—AT GOVERNMENT EXPERIMENT ORCHARD, BLACKWOOD, SOUTH AUSTRALIA.

The trees used for these manurial experiments were planted out in August, 1908, when one year old, so that they are now eight years of age from date of planting. The manure has been applied for seven years in succession, and since this is the first year in which the yield was sufficiently large to be reckoned by weight instead of by number of fruits, the results may be taken as affording some indication of the effect of manure and yield on the development of Pit.

The plot treated with sulphate of iron was planted a year later than the others, and that may account for the very small yield. It was not deemed advisable to include this plot in the general summing up of results.

The total rainfall for 1915 was 30·45 inches, and for the six months from October, 1915, to March, 1916, the rainfall was comparatively light, being only about three inches (Appendix II.). For the previous year (1914) the rainfall was only 15 inches, and the crop was a practical failure, so that the manures for the past season may be presumed to have had their full effect.

TABLE XII.

MANURIAL EXPERIMENTS WITH CLEOPATRA AT GOVERNMENT EXPERIMENT ORCHARD, BLACKWOOD, SOUTH AUSTRALIA—1915-16.

Plot No.	Manure.	Per Tree lbs.	No. of Trees.	Total Yield. lbs. ozs.	Clean. On Trees. lbs. ozs.	Clean. Windfalls. lbs. ozs.	Pitted. On Trees. lbs. ozs.	Pitted. Windfalls. lbs. ozs.	Per cent. Pitted.
1	No manure	—	3	300–2	271	6–7	21–15	0–12	7·6
2	Superphosphate ..	1¼	3	376–7	345–12	2–9	28–2	—	7·4
3	Superphosphate ..	1¼	3	377–9	332–4	5–6	39–15	—	10·6
	Lime	2½							
4	Superphosphate ..	1¼	3	360–4	320–9	7–4	31–12	0–11	9·0
	Sulphate of potash ..	6 oz.							
5	Superphosphate ..	1¼	3	362–10	340–2	7–13	14–11	—	4.0
	Sulphate of potash ..	6 oz.							
	Sulphate of ammonia	6 oz.							
6	No manure	—	3	278–3	265–14	4–15	6–15	0–7	2·5
7	Superphosphate ..	1¼	3	460–5	437–7	5–13	16–6	0–11	3·7
	Lime	2½							
	Sulphate of potash ..	6 oz.							
	Sulphate of ammonia	6 oz.							
8	Lime	2½	3	370–7	355–3	5–2	9–12	0–6	2·7
9	Sulphate of potash ..	6 oz.	3	270	256–3	6–8	7–5	—	2·6
	Sulphate of ammonia	6 oz.							
10	Superphosphate ..	1¼	3	342–7	322	6–4	14–3	—	4·1
	Sulphate of ammonia	6 oz.							
11	Stable manure ..	70	3	315–14	297–8	6–11	11–11	—	3·6
12	No manure	—	3	287–3	267–8	4–15	14–4	0–8	5·0
13	Sulphate of iron ..	6 oz.	3	87–14	66–3	9–1	12–10	—	14·2
	Total		39	4189–5	3877–9	78–12	229–9	3–7	5·5

TABLE XIII.

PERCENTAGE OF PIT IN RELATION TO YIELD AND MANURE.

Manure.	Yield. lbs.	Percentage of Pit.
No manure—3 plots .. .. Average per plot	288	5·2
Superphosphate	376½	7·4
Lime	370½	2·7
Sulphate of iron	88	14·2
Stable manure	316	3·6
Superphosphate + Lime	377½	10·6
Do. + Sulphate of potash	360	9·0
Do. + Sulphate of ammonia	342½	4·1
Do. + Do. + Sulphate of potash	362¾	4·0
Do. + Do. + Do. + Lime	460½	3·7
Sulphate of potash + Do.	270	2·6

The heaviest yield was obtained from a complete manure with lime added, and the lightest from sulphate of potash and sulphate of ammonia, which was practically equal to the unmanured plots.

The plot treated with sulphate of iron was planted a year later than the others, and that may account for the very small yield. It was not deemed advisable to include this plot in the general summing up of results.

The least amount of Pit was in the plot with the lightest yield, although it was practically equal to that with lime alone, which had a good average yield.

The greatest amount of Pit was in the superphosphate and lime plot, which had a yield practically equal to that of lime alone, so that there is not a necessary relation between the total yield and the amount of Pit. It is the size of the fruit which seems to be the determining factor, and when abnormally large it is most subject to it, as shown in the following table:—

TABLE XIV.

PERCENTAGE OF PIT IN RELATION TO THE DIFFERENT GRADES OR SIZE OF FRUIT IN CLEOPATRAS AT GOVERNMENT EXPERIMENT ORCHARD, BLACKWOOD.

Grade. inches.	Total Yield. lbs.	Pitted. lbs.	Per cent. Pitted.
2	57	$\frac{3}{4}$	1·3
$2\frac{1}{4}$	457	$9\frac{3}{4}$	2·1
$2\frac{1}{2}$	$1238\frac{1}{4}$	41	3·3
$2\frac{3}{4}$	1371	$70\frac{1}{2}$	5·1
3	$878\frac{1}{4}$	76	8·6
$3\frac{1}{4}$	$181\frac{1}{2}$	31	17·1
$3\frac{1}{2}$	$6\frac{1}{4}$	4	64·0
Total ..	$4189\frac{1}{4}$	233	5·5

This is a very interesting and instructive return, showing conclusively that the Pit is developed in a regular and progressive manner, according to the size of the apples on the trees. Starting with a grade of two inches in diameter, the Pit is only 1·3 per cent., but it gradually increases with the increase of grade until in the largest, three and a half inches in diameter, it reaches 64 per cent.

It is a well-known fact that on a Pit-liable tree the fruits above the average size are most likely to be pitted. It will also be remembered that in the case of the heaviest known apple—Dunn's Favourite, weighing 2 lbs. 2 ozs.—the specimen was not only phenomenal in size, but also badly pitted. The average size of Cleopatra apples is $2\frac{1}{2}$-$2\frac{3}{4}$ inches in diameter, and above that size they are seen to become increasingly liable.

In recording the results of our experiments, it is a question for consideration whether the number of fruits or the weight of the crop should be taken for determining the amount of Pit. The percentage will be slightly heavier by weight than by number, since the larger apples are almost invariably more subject to Pit than the smaller ones. The fairest mode of presentation would be to give the number of apples affected per hundred, but where large crops and numerous experiments are concerned this is not always an easy matter. The most instructive method would be to give percentages of Pit both by number and weight, and in the Stock Experiments at least an effort will be made to tabulate the results accordingly.

5.—AT MOUNT BARKER ESTATE ORCHARD, WESTERN AUSTRALIA.

This experiment has been conducted for four years in succession on Cleopatra trees, which are now in their eleventh year from the date of planting. In the past season, however, the special manures were not applied to each plot, since there was some uncertainty as to whether the experiments would be continued.

But the orchardist applied in the early autumn 1½ cwt. of superphosphate per acre, and in the early spring 1½ cwt. of blood and bone manure per acre. The continuity of the experiment was thus interrupted, and the results cannot be taken for comparison with the preceding ones. The experiment must now be regarded as a whole, and consists of the application of special manures for the first three years, and in the fourth year a special dressing of superphosphate and blood and bone manure. The whole orchard was thus manured, including the check plots, and the results show the effects of this system of manuring. A final comparison is made between the previous year with the application of special manure and the present year with the general application of the same manure to each plot.

WEATHER CONDITIONS AND PREVALENCE OF PIT.

The rainfall during the critical months of November, December, and January was very light. Then towards the middle of February after this dry spell the rain began to fall when the fruit was ripening, and the record for that month was 1½ inches (Appendix II.). During the early spring months it rained heavily, and rough weather set in, which lasted all through the setting season. These conditions, together with a certain amount of Thrip, accounted for the pollination being defective and the crop scanty.

The apples were picked towards the middle of March, and were irregular in size and shape. The light crop and the dry weather, followed by the February rains, were just the most favourable conditions for the development of Pit.

In West Australia, unlike the other apple-growing States, the crop was lighter than that of the previous season, and in all cases the varieties subject to Pit were badly affected.

Table XV.

Manurial Experiments with Cleopatra at Mount Barker Estate Orchard, Western Australia—1915-16.

(1½ cwt. of superphosphate and 1½ cwt. of blood and bone manure applied per acre this season, and undernoted quantities applied per tree in previous seasons.)

Plot No.	Manure.	Per Tree.	No. of Trees.	Total Yield.	Clean. On Trees.	Clean. Wind-falls.	Pitted. On Trees.	Pitted. Wind-falls.	% Pitted. On Trees.	% Pitted. Wind-falls.	Per cent. Pitted.	Remarks.
		lbs.		lbs.	lbs.	lbs.	lbs.	lbs.				
1	Sulphate of ammonia ..	1½	8	348	47	5	270	26	85	84	85	
	Ordinary superphosphate	4½										
	Sulphate of potash ..	1½										
		7½										
2	Sulphate of ammonia ..	1½	8	232	53	10	147	22	73	68	72	
	Special bonedust ..	1½										
	Ordinary superphosphate	3										
	Sulphate of potash ..	1½										
		7½										
3	Sulphate of ammonia ..	½	8	128	20	3	90	15	82	83	82	
	Special bonedust ..	6										
	Sulphate of potash ..	1½										
		8										

TABLE XV.—MANURIAL EXPERIMENTS WITH CLEOPATRA, ETC.—*continued.*

Plot No.	Manure.	Per Tree.	No. of Trees.	Total Yield.	CLEAN. On Trees.	CLEAN. Wind-falls.	PITTED. On Trees.	PITTED. Wind-falls.	% PITTED. On Trees.	% PITTED. Wind-falls	Per cent. Pitted.	Remarks.
		lbs.		lbs.	lbs.	lbs.	lbs.	lbs.				
4	Sulphate of ammonia ..	1½	8	140	41	5	88	6	68	54	67	
	Ordinary superphosphate	4½										
	Kainit	6										
		12										
5	Sulphate of ammonia ..	1½	8	59	17	2	35	5	67	71	68	
	Thomas' phosphate ..	4½										
	Sulphate of potash ..	1½										
		7½										
6	Ordinary superphosphate	4½	8	449	53	7	362	27	87	80	86	Green manuring, 1913
	Sulphate of potash ..	1½										
		6										
7	Ground limestone ..	15	8	253	87	10	140	16	61	61	61	
8	Ordinary superphosphate	4½	8	206	58	8	126	14	68	63	68	
	Sulphate of potash ..	1½										
		6										
9	Sulphate of ammonia ..	1½	8	318	70	8	227	13	76	62	75	
	Ordinary superphosphate	4½										
		6										
10	Special bonedust ..	6	8	169	26	5	129	9	83	64	81	
	Sulphate of potash ..	1½										
	Sulphate of iron ..	½										
		8										
11	Sulphate of iron ..	1	8	296	117	10	149	20	56	66	57	
12	No manure	—	8	144	40	7	83	14	67	66	67	Green manuring, 1913
13	Ground limestone ..	15	8	94	31	3	47	13	60	81	64	Green manuring, 1913
14	Check plot—no manure	—	8	72	23	5	39	5	60	50	61	
15	Do.	—	8	74	27	4	39	4	59	50	58	
16	Do.	—	8	144	51	10	75	8	58	44	57	

SUMMARY OF MANURIAL EXPERIMENTS—1915-16.

Plot No.	Clean Fruit. lbs.	Pitted Fruit. lbs.	Per cent. Pitted.	Remarks.
1	52	296	85	Fair growth, colour of foliage good, fruit fairly large.
2	63	169	72	Growth not as good as 1, foliage poorer, but colour good; fruit large.
3	23	105	82	Fair to good growth, foliage and colour good, fruit fairly large.
4	46	94	67	Growth fair, foliage and colour fair, fruit large.
5	19	40	68	Trees with "die-back," foliage scanty, and colour medium.
6	60	389	86	Growth medium, foliage and colour good, fruit good to medium.
7	97	156	61	Growth poor, foliage and colour good, fruit fair-sized.
8	66	140	68	Growth poor, foliage and colour good, fruit medium.
9	78	240	75	Growth poor, colour and foliage good, fruit good to medium; a most even sample.
10	31	138	81	Growth poor to medium, colour and foliage good, fruit similar to 9.
11	127	169	57	Growth very poor, foliage scanty and fair colour, fruit medium.
12	47	97	67	Growth poor, colour and foliage fair, fruit fair.
13	34	60	64	Growth poor, colour and foliage fair, fruit medium.
General average			73	
				SUMMARY OF CHECK PLOTS.
14	28	44	61	No growth, foliage weak, and colour fair; fruit poor.
15	31	43	58	Very little growth, foliage weak, and colour fair; fruit poor.
16	61	83	57	No growth, foliage weak, and colour fair; fruit fair.
General average			58	

TABLE XVI.

PERCENTAGE OF PIT IN RELATION TO YIELD AND MANURE.

Manure.	Yield. 1915. lbs.	Percentage of Pit.	Yield. 1916. lbs.	Percentage of Pit.
No manure—3 plots .. .. Average per plot	400	20	97	58
Ground limestone	338	35	253	61
Sulphate of iron	358	26	296	57
Superphosphate + Sulphate of potash	1197	38	206	68
Do. + Sulphate of ammonia	1421	42	318	75
Do. + Do. + Sulphate of potash	889	57	348	85
Do. + Do. + Kainit	863	30	140	67
Do. + Do. + Sulphate of potash + Special bonedust	983	33	232	72
Sulphate of potash + Sulphate of ammonia + Special bonedust ..	1136	41	128	82
Do. + Do. + Thomas' phosphate	641	29	59	68
Do. + Sulphate of iron + Special bonedust	1291	38	169	81
Green manuring with peas	538	21	144	67
Do. + Ground limestone	447	31	94	64
Do. + Superphosphate + Sulphate of potash ..	935	59	449	86

On comparing the present with the past season, it is found that the total yield is very much reduced. The yield is only about one-fourth of the previous season. The average per tree in the

manured plots is 27 lbs., as compared with 106 lbs. in the previous season, and in the check plots 12 lbs., as compared with 50 lbs.

The highest yield was in plot 6, with superphosphate and sulphate of potash combined with green manuring, while in the previous season it was in plot 9, with superphosphate and sulphate of ammonia.

The lowest yield was in plot 13, with ground limestone and green manuring, and in the previous season it was in plot 7, with ground limestone alone. Accompanying the small yield there is a considerable increase in the amount of Pit. In the manured plots there is 73 per cent., as compared with 40 per cent. the preceding year, and in the unmanured plots there is 58 per cent., as compared with 20 per cent.

As before, the Pit is least in the unmanured plots, as might be expected from the relatively light crop and the small size of the fruit.

The least amount of Pit occurred in plot 11, where sulphate of iron was used alone, and the highest amount in plot 6, with superphosphate and sulphate of potash combined with green manuring. The heaviest yield was associated with the greatest amount of Pit. In the previous season green manuring alone gave the lowest amount of Pit, being practically equal to that of no manure, and sulphate of iron came next. The highest amount occurred in the same plot as the present year, although not associated with the highest yield.

In the general table (page 36), showing the relation of Pit to the yield obtained and the manures used in the various States, there is a wide variation in respect of yield and Pit.

The yield ranges from an average of 200 lbs. per tree to 29 lbs., and from 86 per cent. of Pit to ½ per cent.

Although quite a number of different manures have been tried, only three have been tested in all the experimental plots, viz., a complete manure (superphosphate, sulphate of potash, and sulphate of ammonia), the same without potash, and a third without nitrogen. Taking the most general view of the results obtained from these manures, irrespective of soil or climate, it was found that a complete manure gave the highest yield, without potash the least, and without nitrogen intermediate.

Comparing these results with those obtained from no manure, both the complete manure and the same without nitrogen gave a superior yield to the unmanured plots, while a complete manure without potash yielded considerably less than the unmanured plots.

If a similar test is applied to the effect of these manures on Pit, there is no very marked difference between the three manures, but the unmanured plots have decidedly less Pit. This is probably owing to the smaller size of the fruit and the absence of any stimulating effect from the action of fertilizers.

B.—PRUNING EXPERIMENTS.

These experiments have now been conducted for five years in succession, and the mode of pruning has had sufficient time to produce its effect upon the tree and its fruit. The results are very striking as to the influence of the mode of pruning upon the development of Bitter Pit, and they have induced me to give prominence to such subjects as fruit-buds in relation to pruning and the pruning of apple trees grown in pots.

In the Fifth Report of the Woburn (England) Experimental Fruit Farm (1905) the introductory paragraph under the heading of "Experiments on Pruning" is so appropriate to our own that I make no apology for quoting it:—

> "Experiments on pruning must always be somewhat uncertain in character, for pruning is an art and depends greatly on the skill and judgment of the pruner. The work must of necessity be left in the hands of the ground-manager, and, as is well known, even the most highly skilled horticulturists differ amongst themselves in the application of their art. There is always a possibility, therefore, that under different management the results might have been somewhat different. According to our own personal opinion, which seems to be borne out by some of the experiments themselves, the pruning in the past years has erred on the side of being too severe, and especially in removing too many laterals, or cutting them back too close to the branches. A less severe treatment will be adopted in future, and as regards the standard trees the pruning will be confined to the removal of superfluous branches."

TABLE XVII.

PERCENTAGE OF PIT IN RELATION TO YIELD AND MANURE IN VARIOUS STATES.

	Manures.	Box Hill, V. (8 trees in plot).		Bathurst, N.S.W. (6 trees in plot).		Blackwood, S.A. (3 trees in plot).	
		Per Tree. Yield.	Percentage of Pit.	Per Tree. Yield.	Percentage of Pit.	Per Tree. Yield.	Percentage of Pit.
		lbs.		lbs.		lbs.	
1.	No manure	176	3·61	136	5·24	96	5·08
2.	Superphosphate	—	—	—	—	125	7·4
3.	Lime	—	—	—	—	123	2·7
4.	Sulphate of iron	128	4·00	—	—	29	14·2
5.	Stable manure	—	—	—	—	105	3·6
6.	Superphosphate + Sulphate of potash	136	3·52	129	6·47	120	9·0
7.	Do. + Sulphate of ammonia	69	8·63	156	1·81	114	4·1
8.	Do. + Lime	—	—	—	—	126	10·6
9.	Do. + Sulphate of potash + Sulphate of ammonia	200	2·87	140	6·57	121	4·0
10.	Do. + Kainit + Do.	199	4·78	—	—	—	—
11.	Do. + Sulphate of potash + Do. + Special bonedust	188	1·73	—	—	—	—
12.	Do. + Do. + Do. + Lime	—	—	—	—	153	3·7
13.	Do. + Do. + Ground limestone	—	—	175	0·45	—	—
14.	Sulphate of potash + Sulphate of ammonia	—	—	—	—	90	2·6
15.	Do. + Do. + Ground limestone	—	—	122	5·41	—	—
16.	Do. + Do. + Special bonedust	—	—	164	0·86	—	—
17.	Green manuring with peas + Ground limestone	192	3·52	—	—	—	—
18.	Do. + Superphosphate + Sulphate of potash	174	3·59	—	—	—	—

In the typical experiments carried out at Deepdene, near Melbourne, on the principle of a regular gradation from no pruning, through leader and light, to severe pruning, the pruning was done each succeeding year by Mr. E. E. Pescott, F.L.S., and therefore there was uniformity throughout the operations.

Since the striking results obtained in the checking of Bitter Pit by a particular type of pruning has created widespread interest, I am giving full details of the experiments, together with illustrations of the two contrasted systems of light and severe pruning.

The description of the methods pursued by Mr. Pescott is given in his own words :—

> "Mr. McAlpine decided to include pruning within the scope of his enquiry and experiments, it having been stated for years that if the apple tree were allowed to pursue its natural growth unchecked by the force of pruning, little or no Bitter Pit would result in the fruit.
>
> "Further, it had been stated by some growers that there was less Bitter Pit in the fruit on trees which had been allowed to retain an extensive lateral system, and that both Pit and 'crinkle' were very prevalent in such varieties that were pruned so as to produce spurs on the leaders and sub-leaders, *e.g.*, the London Pippin.
>
> "Hence it was decided to select a row of London Pippin apple trees which were growing in the Burnley Horticultural Gardens, and submit them to an exhaustive *comparative* pruning test. The trees had been allowed to develop a good lateral system throughout in the season previous. In designing the experiment, commercial pruning, or rather pruning these London Pippin trees according to the system in vogue in most orchards, viz., pruning off all laterals and filling the leaders and sub-leaders with spur systems, was not considered. Indeed it was necessary to have a good lateral system on each tree for comparative purposes, and also to consider the suggestion previously referred to, that less Pit developed upon the laterals than upon the spur systems.
>
> "The trees were separated into four sections, and three types of pruning in regard to the lateral system were designed :—
>
> (1) The laterals and leaders were all to be severely pruned, leaving short spurred laterals.
>
> (2) The laterals were to be lightly pruned and left considerably longer and more extensive than in the first section.
>
> (3) The laterals were to be left entirely unpruned, pruning and thinning out the terminals of the leaders and sub-leaders, so as to retain their strength of character and to stimulate their growth.
>
> (4) To provide a check on the three sections, a fourth section was left quite unpruned during the whole course of the experiment.
>
> "From the Figs. 59 and 60 the comparison between the severe and light systems of pruning will be readily noted.
>
> "In Fig. 60, illustrating severe pruning, the laterals have all been pruned and repruned back, so that very few of them are more than nine or ten inches in length. In addition, several have been entirely removed from the leader.
>
> "In Fig. 59, illustrating light pruning, the laterals have been left considerably longer, averaging from one foot to two feet in length, and even longer in some cases.
>
> "The comparison, therefore, is that in one the laterals are severely cut back, and in the other they are much less interfered with."

This contrast between light and severe pruning of the London Pippin might also be put to the test by means of pot experiments.

6.—At Burnley Horticultural Gardens, Victoria.

This is the fifth consecutive year in which the London Pippin has been pruned on a definite system. There was a good average crop in all the plots, but on account of the small size of the fruit there was not sufficient Pit to discriminate between the different systems.

The trees are now about 14 years old, on Northern Spy stocks, and were pruned on 31st August, 1915. The fruit was picked on 21st March, 1916, with the result shown in the following table :—

TABLE XVIII.

RESULTS OF DIFFERENT METHODS OF PRUNING ON LONDON PIPPIN—SEASON 1915-16.

No. of Tree.	Pruning.	Yield.	Clean. On Tree.	Clean. Windfalls.	Pitted. On Tree.	Pitted. Windfalls.	Per cent. Pitted.	Remarks.
		lbs.	lbs.	lbs.	lbs.	lbs.		
2	Severe	172	162	8	2	(a few apples)	1·1	Zinc band
3	,,	227	199	26	(1 apple)	2	·9	
	Severe pruning	399	361	34	2	2	1	
5	Light	293	262	27	4	—	1·3	Zinc band
8	,,	138	131	6	1	—	·7	
9	,,	228	214	13	1	—	·4	Zinc band
	Light pruning	659	607	46	6	—	·9	
10	Leader	236	212	14	10	—	4·2	
12	,,	270	238	24	8	—	3·0	
	Leader pruning	506	450	38	18	—	3·5	
13	Unpruned	124	112	8	4	—	3·2	Zinc band
14	,,	196	170	22	3	1	2·0	
	No pruning	320	282	30	7	1	2·5	

AMOUNT OF PIT.

Although the yield was the highest of all the five years of the experiment, yet the individual apples were rather small, and consequently the development of Pit was not so pronounced. There is no clear distinction, however, between the different modes of pruning and the prevalence of Pit, as in some of the previous years, and the only general remark that can be made about the amount of Pit is, that the light and severe pruning produced about 1 per cent. of Pit respectively, while the absence of pruning and leader pruning were responsible for $2\frac{1}{2}$ to $3\frac{1}{2}$ per cent. of Pit respectively.

It is the relatively small amount of Pit during the past season which prevents us from drawing any general conclusions, but the relation between "Pit" and "crinkle" in this particular variety of apple may be profitably discussed.

RELATION BETWEEN "PIT" AND "CRINKLE."

The London Pippin is rather noted for being subject to distorted and irregular appearances, and to such appearances, which also occur in other varieties, I gave the name of "crinkle" to indicate the general wave-like and irregular contour of the surface. This distorted appearance is called by various names, such as Pig-face, Monkey-face, etc., and it is invariably the case that when such apples are cut across the irregular surface, the skin is found to be unaffected as far as its chlorophyll content is concerned, but the pulp-cells beneath are brown and spongy and shrunken.

But when this striking appearance is closely observed, it will be found that the ordinary Pits or depressions of Bitter Pit are often associated with it, and in some seasons, such as the present, London Pippin is seen to be subject to Pit, without any trace of the so-called "crinkle" (see Frontispiece).

As I have already shown, "crinkle" is just an extreme form of Pit, and may be distinguished as confluent Bitter Pit. So that in dealing with this disease, whether in the "discrete" form or "con-

fluent" form, as in small-pox, whatever measures are found to alleviate the one may be expected to produce a similar effect on the other.

The following summary will show how the London Pippin has been affected during the last five seasons, sometimes taking the form of Pit, and only an occasional apple crinkled; or it may be the reverse, and to the eye of the ordinary orchardist only the crinkled form is apparent.

SUMMARY OF THE RELATIVE AMOUNTS OF PIT AND "CRINKLE" FOR FIVE CONSECUTIVE YEARS.

Season.	No. of Trees.	Yield. lbs.	Pit and "Crinkle."	Prevalence of Pit or "Crinkle."
1911-12	10	1108	Very slight—highest 23 apples with leader pruning, and 5 apples with no pruning.	"Crinkle"—only an occasional apple pitted.
1912-13	9	1361	Varying from 15 per cent. with no pruning to 30 per cent. with severe pruning.	Pitting most prominent, and "crinkle" in abeyance; 231 lbs. pitted, and 63 lbs. "crinkled."
1913-14	9	956	Amount too small for giving percentage; 6 lbs. pitted, and 2 lbs. crinkled.	Pit three times the amount of "crinkle."
1914-15	9	560	Varying from 5 per cent. with no pruning to 50 per cent. with severe pruning.	"Crinkle" most prominent—96 lbs. crinkled, and 12 lbs. pitted.
1915-16	9	1891	Varying from ·9 per cent. with light pruning to 3½ per cent. with leader pruning.	Pit, with only an occasional apple crinkled.

EFFECT OF ZINC BAND ROUND TRUNK OF TREE.

There was no evident advantage from the constriction of the stem of the tree by the zinc band, either as regards the yield or the amount of Pit. The trees with the highest and the lowest yield respectively were constricted, and there was no appreciable lessening of the Pit. The finest fruit was produced by tree No. 9, which was constricted, but tree No. 3 was nearly equal, without the zinc band.

7.—AT ALBERT SMITH'S ORCHARD, DEEPDENE, NEAR MELBOURNE.

This is now the fifth consecutive year in which these Cleopatra apple trees have been variously pruned, commencing in August, 1911. The pruning was done each year by Mr. E. E. Pescott, Principal of the School of Horticulture, Burnley, and thus there was continuity in the methods employed. There are twelve trees in the experimental block, arranged in four rows of three trees each, and each row has been pruned according to a definite system. The leader, light, and severe methods of pruning have been already explained; one row has been left unpruned as a check (Fig. 41).

The trees were at a very suitable age to start with, viz., nine years old, and since they are all growing alongside of each other, of the same age, similar in size and vigour, grafted on the same stock (Northern Spy), and treated alike in every respect, with the exception of pruning, I consider that the natural conditions were most favourable for an experimental test of the effect of different methods of pruning on the development of Bitter Pit in a variety very subject to it.

Besides, it is well known that trees sometimes take a few seasons to respond properly to systems of pruning differing from that to which they have been accustomed, and the five years' continuous pruning on the same system should by this time exhibit its special effect on the fruit of the tree. This effect is very decided, and very instructive as far as Bitter Pit is concerned.

The nature of the past season forms a striking contrast to that of 1914-15, when, owing to the dry weather and the unusual heat early in October, the Thrip pest was very bad, and this, combined with a severe frost in October, prevented the setting of the apple fruit. That season's enforced rest has evidently reacted favourably on the present one, for the yield is one of the most prolific known.

The generally good yield obtained, combined with the continuity of the experiments, enabled conclusions to be drawn with more certainty than in any previous year.

The trees were pruned on 2nd August, 1915, and the fruit was picked on 3rd and 4th April, 1916.

TABLE XIX.

RESULTS OF DIFFERENT METHODS OF PRUNING ON CLEOPATRA APPLE TREES—SEASON 1915-16.

No. of Tree.	Pruning.	Yield.	CLEAN.		PITTED.		PER CENT. PITTED.		Per cent. Pitted.	Remarks.
		lbs.	On Tree. lbs.	Windfalls. lbs.	On Tree. lbs.	Windfalls. lbs.	On Tree.	Windfalls.		
1	None	240	206	19	7½	7½	3·51	28·30	6·25	Zinc band
2	,,	167	140	17	5	5	3·45	22·72	6·00	
3	,,	135½	115½	14	3	3	2·53	17·64	4·42	
	No pruning	542½	461½	50	15½	15½	3·25	23·66	5·71	
4	Leader	271¼	233½	27	5	5¾	2·09	17·55	3·96	
5	,,	242½	216	18	6	2½	2·70	12·19	3·50	
6	,,	309	264	30	7½	7½	2·76	20·00	4·85	Zinc band
	Leader pruning	822¾	713½	75	18½	15¾	2·52	17·35	4·16	
7	Light	229	183½	38	4½	3	2·39	7·32	3·27	Zinc band
8	,,	223¾	184½	21¾	12½	5	6·34	18·69	7·82	
9	,,	169¼	124¼	31	7½	6½	5·69	17·33	8·27	
	Light pruning	622	492¼	90¾	24½	14½	4·74	13·77	6·27	
10	Severe	145½	78½	20½	25	21½	24·15	51·19	31·95	
11	,,	264½	201½	23½	35½	4	15·00	14·54	14·93	Zinc band
12	,,	206	129	27½	39	10½	23·21	27·63	24·02	
	Severe pruning	616	409	71½	99½	36	19·56	33·48	22·00	

SUMMARY OF PRUNING EXPERIMENTS AT DEEPDENE—SEASON 1915-16.

Pruning.	Clean Fruit. lbs.	Pitted Fruit. lbs.	Total Yield. lbs.	Per cent. Pitted.	Remarks.
None	511½	31	542½	5·71	Growth poor, foliage of good colour, fruit mostly under-sized.
Leader	788½	34¼	822¾	4·16	Growth medium, foliage of good colour, fruit of fair size.
Light	583	39	622	6·27	Growth superior to preceding, foliage of good colour, fruit slightly larger than preceding.
Severe	480½	135½	616	22·00	Growth good, foliage of good colour, fruit superior in size to others.

In contrasting no pruning with severe pruning, it will be observed that the growth was poor and the fruit under-sized in the one instance, and growth good and fruit superior in size in the other. This shows that a decreased percentage of Pit may not always mean an increased profit, and the orchardist must use his judgment and experience in deciding between less Bitter Pit and the marketable value of the fruit. Thinning the fruit, combined with light pruning, may be found to be effective against Pit, while lessening the danger of strain in young trees and the undue proportion of small fruit.

AMOUNT OF PIT.

A glance at the table and the summary will show in an unmistakable manner, that the mode of pruning when the tree is in bearing, exercises an important influence on the development of Bitter Pit. While the severely pruned trees yielded fruit affected with Pit to the extent of 22 per cent., those that had been lightly or leader pruned were only affected to the extent of 4–6 per cent. From the very nature of this disease one cannot expect absolutely to prevent it, since we cannot exercise complete control over the flow of sap, but the small amount of Pit accompanying light or lateral pruning is very satisfactory.

YIELD IN RELATION TO MODE OF PRUNING.

As regards the yield, the smallest was obtained from the unpruned trees. Among the pruned trees, severe pruning gave the lowest yield, although light pruning produced practically the same. The leader-pruned trees gave the highest yield, along with the smallest percentage of Pit.

INDIVIDUAL TREES IN RELATION TO PIT.

There was one tree which stood out among all the others as having evidently made the most growth with the lightest crop and apparently the greatest amount of Pit. No. 10 tree had the lightest crop of all the pruned trees, made the greatest growth, bore the largest and ripest fruit, and was the worst pitted, reaching 32 per cent.

There is a correlation between these various characters, for the light crop and the large fruit, together with the more rapid growth in a given time, are associated with those physiological disturbances which produce Bitter Pit.

WINDFALLS AND PIT.

If we consider the amount of Pit in the fruit picked off the trees, and this is the commercial aspect of it, we find that it is invariably less than when the windfalls are included.

The percentage of Pit in the windfalls is much higher than that of the fruit on the tree. In the severely pruned trees the difference is less marked than in the other methods of pruning. Although the relative proportion of windfalls to the different modes of pruning has not been observed sufficiently long or extensively to enable us to draw definite conclusions, yet it is worthy of note that the proportion in these experiments is 17 per cent. in the light and severe pruning, while it is about 12 per cent. in the leader and no pruning.

8.—At Government Farm, Bathurst, New South Wales.

This is the fifth year in succession in which these experiments have been carried out with Cleopatra trees, and the results should show the relative merits of the different systems of pruning, as far as yield and Pit are concerned. In the early stages of the experiment the severely and lightly pruned trees were unfortunately interchanged, but for the last three seasons the plots have been pruned as shown in the tables. The unpruned trees show the effect of non-interference for five seasons. These trees are now about twenty years old, of the same age as those used in the manurial experiments.

Table XX.

Severe Pruning—Ten Cleopatra Trees in Two Rows.

	Tree.	Fruit. Sound. lbs.	Fruit. Pitted. lbs.	Total Fruit. lbs.	Per cent. Pitted.
Row 1	1	48	4½	52½	8·57
	2	27	12	39	30·76
	3	72	3	75	4·
	4	78	8	86	9·30
	5	36	2¼	38¼	5·88

TABLE XX.—SEVERE PRUNING—*continued.*

	Tree.	Fruit. Sound. lbs.	Fruit. Pitted. lbs.	Total Fruit. lbs.	Per cent. Pitted.
Row 2	1	34	17	51	33·33
	2	23	8	31	25·80
	3	30	13	43	30·23
	4	52	8	60	13·33
	5	99	21½	120½	17·84
	Total	499	97¼	596¼	—
	Averages	49·90	9·72	59·62	16·31

TABLE XXI.

LIGHT PRUNING—ELEVEN CLEOPATRA TREES IN TWO ROWS.

	Tree.	Fruit. Sound. lbs.	Fruit. Pitted. lbs.	Total Fruit. lbs.	Per cent. Pitted.
Row 1	1	239	14	253	5·53
	2	160	15	175	8·57
	3	109	—	109	—
	4	110	3	113	2·65
	5	91	17	108	15·74
	6	28	10	38	26·31
Row 2	2	153	3½	156½	2·23
	3	105	½	105½	0·47
	4	209	1	210	0·47
	5	72	2½	74½	3·35
	6	46	10	56	17·85
	Total	1322	76½	1398½	
	Average	120·18	6·95	127·13	5·47

TABLE XXII.

NO PRUNING—TWELVE CLEOPATRA TREES IN TWO ROWS.

	Tree.	Fruit. Sound. lbs.	Fruit. Pitted. lbs.	Total Fruit. lbs.	Per cent. Pitted.
Row 1	1	17	—	17	—
	2	1½	—	1½	—
	3	6	—	6	—
	4	53	—	53	—
	5	15	—	15	—
	6	21	½	21½	2·32
Row 2	1	32	—	32	—
	2	15	—	15	—
	3	13	—	13	—
	4	8¼	—	8¼	—
	5	3¼	—	3¼	—
	6	51	—	51	—
	Total	236	½	236½	
	Average	19·66	0·04	19·70	0·21

There is a very decided difference in favour of the light pruning, both in yield and Pit. The unpruned trees bear such light crops, although practically free from Pit, that they are only retained as a scientific standard with which to compare the others. The average yield of the lightly pruned trees is fully twice that of the severely pruned, and as regards Pit it is only about one-third that of the other. The fruit on the single Cleopatra tree which had been unpruned for fourteen years was rather small, but still marketable. Just as in the case of the manurial experiments, it is the individual trees with small yields which raise the average of the Pit considerably, and if these were excluded in the lightly pruned trees, the amount of Pit would be reduced to a minimum of 3 per cent.

The single Cleopatra tree which was unpruned for the past fourteen years, bore a crop weighing 131¼ lbs. Of these only ¼ lb. was Pitted, so that the percentage of Pit was 0·19. This is practically the same as that for all the unpruned trees, and when the small size of the fruit is taken into account, it justifies the inference that the nearer the Crab apple the less Pit, while the bigger and more succulent the apple, *i.e.*, the more artificial, the greater the amount of Pit.

9.—At Yanco Government Farm, New South Wales.

Since 1912 the four young Cleopatra trees have been pruned similarly, and, although there is only an individual tree for each system of pruning, yet the results are shown under irrigation conditions. The trees were pruned on 16th September, 1915. No manure was applied except grey field peas, sown at the rate of one bushel, and 60 lbs. of superphosphate to the acre, then ploughed in during the spring.

The trees were irrigated during November and December, 1915, and January and February, 1916. The mature apples were harvested on 16th February, and the remainder of the crop on 28th February.

Unfortunately, the yield from each individual tree was lost, but the windfalls were accurately recorded. This will give some idea of the relative amount of Pit. One case from each tree was also forwarded to me in Melbourne on 22nd February for placing in the Government Cool Stores. They were free from Pit when packed, but on being examined by me on 28th February a few were found pitted.

Table XXIII.

Development of Pit in Windfalls according to Different Methods of Pruning.

No. of Tree.	Pruning.	Windfalls. No.	Clean. No.	Pitted. No.	Per cent. Pitted.
1	Severe	82	78	4	4·8
2	Light	107	102	5	4·7
3	Leader	53	51	2	3·8
4	Unpruned	80	80	—	—

Table XXIV.

Development of Pit in One Case from Each Tree after Keeping for Six Days.

Pruning.	Apples in Case. No.	Clean. No.	Pitted. No.	Per cent. Pitted.
Severe	140	129	11	7·8
Light	139	137	2	1·4
Leader	154	153	1	·6
Unpruned	155	154	1	·6

The trees were planted in the winter of 1908, and are now producing sufficient fruit to show how the development of Pit is affected by different modes of pruning. The orchardist at Yanco Experiment Farm is able to give approximately the yield of the different trees, viz., severely pruned, 7 bushels; lightly pruned, 8½ bushels; leader pruned, 9 bushels; and unpruned, 10 bushels. And in accordance with the information derived from the windfalls, he found that trees 1 and 2 showed the greatest amount of Pit.

10.—At Government Experiment Orchard, South Australia.

The trees are now five and six years old, just at an age when they are beginning to bear, and during the next five years the comparative results should be instructive.

The three principal varieties of apples grown for export, at least in Victoria, are Jonathan, Rome Beauty, and Dunn's Favourite, and the effect of pruning and thinning on the development in such varieties should be particularly valuable.

At the present stage of the experiment Cleopatra is practically the only variety which has produced Pit to any extent, but the unpruned trees where the fruit was thinned and the crop very light were free from Pit.

The form of pruning applied is practically identical with what has been described as "light pruning" in the experiments conducted in other States.

Table XXV.

Tree No.	Variety.	Total Yield. lbs.	Pitted. lbs.	Per cent. Pitted.
1	Cleopatra	$86\frac{1}{2}$	$6\frac{1}{4}$	7·2
2	,,			
3	Dunn's Favourite	$99\frac{3}{4}$	—	—
4	,,			
5	Jonathan	$44\frac{3}{4}$	—	—
6	,,			
7	Scarlet Nonpareil	$64\frac{1}{4}$	2	3·1
8	,,			
1.—Pruned Every Year—Fruit Not Thinned. (Trees Planted August, 1910.)				
1	Cleopatra	41	$3\frac{3}{4}$	9·1
2	,,			
3	Dunn's Favourite	$115\frac{1}{2}$	—	—
4	,,			
5	Jonathan	$87\frac{3}{4}$	—	—
6	,,			
7	Scarlet Nonpareil	74	—	—
8	,,			
2.—Pruned Every Year—Fruit Thinned. (Trees Planted August, 1910.)				
1	Cleopatra	$24\frac{1}{4}$	$1\frac{1}{8}$	4·6
2	,,			
3	Dunn's Favourite	$162\frac{1}{4}$	—	—
4	,,			
5	Jonathan	$144\frac{3}{4}$	$\frac{3}{4}$	·51
6	,,			
7	Scarlet Nonpareil	$101\frac{1}{4}$	1	·98
8	,,			
3.—Never Pruned—Fruit Not Thinned. (Trees Planted August, 1910.)				
1	Cleopatra	$5\frac{1}{4}$	—	—
2	,,			
3	Dunn's Favourite	$16\frac{3}{4}$	—	—
4	,,			
5	Jonathan	$2\frac{1}{4}$	—	—
6	,,			
7	Scarlet Nonpareil	$5\frac{1}{2}$	$\frac{3}{4}$	13·6
8	,,			
4.—Never Pruned—Fruit Thinned. (Trees Planted August, 1910.)				

TABLE XXV.—*continued.*

5.—PRUNED EVERY WINTER AND SUMMER PRUNED. (TREES PLANTED AUGUST, 1909.)

Tree No.	Variety.	Total Yield. lbs.	Pitted. lbs.	Per cent. Pitted.
1	Rome Beauty	68	$1\frac{1}{8}$	1·6
2	,,			
3	Dunn's Favourite	136	—	—
4	,,			
5	Cleopatra	$61\frac{1}{2}$	5	8·1
6	,,			
7	Jonathan	$99\frac{1}{2}$	$\frac{1}{8}$	·1
8	,,			

6.—PRUNED FOR THREE YEARS, THEN EVERY SECOND WINTER ONLY. (TREES PLANTED AUGUST, 1909.)

1	Rome Beauty	$23\frac{3}{4}$	$\frac{3}{16}$	·8
2	,,			
3	Dunn's Favourite	$62\frac{3}{4}$	—	—
4	,,			
5	Cleopatra	$72\frac{1}{2}$	$2\frac{3}{4}$	4·0
6	,,			
7	Jonathan	108	—	—
8	,,			

PRUNING OF LONDON PIPPIN AND ROME BEAUTY AT RINGWOOD.

An orchardist at Ringwood had a row of London Pippins about ten years old, which were pruned very heavily in 1914. They were cut well back in order to encourage fruiting, and the result was that the trees yielded, on an average, $2\frac{1}{2}$ bushel cases. About 90 per cent., however, were affected with "crinkle," and the fruit as a whole was unmarketable.

In 1915 he adopted a system of very light pruning in order to test its effect on the yield and the amount of Pit. Fig. 42 gives a representation of one of the trees towards the end of April and when ready for picking. There was a very good crop for the size of the tree, which was about 14 feet high. The yield was 6 bushel cases picked off the tree, and $2\frac{1}{2}$ cases of windfalls. The fruit was of average size and marketable, and only eight apples were found pitted, weighing 26 ounces.

The treatment of the trees was similar in both seasons. A light dressing of stable manure was given, then sprayed with Red Oil for the Woolly Aphis, with Bordeaux Mixture for Black Spot, and two sprayings with arsenate of lead in October and December respectively for Codlin Moth.

The remarkable freedom from Pit or "crinkle" might be attributed to the nature of the season, but there were other varieties growing near which had been heavily pruned, such as Lord Wolseley (Fig. 44), and so badly pitted that only about 5 per cent. were clean. The photograph will convey some idea of the wholesale pitting of the fruit on this tree.

In the same orchard a Rome Beauty is shown (Fig. 43), which had been very lightly pruned for two seasons. In 1914 the leaders were simply topped, and the tree made good growth, but produced no fruit (see Report IV., Fig. 49). In 1915 the same system was followed, and the yield was three bushels off the tree and one bushel of windfalls, with only an occasional apple pitted.

PRUNING OF GANSEL'S BERGAMOT PEAR TREE AT BENDIGO.

The pear tree shown in Fig. 45 is nine years old. The heavy crop of nine bushel cases is seen to be produced on the laterals, and the efficacy of light pruning is illustrated.

At first this tree was heavily pruned and failed to produce a payable crop. Then the orchardist altered his method of pruning. For the last four years none of the laterals have been pruned, with the result that the tree has borne an abundant crop every year.

"SPORT" FROM WILLIAMS PEAR.

In the same orchard a very interesting "sport" has been produced on the main stem of a Williams Pear tree. The branch is shown in Fig. 46, bearing six pears. These pears are of a golden-brown colour, with a flesh quite similar in texture to Gansel's Bergamot, much similar in taste, but of more excellent flavour and keeping quality. The branch is now five years old, and has fruited for three years. It maintains its type in all the fruits produced, and is thus seen to be a true sport. I am indebted to Orchard Supervisor Cock for these two instructive photographs.

EFFECT OF PRUNING AT DIFFERENT SEASONS.

The effect of pruning the tree when dormant and when in full flower was tested on two apple trees of the Bismarck variety, growing alongside each other and of the same age, in the Burnley Horticultural Gardens. They were pruned lightly, the one on 18th July, and the other on 7th October, 1913, when in full flower. The result was that only a very few apples of relatively large size were produced on the winter-pruned tree, while the spring-pruned tree yielded a very light crop of small apples. The growth, however, was much better than that of the other, and the foliage was dense and dark green.

Next season the winter pruning was done on 23rd July, and the spring pruning on 19th October, 1914, when the tree was in full bloom. The fruit was picked on 4th February, 1915, and while the winter-pruned tree bore 62 apples, with 35 per cent. of Pit, the spring-pruned tree bore only one apple, which was clean. The two trees were again pruned lightly on 28th July and October, 1915, respectively. Unfortunately the winter-pruned tree died in November, so that only one tree remains, and no comparison can be made between the winter and spring pruned trees.

The results, however, may be given :—

Total Yield.	Clean.		Pitted.		Per cent. Pitted.
	On Trees.	Windfalls.	On Trees.	Windfalls.	
No.	No.	No.	No.	No.	
881	556	136	107	82	21

A similar experiment was carried out at Mr. Hatfield's orchard, Box Hill, with two Cleopatra apple trees of the same age and general vigour. The one was pruned towards the end of August, and the other late in October. Both trees bore a fair crop of fruit, and the apples on the spring-pruned tree were rather larger than on the other. In both cases there was a very large proportion of badly pitted apples, and there seemed to be no advantage gained by late pruning.

ROOT PRUNING.

No systematic experiments with root pruning have been carried out, since in our variable climate and in cases where the orchard is dependent on the natural rainfall, there is a danger of root-pruned trees suffering at a critical period of their growth from want of water. There is a risk, therefore, of losing the tree, or at least of a set-back in its growth.

However, an apple tree of the Bismarck variety was used for the purpose at Burnley Horticultural Gardens. It is now about fifteen years old, and was rooted out in June, 1912, in order to show the nature and spread of the root system as compared with the shoot system (Report I., Fig. 133). Then after cutting back the roots to within three feet of the trunk, the tree was re-planted.

In June, 1913, it flowered abundantly, but, as might have been anticipated from the unusual time of flowering, no fruit was produced. It was then pruned lightly in July, 1914, and flowered from the 5th to 19th October, but owing to the exceptional drought no fruit set. The tree produced

abundance of foliage, and had a healthy appearance. It was heavily pruned in July, 1915, and the fruit was picked on 16th March, 1916, with the following result :—

Total Yield.	Clean. On Tree.	Clean. Windfalls.	Pitted. On Tree.	Pitted. Windfalls.	Per cent. Pitted.
No.	No.	No.	No.	No.	
181	132	38	6	5	6

Considering the treatment to which this tree was subjected, the recovery was good, and in some instances as much as a foot of new wood was added during the season's growth. The amount of Pit is much reduced, compared with other trees of the same variety in the orchard treated in the ordinary way.

PRUNING TO BUDS AT DIFFERENT ANGLES.

In order to test the effect on the growth of the bud of pruning a leader so that the cut was towards the bud, away from the bud, and level with the bud respectively, a Cleopatra tree was chosen, in which the leaders had made average growth. Each of three leaders of equal vigour was pruned accordingly on 28th August, and the tree did not flower.

The growth made by the leaders pruned at different angles was determined in July, 1916, and the best growth was made where the cut was away from the bud, while the poorest growth was made where the cut was down towards the bud. The best cut is evidently one which leads up to the bud and leaves sufficient wood around it to supply nourishment without leaving any dead wood for rot to set in.

A simple experiment like this throws light upon the movement of the sap by means of the resulting growth. It is evident that the amount of sap varies, according to the angle at which it traverses the wood. Where the bud was at the highest point of the leader the growth was greatest, because the sap travels fastest on upright lines, and where the movement was horizontal there was a less amount of sap and less growth. Further, there will be a greater pressure of the sap in the perpendicular or upright shoot, just as the river in flood, with its greater volume of water, exercises more force than when following its normal course.

LATERALS IN THEIR RELATION TO BITTER PIT.

The fruit-growing laterals previously selected all bore fruit this season, although generally in small quantities (Figs. 50-58).

The following table shows the relative amount of Pit, as compared with that on the rest of the tree :—

TABLE XXVI.

LATERALS OF APPLE TREES, SHOWING YIELD AND AMOUNT OF PIT.

Variety.	Age of Lateral.	Yield.	When Gathered.	Clean.	Pitted.	Per cent. Pitted.	Crop on Tree.	Pit on Tree. Per cent.
Pomme de Neige ..	3 seasons	14	March 9	11	3	21	Fair	3
Boston Russet ..	4 ,,	8	,,	8	—	—	Good	—
Shockley	4 ,,	7	,,	5	2	28	Good	40
Rhode Island Greening	3 ,,	5	,,	5	—	—	Good	1
Statesman	3 ,,	5	,,	5	—	—	Good	4
Reinette du Canada	4 ,,	5	,,	5	—	—	Fair	—
London Pippin ..	4 ,,	12	,,	11	1	8	Good	4
Yates	4 ,,	12	,,	12	—	—	Fair	—
Crow's Egg	4 ,,	5	,,	5	—	—	Fair	50
Swaar	4 ,,	22	,,	18	4	18	Heavy	1
Stayman's Winesap	4 ,,	13	,,	13	—	—	Heavy	—
Jonathan	4 ,,	12	,,	12	—	—	Heavy	1

This is the third season during which the laterals have been observed in fruit. They were described and photographed in February, 1914 (Report III., Figs. 10-22). The fruit on the laterals in each of the varieties was free from Pit, although in some instances the rest of the tree was badly affected, as in Shockley and Crow's Egg.

Owing to the failure of the crop in 1915, only one of the laterals bore fruit, and of the two apples one was clean and one pitted. During the past season, as the table shows, the lateral of every variety produced fruit, and out of twelve varieties eight were free from Pit and four affected. In some instances, as in Crow's Egg, the tree was badly affected, while the fruit on the lateral was clean, and in other cases the fruit on the lateral, as well as on the rest of the tree, was pitted.

Shockley is a variety very subject to Pit, and the fruit on the tree was carefully picked on 9th March in order to compare with that on the lateral.

	No. of Fruits.	Clean.	Pitted.	Per cent. Pitted.
Lateral	7 ..	5 ..	2 ..	28
Rest of Tree	732 ..	442 ..	290 ..	40

Of course, even on a lateral when the yield is very light Pit may develop, and the varying results obtained in the three seasons during which the experiment was conducted show, that a longer period of time is necessary to arrive at final conclusions.

C.—EXPERIMENTS WITH STOCKS.

Just as the soil has an influence upon the plant which is dependent upon it for supplies, so the stock may be supposed to influence the scion growing upon it. But just what that influence consists in and how it manifests itself has not been accurately determined. We know that the Paradise stock produces a dwarfing effect on the graft, because the stock itself is naturally of small stature, and that Wild Crab apple and pear stocks favour the formation of strong woody shoots. Generally, however, there is some subtle influence exerted, but in what direction it is not always easy to trace, and a number of experiments have been initiated in the definite direction of testing, if the stock influences the development of Bitter Pit in any given variety.

It would be both misleading and premature to draw any conclusions as to whether the disease is likely to be influenced by the stock, from the limited time during which the experiments have been carried on. Simultaneous experiments on similar lines in each of the States would require to be continued for a number of years in order to supply reliable data.

While the main point to be determined is the influence of the stock upon the development of Bitter Pit, attention will be given at the same time to the relative yield of fruit and the relative size of the trees. The influence of the stock upon the growth of the tree, the yield of fruit, and the amount of Pit will thus be shown relatively to each other.

11.—At Burnley Horticultural Gardens, Victoria.

(1) Bark-grafting of Liable Varieties on Blight-proof Stocks.—Originally six stocks were selected in 1911, but only three have survived (the other three dying from an attack of Root Rot), and the results of grafting on these is shown in the following table :—

Table XXVII.

Blight-proof Stocks with Grafts Liable to Bitter Pit.

Stocks.	Grafts.	Fruits. No.	Clean.	Pitted.	Per cent. Pitted.	Remarks.
Coral Crab	.. ..	—	—	—	—	
	Cleopatra	—	—	—	—	2 grafts; growth very poor
	Annie Elizabeth ..	—	—	—	—	Dead
	Cox's Orange Pippin	—	—	—	—	Dead
	Bismarck	—	—	—	—	Dead

TABLE XXVII.—BLIGHT-PROOF STOCKS WITH GRAFTS LIABLE TO BITTER PIT.—*continued.*

Stocks.	Grafts.	Fruits. No.	Clean.	Pitted.	Per cent. Pitted.	Remarks.
Lord Wolseley		248	68	180	72	
	Cleopatra	—	—	—	—	Dead
	Annie Elizabeth ..	—	—	—	—	Dead
	Cox's Orange Pippin	27	13	14	52	1 graft ; growth good
	Bismarck	1	—	1	—	1 graft; growth very poor
Northern Spy		Light crop	—	—	—	About one-half pitted
	Cleopatra	1	1	—	—	1 graft ; growth fair
	Annie Elizabeth ..	—	—	—	—	2 grafts; growth medium
	Cox's Orange Pippin	—	—	—	—	2 grafts ; growth strong
	Bismarck	—	—	—	—	1 graft ; growth fair

The only graft which yielded a fair supply of fruit was that of Cox's Orange Pippin on Lord Wolseley. Both stock and scion were badly affected with Bitter Pit, although Cox's Orange Pippin on Northern Spy stock, grown in the general orchard and observed for four years in succession, was only slightly affected, as shown in Report IV., Appendix II.

(2) VARIETIES ON VARIOUS STOCKS, PLANTED IN BIRD-PROOF ENCLOSURE.—The trees are now in their fifth year from planting, with four exceptions which are in their third year, and a few of them are beginning to bear a fair amount of fruit. During the next five years there should be abundance of fruit produced, and it will be interesting to trace the influence of the various stocks on the yield of fruit and amount of Pit (Figs. 61-66).

At present no conclusions of any value can be drawn, since the trees are still comparatively young and have not yet attained to their final shape, nor have they as yet produced a sufficient amount of strong and vigorous fruit-bearing wood. While the experiments with stocks were undertaken primarily to test the effect of the stock on the tree, with regard to the development of Bitter Pit, there are many other points of interest observed at the same time. The effect of the stock on flowering, on fruiting, on the vigour of the tree, etc., are all noted, but the main points to be determined are which stocks are associated with the least pitting and the largest yield, as well as the most vigorous tree. When the trees have reached the age of ten years at least, results of some value should be available for settling these points.

Since the majority of the trees have now fruited, it was possible to check the naming of the varieties from the nature of the fruit. It was found that four varieties which had been obtained from outside sources were wrongly named. No. 19 is Scarlet Nonpareil ; No. 25, Reinette du Canada ; No. 28, Rome Beauty ; and No. 52, Boston Russet. Seven of the varieties planted have failed to produce fruit, even although six of them are now in their fifth year.

The blooming periods for 1915 are not available, because it had not been decided to continue the experiments before the beginning of 1916. The period of first bloom indicates when the first flower had fully opened, full bloom when all the flowers had opened, and finished bloom when all the petals had fallen.

The pruning has been done throughout by the Principal of the School of Horticulture, and the trees were thus trained on a definite plan. They were pruned on 19th July for the coming season, and the object kept in view was to get as much fruit as possible in order to test the liability to Pit.

The pruning was generally light, and when heavy it was done either to encourage growth which was poor or to correct the shape of a one-sided tree. In some instances the tree had made such poor growth that the stock was evidently unsuitable under the given conditions. Such trees are marked with an asterisk (*).

The following table gives the results for 1916, and the relative growth is also stated, based upon the amount of wood formed during the season, being as much as three feet in some instances :—

TABLE

VARIETIES ON VARIOUS STOCKS

No.	Variety.	Stocks.	When Planted.	Fruits Gathered.	CLEAN. On Tree.	CLEAN. Wind-falls.	PITTED. On Tree.	PITTED. Wind-falls.	Per cent. Pitted.
				No.	No.	No.	No.	No.	
1	Sturmer Pippin ..	Winter Majetin ..	23/8/11	2	1	1	—	—	—
*2	Cox's Orange Pippin ..	,, ...	,,	7	3	4	—	—	—
3	,, ..	Paradise on Spy ..	,,	173	51	45	22	55	44
4	Blenheim Orange ..	Spy	,,	13	—	3	1	9	77
5	Ribston Pippin ..	,, ...	,,	27	10	16	—	1	3
6	King David	,, ...	,,	79	60	15	1	3	5
7	Bismarek	Paradise on Spy ..	,,	103	49	26	18	10	27
8	,, ...	Spy	,,	93	32	34	10	17	29
9	Cleopatra	,, ...	,,	96	32	13	26	25	53
10	,, ...	Yarra Bank	,,	83	30	13	12	28	48
11	,, ...	,, ...	,,	134	62	38	18	16	25
12	,, ...	Duchess of Oldenburg	,,	80	13	22	12	33	56
13	Annie Elizabeth ..	Spy	,,	6	—	—	6	—	100
14	Esopus Spitzenberg ..	Magg's Seedling ..	,,	34	18	12	1	3	12
15	Annie Elizabeth ..	,, ..	,,	4	2	—	2	—	50
16	Clerome (Cleopatra × Rome Beauty) ..	Annie Elizabeth on Yarra Bank ..	..	63	23	26	2	12	22
17	Annie Elizabeth ..	Yarra Bank ..	..	4	2	—	2	—	50
18	Esopus Spitzenberg ..	Winter Majetin ..	,,	5	3	1	1	—	20
*19	Scarlet Nonpareil ..	Cole's Paradise ..	,,	14	13	1	—	—	—
20	Reinette du Canada ..	,, ..	,,	10	4	6	—	—	—
21	Jonathan	,, ..	,,	28	22	4	—	2	7
22	Cleopatra	,, ..	,,	4	—	—	—	4	100
23	Rome Beauty	,, ..	,,	20	11	7	2	—	10
24	Gravenstein	,, ..	,,	No bloom	—	—	—	—	—
25	Reinette du Canada ..	,, ..	,,	11	6	5	—	—	—
*26	Rokewood	,, ..	,,	9	8	1	—	—	—
27	Cleopatra	Winter Majetin ..	,,	6	2	—	3	1	66
28	Rome Beauty	London Pippin Seedling	,,	8	7	—	1	—	12
29	Jonathan	,, ..	,,	1	1	—	—	—	—
30	Benoni	Cole's Paradise ..	,,	No bloom	—	—	—	—	—
31	Duke of Clarence ..	,, ..	,,	2	1	1	—	—	—
32	Kennerley's May ..	,, ..	,,	18	7	7	2	2	22
33	Statesman	,, ..	,,	5	4	1	—	—	—
34	American Mother ..	,, ..	,,	13	1	7	—	5	38
35	Yapeen	,, ..	,,	1	1	—	—	—	—
36	Scarlet Summer Pearmain	,, ..	,,	6	—	4	—	2	33
37	Cleopatra	Magg's Seedling ..	,,	30	6	13	2	9	36
38	Sturmer Pippin ..	,, ..	,,	38	35	3	—	—	—
39	Dunn's Favourite ..	,, ..	,,	16	12	3	1	—	6
40	Annie Elizabeth ..	,, ..	,,	1	1	—	—	—	—
41	Cox's Orange Pippin ..	,, ..	,,	64	49	9	2	4	9
42	Newtown Pippin ..	London Pippin Seedling	,,	No bloom	—	—	—	—	—
43	Yates	,,	,,	42	36	6	—	—	—
44	Annie Elizabeth ..	Siberian Crab on Spy	26/7/13	2	—	—	2	—	100
45	Cleopatra	Seedling (unknown)	,,	No bloom	—	—	—	—	—
46	,, ...	Perfection on Spy ..	23/8/11	2	1	—	—	1	50
47	,, ...	,, ...	,,	8	1	1	2	4	75
48	Dumelow	Spy	,,	14	7	2	4	1	36
49	Cleopatra	,, ...	,,	36	12	13	6	5	31
50	French Crab	,, ...	,,	No fruit	—	—	—	—	—
51	Blenheim Orange ..	,, ...	,,	No fruit	—	—	—	—	—
52	Boston Russet	,, ...	,,	13	2	11	—	—	—
53	Duchess of Oldenburg	,, ...	,,	No bloom	—	—	—	—	—
54	Prince Alfred	,, ...	,,	7	3	3	—	1	14
*55	Cleopatra	Siberian Crab on Spy	26/7/13	11	5	3	1	2	27
56	Jonathan	,,	,,	9	9	—	—	—	—

PLANTED IN BIRD-PROOF ENCLOSURES.

How Worked.	Growth.	Pruning.	1913.			1914.			1916.		
			First Bloom.	Full Bloom.	Final Bloom.	First Bloom.	Full Bloom.	Final Bloom.	First Bloom.	Full Bloom.	Final Bloom.
Budded	Fair	Light			16/10	3/10	5/10	12/10	7/10	12/10	17/10
,,	Poor	Heavy			15/10	3/10	6/10	17/10	26/9	10/10	12/10
Grafted	Very good	Light		15/10	28/10	3/10	16/10	23/10	2/10	14/10	17/10
Budded	Excellent	,,	—			—			7/10	14/10	17/10
Grafted	Good	,,		15/10	25/10	5/10	12/10	27/10	19/9	10/10	14/10
Budded	Very good	,,	—			9/10	14/10	23/10	10/10	14/10	19/10
Grafted	Good	,,		15/10	25/10	3/10	15/10	27/10	7/10	14/10	17/10
Budded	,,	,,		16/10	3/11	9/10	14/10	23/10	6/10	14/10	21/10
,,	Very good	,,		16/10		1/10	6/10	20/10	26/9	10/10	12/10
,,	,,	,,			28/10	—			20/9	7/10	10/10
,,	Good	,,			25/10	3/10	6/10	12/10	19/9	7/10	10/10
,,	,,	,,			22/10	1/10	6/10	12/10	20/9	7/10	10/10
,,	Fair	,,	—			—			21/10	4/11	7/11
,,	Good	,,			16/10	—			12/10	15/10	17/10
,,	Medium	Heavy	—			—			2/11	4/11	7/11
Grafted	Good	Light	—			5/10	9/10	20/10	6/10	14/10	17/10
,,	Fair	,,	—			—			9/11	15/11	19/11
Budded	Very good	,,	—			6/10	9/10	14/10	26/9	14/10	17/10
Grafted	Very poor	Heavy	—		16/10	6/10	9/10	12/10	5/10	7/10	10/10
Budded	Very good	Light	—			—			12/10	19/10	21/10
Grafted	Medium	,,	—			—			10/10	12/10	14/10
Budded	Very good	,,	15/10			—			26/9	10/10	17/10
Grafted	Good	,,	—			—			12/10	28/10	4/11
Budded	Very good	,,	—			—			—		
Grafted	,,	,,	—			—			7/10	21/10	24/10
Budded	Poor	Heavy		16/10	18/10	—			—		
,,	Very good	Light	—			—			5/10	10/10	12/10
,,	,,	,,	—			—			10/10	19/10	21/10
,,	,,	,,	—			—			5/10	10/10	12/10
,,	,,	,,	—			—			—		
,,	Medium	,,			16/10	—			28/9	10/10	12/10
,,	Good	,,	—			—			20/9	12/10	14/10
,,	,,	,,	—			—			—		
,,	,,	,,	—			—			—		
,,	,,	,,	—			—			8/10	10/10	12/10
,,	Medium	,,	—			5/10	7/10	12/10	5/10	10/10	12/10
,,	Good	,,			16/10	1/10	3/10	5/10	26/9	5/10	7/10
,,	Medium	,,	—			3/10	12/10	20/10	8/10	10/10	12/10
,,	Good	,,	—			—			—		
,,	,,	,,	—			—			—		
,,	Very good	,,		16/10	28/10	10/10	16/10	24/10	—		
Grafted	,,	,,	—			—			—		
Budded	Good	,,	—			—			5/10	10/10	12/10
Grafted	Medium	,,		16/10	—				12/11	19/11	22/11
Budded	Very good	Heavy	—			—			—		
Budded on Perfection	Good	Light	—			—			28/9	10/10	12/10
,,	,,	,,	—			—			5/10	10/10	12/10
Budded	,,	,,	15/10	22/10		—			9/10	17/10	19/10
,,	,,	,,		20/10		—			1/10	7/10	10/10
,,	Very good	,,		16/10		—			—		
,,	Very strong	,,	—			—			—		
,,	Poor	,,		18/10		3/10	12/10	20/10	2/10	7/10	10/10
,,	Medium	Heavy		16/10		3/10	7/10	12/10	30/9	5/10	7/10
,,	Poor	Medium			18/10	3/10	11/10	15/10	26/9	12/10	17/10
Grafted	Very poor	Heavy	—			3/10	10/10	12/10	7/10	10/10	12/10
,,	Poor	Medium	—			—			12/10	17/10	19/10

The blooming season is reckoned from the date of the first bloom up to the end of the final bloom, when the petals have all fallen. The first date of bloom was 19th September (Ribston Pippin and Cleopatra). The last date of the first bloom was 12th November (Annie Elizabeth). The shortest season of blooming was four days (Jonathan, Yapeen, and Sturmer Pippin), and the longest twenty-five days (Ribston Pippin). The blooming season of apples in the screen extended from 19th September to 22nd November, and averaged twelve days.

The value of the data obtained from the period of blooming may be shown in various ways.

The early and late blooming varieties can be planted in that portion of the orchard most suitable for them.

For purposes of cross-pollination, it is evident that only those sorts which bloom about the same time should be inter-planted. There are some orchard operations which depend upon the time of blooming and the dropping of the petals, so that labour may be economized, by planting varieties together which require to be sprayed about the same time.

Lastly, there is a scientific value attaching to the determination of the blooming period, for it may be shown that the stock has a determining influence upon the time of blooming, and thus be one of the factors causing variations in the same variety.

THE SAME VARIETY ON DIFFERENT STOCKS FOR COMPARISON.

The same variety is usually grown on different stocks for comparison, and an example may be given of Cleopatra, which is grown on nine different stocks as follows :—

TABLE XXIX.

CLEOPATRA ON DIFFERENT STOCKS, SHOWING YIELD AND PER CENT. OF PIT.

No.	Stock Used.	Yield. No.	Per cent. Pitted.
9	Northern Spy—*a*	96	53
49	,, *b*	36	31
10	Yarra Bank—*a*	83	48
11	,, *b*	134	25
12	Duchess of Oldenburg	80	56
22	Cole's Paradise	4	100
27	Winter Majetin	6	66
37	Magg's Seedling	30	36
45	Seedling (unknown)	—	—
46	Perfection on Spy—*a*	2	50
47	,, ,, *b*	8	75
55	French Crab on Spy	11	27

The most striking feature in this table is the great variation in the yield, and the only one producing more than 100 apples is that on the Yarra Bank stock. It is the second highest yield of all the varieties, and the smallest amount of Pit, but the results of this one season allow no final conclusions to be drawn.

VARIETIES BARREN.

During season 1914-15, out of fifty-four varieties only eight yielded fruit, while during the past season the majority fruited, and only seven were barren. All of the barren varieties were budded with the exception of Newtown Pippin, and it is generally found that grafts come into bearing earlier than buds. The Duchess of Oldenburg was the only one of the seven which had produced fruit previously (up to four apples at the most), and it was rather unexpected that in a prolific season like this it should be altogether barren.

In the case of Blenheim Orange there are two trees of this variety, both on the Spy stock, and while one is barren, the other has produced thirteen apples. Both are budded on similar stocks,

so that the non-bearing is not due to the nature of the stock. In 1915 the Blenheim Orange which has fruited was the most luxuriant-growing tree in the screen, and this season it still maintains its superiority.

RELATIVE SIZE OF THE TREES.

The most luxuriant-growing tree in 1915 was considered to be Blenheim Orange on Spy (No. 4), which, however, bore no fruit. In 1916 four trees were selected of the same age and apparently similar in growth, all of which bore a small amount of fruit, with the exception of French Crab.

It is no easy matter to determine accurately the size of a growing tree, since there are so many factors entering into the calculation which cannot be properly estimated. I have, however, taken as a basis the three principal factors of the girth of the stem, the height of the tree, and the spread of the branches, and by taking the mean of these three measurements an approximate result is obtained.

Applying this test to the four trees selected, the following table gives the results as determined on 1st June :—

TABLE XXX.

MEASUREMENT OF HEIGHT OF TREE, SPREAD OF BRANCHES, AND GIRTH OF STEM.

No.	Variety.	Stock.	Height.	Spread.	Girth.	Mean.
4	Blenheim Orange	Spy	(108 ins.) 100	(90 ins.) 100	(8 ins.) 100	100
50	French Crab	Spy	(108 ins.) 100	(53 ins.) 59	($7\frac{1}{2}$ ins.) 94	84
22	Cleopatra	Cole's Paradise	(108 ins.) 100	(63 ins.) 70	($5\frac{5}{8}$ ins.) 70	80
27	Cleopatra	Winter Majetin	(102 ins.) 94	($46\frac{1}{2}$ ins.) 52	($6\frac{1}{8}$ ins.) 77	74

The Blenheim Orange is taken as the standard, because the three measurements are highest in this variety, and the actual measurements in inches are given in brackets. It will be seen in future years which of these varieties shows the greatest variation and whether the increase in size is most marked in height or spread of tree or diameter of stem.

(3) CLEOPATRA BUDDED AND GRAFTED ON TO PEAR STOCK.—The object of this experiment is to test practically whether a stock non-liable to Bitter Pit will influence the scion of a susceptible variety so that it will produce fruit free from the disease. There is a difficulty in getting a blight-proof and non-susceptible variety of apple, and since the pear is generally free from the disease in the Burnley Horticultural Gardens, it was chosen as a stock.

There are two top-grafted trees of Cleopatra, grafted in September, 1914, and planted out in July, 1915, one of which is much superior to the other. The tree which has made the poorest growth, has produced one fruit, and when examined fully half-grown there was no external sign of Pit. When ready for picking in March, however, four pits had developed on one side.

Only one Cleopatra, budded on to a seedling pear in February, 1914, grew, and made but poor growth. However, it has produced one fruit, which developed one pit. In the early stages of growth at least, a stock which is non-liable does not confer immunity on the scion of a susceptible variety, whether budded or grafted (Fig. 69).

(4) VARIETIES ON THEIR OWN ROOTS.—The three varieties of Gravenstein, Magg's Seedling, and Winter Majetin were planted out on their own roots on 13th July, 1913. The Northern Spy has now been added to the list for comparison, since it is almost universally used as a stock, and was planted out in July, 1916.

The object of this experiment is mainly to test the assertion so frequently made that varieties grown on their own roots are free from Bitter Pit.

Gravenstein.—There are six trees of this variety, and the growth is fairly equal throughout. They have all made satisfactory growth, and reached an average height of $3\frac{1}{2}$ feet three years from planting.

It is a peculiarity of this tree, and some even consider it a hereditary quality, that it produces a ribbed and fluted trunk, and the branches are twisted and deformed. It is noticeable in each of these young trees on their own roots that there is no appearance of wrinkling, and the branches are regular without any twisting.

Magg's Seedling.—There are three trees of this variety, and all are growing well. They have reached an average height of three feet.

Winter Majetin.—There are two trees of this variety, one growing remarkably well, and the other not so far advanced. The average height is about three feet.

(5) Crab Stocks.—The stocks used for apples belong to two groups, standard and dwarfing stocks, and in each of these groups there are several more or less distinct forms. We are only concerned here with the standard stocks. For standard trees there are at least two kinds of stocks: those grown from seeds of wild apples and seedlings of cultivated varieties. They are both derived from the common apple, *Pyrus malus.* The Crab stock should be derived from the Wild Crab apple, but, as a matter of fact, many trees are sent out by nurserymen as being on the Crab stock while they are really on the so-called "free" stock, *i.e.*, stock raised from pips of any sort of apples. The necessity for and importance of studying the Wild Crab apple in its relation to Bitter Pit, both as a stock and a cross with cultivated varieties, and also for pollination, was recognized at the outset of this investigation. In order to make certain that the seedlings used were from wild trees, I had pips sent out from Britain. Stocks of the Wild Crab apple were sent at the same time, and both arrived here in good condition during May, 1916.

The seeds were planted in a cold frame, and one of the young seedlings is shown in Fig. 70.

The seedlings were planted out on 18th October, and should be of sufficient size for budding and grafting next season. The stocks were kept in the nursery, and planted out on 6th July. A Wild Crab apple fruited in these gardens years ago, but it was rooted out. Although not blight-proof, there was very little Woolly Aphis upon it.

The Crab stocks were supplied by the Royal Nurseries, Sheffield, England, and the Managing Director writes as follows:—"With reference to your query as to the Wild Crab stock being blight-proof, we should say not. The Northern Spy stock you mention is not used in Britain. The Wild Crab stock is in favour here for standard orchard trees."

12. Influence of Stock on Scion as regards Pit at Campbell's Creek, Victoria.

This experiment was designed to test the effect of grafting from a tree badly affected with Bitter Pit on to a tree of the same variety which had never produced Pit, and the reverse. Two varieties of pear tree were found fulfilling these conditions, viz., Josephine and Winter Nelis, and they were grown on seedling stocks. In one orchard two Josephine pear trees were selected. The one bore badly pitted fruit, although otherwise perfectly healthy; and the other, planted at the same time in the same row, had never been known to produce pitted fruit according to the orchardist, although about eighteen years old.

In another orchard adjoining, the variety Winter Nelis was selected. One tree was specially liable to Pit, as in the year preceding the experiment it bore between three and four cases of fruit, and every pear was pitted. The second tree in another portion of the orchard had never produced pitted fruit. The grafting was done in September, 1912, when the buds were swelling, and was more or less successful in every instance. This was the first season in which fruit was produced on any of the grafts, with the exception of two pears on No. 2 Josephine graft in 1914, and the results are shown in the following table of an examination made on 1st March, 1916, along with the Orchard Supervisor, Mr. Cock:—

TABLE XXXI.

RESULTS OF GRAFTING FROM PIT-FREE ON TO PIT-PRODUCING TREES, AND THE REVERSE.

No.	Variety of Pear.	Pitted or Free.	Source of Graft.	Results.
1	Josephine ..	Pitted ..	Tree free from Pit (supposed) ..	10 Pears—4 clean and 6 pitted. Tree with very light crop and a large proportion badly pitted.
2	Josephine ..	Free in 1913 (pitted in 1914)	Tree with pitted fruit	8 Pears—all clean. Tree with medium crop and no sign of Pit. Two pitted pears were produced on graft in 1914, when the tree itself bore pitted fruit.
3	Winter Nelis	Pitted ..	Tree free from Pit ..	7 Pears—all clean. Tree with very light crop and one pear pitted.
4	Winter Nelis	Free ..	Tree with pitted fruit	No fruit. Tree with light crop and no Pit.

Although the experiment has been continued for four seasons—1912-13 to 1915-16—it is only during the past season that the grafts have borne fruit of any consequence. In the first season there was no fruit; in the second season only two pitted pears were produced on the No. 2 Josephine graft; in the third season there was no fruit on any of the grafts, owing to the drought; and in the last season fruit was produced on the various grafts, with the exception of that on No. 4 Winter Nelis.

As regards the Josephine pear trees, when the graft from the supposed non-liable tree was worked on to a liable tree, there was 60 per cent. of Pit, but since the supposed non-liable tree from which the graft was taken had 69 per cent. of Pit in 1914, the results have no value.

In the case of the Winter Nelis variety, the grafts from the non-liable tree bore seven pears, all clean; while the liable tree on which it was grafted had only a very light crop and one fruit pitted. *So that, as far as this experiment has gone, there is no definite indication that the graft or scion is influenced by the stock on which it is worked, as regards Pit.*

13.—AT GOVERNMENT EXPERIMENT ORCHARD, BLACKWOOD, SOUTH AUSTRALIA.

The stock tests initiated by Mr. Quinn are arranged in three series, and date from August, 1908, 1910, and 1911 respectively. They are arranged on such a definite plan and have such a judicious combination of stocks that they cannot fail to yield results of the highest value.

TABLE XXXII.

TESTING THE INFLUENCE OF DIFFERENT STOCKS ON THE DEVELOPMENT OF PIT—1915-16.

SERIES 1.—NORTHERN SPY ROOTS WITH INTERMEDIATE STOCKS.

No.	Variety.	Stocks.	Total Yield.	CLEAN.		PITTED.		PER CENT. PITTED.		Per cent. Pitted.
				Off Trees.	Wind-falls.	Off Trees.	Wind-falls.	Off Trees.	Wind-falls.	
			lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz.	lbs oz.			
1	Baldwin	Dunn's Favourite on Spy ..	14–2	10–11	—	3–4	0–3	23·3	100·0	24·3
2	Baldwin	Rokewood on Spy	2–2	1–0	0–2	1–0	—	50·0	—	47·0
3	Baldwin	Spy	—							—
4	Cleopatra	Dunn's Favourite on Spy ..	62–11	56–11	1–11	4–0	0–5	6·5	15·6	6·8
5	Cleopatra	Rokewood on Spy	40–2	34–11	1–14	3–6	0–3	8·8	9·9	8·8
6	Cleopatra	Spy	25–2	16–7	1–1	6–3	1–7	27·3	57·5	30·3
7	Cleopatra (Q.) ..	Dunn's Favourite on Spy ..	37–8	29–7	1–6	6–2	0–9	17·2	29·0	17·8
8	Cleopatra (Q.) ..	Rokewood on Spy	89–10	72–13	0–14	14–11	1–4	16·7	58·8	17·7

TABLE XXXII.—SERIES 1.—TESTING THE INFLUENCE OF DIFFERENT STOCKS, ETC.—*continued.*

No.	Variety.	Stocks.	Total Yield.	Clean. Off Trees.	Clean. Wind-falls.	Pitted. Off Trees.	Pitted. Wind-falls.	Per cent. Pitted. Off Trees.	Per cent. Pitted. Wind-falls.	Per cent. Pitted.
			lbs. ozs.	lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz.			
9	Cleopatra (Q.) ..	Spy	149–7	112–2	1–6	35–0	0–15	23·7	40·5	24·0
10	Esopus Spitzenberg	Dunn's Favourite on Spy ..	44–3	38–12	1–12	3–6	0–5	8·0	15·1	8·3
11	Esopus Spitzenberg	Rokewood on Spy	53–10	45–10	4–8	2–10	0–14	5·7	16·2	6·5
12	Esopus Spitzenberg	Spy	8–3	5–8	1–13	—	0–14	—	32·5	10·6
13	Jonathan	Dunn's Favourite on Spy ..	44–7	43–12	0–11	—	—	—	—	—
14	Jonathan	Rokewood on Spy	49–9	48–5	1–4	—	—	—	—	—
15	Jonathan	Spy	77–1	75–0	2–1	—	—	—	—	—
16	Shockley	Dunn's Favourite on Spy ..	65–6	52–10	0–14	11–3	0–11	17·5	44·0	18·1
17	Shockley	Rokewood on Spy	43–2	27–14	0–6	14–7	0–7	34·1	53·8	34·4
18	Shockley	Spy	12–12	8–2	—	4–10	—	36·2	—	36·2

Jonathan is the only variety free from Pit, and this is irrespective of the stocks.

The highest percentage of Pit was found in Baldwin, and the next highest was Shockley.

It is rather a striking result that in every instance the varieties on Northern Spy roots alone, without any intermediate stock, were the worst affected. Cleopatra on Spy also gave the highest yield, 149 lbs.

The Cleopatra trees marked (Q) are special. The scions from which these trees were worked were obtained from an old stunted tree in Mr. Quinn's private garden, the fruit of which, up to the time of working the test trees, had not been known to have had Pit. Afterwards, however, when stimulated by tillage and water, it produced larger-grade apples, very much affected by Bitter Pit.

SERIES 2.—PARADISE, WINTER MAJETIN, AND NORTHERN SPY ROOTS AND COMBINATIONS.

No.	Variety.	Stocks.	Total Yield.	Clean. Off Trees.	Clean. Wind-falls.	Pitted. Off Trees.	Pitted. Wind-falls.	Per cent. Pitted. Off Trees.	Per cent. Pitted. Wind-falls.	Per cent. Pitted over all.
			lbs. oz.	lbs oz.	lbs. oz.	lbs. oz.	lbs. oz.			
19	Baldwin	Paradise ..	—							
20	Baldwin	Paradise on Spy	0–13	—	—	0–5	0–8	100	100	100
21	Baldwin	Winter Majetin	—							
22	Baldwin	Winter Majetin on Spy ..	—							
23	Cleopatra	Paradise ..	0–9	—	0–9	—	—	—	—	—
24	Cleopatra	Paradise on Spy	22–4	17–5	—	4–15	—	22·1	—	22·1
25	Cleopatra	Winter Majetin	5–10	5–1	—	0–9	—	10	—	10
26	Cleopatra	Winter Majetin on Spy ..	—							
27	Cleopatra (Q.) ..	Paradise ..	16–14	13–4	—	3–0	0–10	18·4	100	21·4
28	Cleopatra (Q.) ..	Paradise on Spy	12–9	11–0	0–5	0–14	0–6	7·3	54·5	9·9
29	Cleopatra (Q.) ..	Winter Majetin	6–12	6–12	—	—	—	—	—	—
30	Cleopatra (Q.) ..	Winter Majetin on Spy ..	5–12	5–0	0–12	—	—	—	—	—
31	Esopus Spitzenberg	Paradise ..	1–13	1–13	—	—	—	—	—	—
32	Esopus Spitzenberg	Paradise on Spy	0–5	—	0–5	—	—	—	—	—
33	Esopus Spitzenberg	Winter Majetin	3–0	2–6	—	0–10	—	20·8		20·8
34	Esopus Spitzenberg	Winter Majetin on Spy ..	0–5	—	—	—	0–5	100	—	100
35	Jonathan	Paradise ..	15–8	13–12	1–4	—	0–8	—	28·5	3·2
36	Jonathan	Paradise on Spy	7–3	6–10	0–9	—	—	—	—	—
37	Jonathan	Winter Majetin	—							

TABLE XXXII.—SERIES 2.—PARADISE, ETC., ROOTS AND COMBINATIONS—*continued.*

No.	Variety.	Stocks.	Total Yield.	CLEAN. Off Trees.	CLEAN. Wind-falls.	PITTED. Off Trees.	PITTED. Wind-falls.	PER CENT. PITTED. Off Trees.	PER CENT. PITTED. Wind-falls.	Per cent. Pitted over all.
			lbs. ozs.	lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz.			
38	Jonathan	Winter Majetin on Spy ..	3–11	3–5	0–6	—	—	—	—	—
39	Shockley	Paradise ..	4–8	2–13	—	1–11	—	37·5	—	37·5
40	Shockley	Paradise on Spy	7–1	4–7	0–2	2–6	0–2	34·8	50·	35·3
41	Shockley	Winter Majetin	2–10	1–13	—	0–13	—	30·9	—	30·9
42	Shockley	Winter Majetin on Spy ..	9–4	6–7	—	2–13	—	30·4	—	30·4

There is no variety entirely free from Pit, but Jonathan has the smallest percentage.

The highest percentage of Pit was found in Baldwin, but only one tree produced fruit, and that was less than a pound. Shockley was consistently pitted on every kind of stock.

The variety which produced the highest yield was Cleopatra on Paradise on Spy, and it had also the highest percentage of Pit, with the exception of Shockley.

SERIES 3.—NORTHERN SPY ROOTS WITH ROME BEAUTY AS INTERMEDIATE STOCK.

No.	Variety.	Stocks.	Total Yield.	CLEAN. Off Trees.	CLEAN. Wind-falls.	PITTED. Off Trees.	PITTED. Wind-falls.	PER CENT. PITTED. Off Trees.	PER CENT. PITTED. Wind-falls.	Per cent. Pitted over all.
			lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz.			
43	Baldwin	Rome Beauty on Spy	—							—
44	Cleopatra	,,	0–6	0–6	—	—	—	—	—	—
45	Esopus Spitzenberg	,,	1–8	1–8	—	—	—	—	—	—
46	Jonathan	,,	—							—
47	Shockley	,,	1–9	1–1	—	0–8	—	32	—	32
48	Baldwin	,,	2–12	2–8	—	0–4	—	9·9	—	9·9
49	Cleopatra	,,	5–8	5–8	—	—	—	—	—	—
50	Esopus Spitzenberg	,,	10–0	9–0	1–0	—	—	—	—	—
51	Jonathan	,,	1–3	1–3	—	—	—	—	—	—
52	Shockley	,,	0–12	0–4	—	0–8	—	66·6	—	66·6

The yields were very light, the highest being 10 lbs., obtained from Esopus Spitzenberg, so that there are no very definite results.

Shockley and Baldwin were the only two varieties showing Pit.

D.—TILLAGE TESTS.

14.—AT GOVERNMENT EXPERIMENT ORCHARD, BLACKWOOD, SOUTH AUSTRALIA.

The effect of cultivation on the development of Pit should become evident as the trees become older and the crops become heavier. The trees are now six years old, and the yield of both varieties tested is fairly equal under the different systems of tillage.

TABLE XXXIII.

TILLAGE TESTS.

Test.	Tree No.	Variety.	Yield.	Pitted.	Per cent. Pitted.
			lbs.	lbs.	
Land subsoiled, ploughed once, and summer tilled ..	1	Cleopatra	48¾	2½	5·0
	2	Jonathan	41	—	—
Land subsoiled, ploughed twice, and summer tilled ..	1	Cleopatra	28¼	14 oz.	3·1
	2	Jonathan	38½	—	—
Land not subsoiled, ploughed twice, and summer tilled	1	Cleopatra	45	15 oz.	2·0
	2	Jonathan	43¾	3 oz.	·4

E.—IRRIGATION EXPERIMENTS.

Experiments have been conducted in Mr. Cowan's orchard, Bacchus Marsh, since 1911 with Sturmer Pippin. There was no crop on this variety in 1914-15, as a result of drought, heat, and Thrips. In 1915-16 there was a very heavy crop, but the fruit was smaller than usual, and not a sign of Pit.

These experiments were only of a preliminary character, as the conditions were not suitable for extended operations and were merely intended to show the effect on Bitter Pit of applying irrigation water at different seasons of the year.

The Sturmer Pippin variety of apple was chosen, since it was consistently badly pitted year after year, and one-half of the row was irrigated once, while the other half was irrigated twice. There was nothing very definite in the way of results, except that there was a slight difference in favour of the trees receiving two irrigations, as compared with those receiving only one.

In isolated cases it was observed that Sturmer Pippins, which had been heavily watered at the ripening period, were very badly pitted, and a single Cleopatra tree which was lightly and constantly watered throughout the season bore no pitted fruit. In another part of the orchard Cleopatra trees which had been irrigated only once towards the end of November showed a moderate amount of pitted fruit.

In the United States of America Professor C. Brooks (3) carried out irrigation experiments in 1915, which show very decidedly for one season, that when apple trees are heavily watered, and particularly late in the season, there is a much higher percentage of Pit present than when medium or light watering is applied. The variety chosen was Grimes, five years old, and a susceptible variety at a susceptible age.

The following table gives the results :—

TABLE XXXIV.

PERCENTAGE OF BITTER PIT IN HEAVILY, MEDIUM, AND LIGHTLY WATERED TREES.

Irrigation.	12 Days after Picking. Per cent.	After 6 Weeks in Cellar Storage. Per cent.
Heavily watered throughout season	43	73
Medium supply of water throughout season	17	54
Medium supply of water until 1st August (February in Australia) then heavily watered	49	81
Lightly watered throughout season	14	40

It will be observed that when water was applied liberally late in the season there was absolutely the highest percentage of Pit, while the least occurred in those trees lightly watered throughout the season.

In order to reduce Pit, therefore, where irrigation water is used, it should be applied in such quantities and at such times as to enable the tree to make a steady, as opposed to a spasmodic, growth.

Excessive watering, especially late in the season, should be avoided, and a uniform supply of water maintained.

F.—COLD STORAGE EXPERIMENT.

This experiment was continued with apples grown at the Yanco Government Farm under irrigation conditions, as it is considered by many that such apples are more liable to Bitter Pit than those grown with the natural rainfall. The trees are comparatively young, being between seven and eight years old, and the apples were picked on the green side, when they had reached their full size, but not yet perfectly mature. They were wrapped and packed as for export, so that the conditions were exactly similar to those adopted for the oversea market.

They were placed in the Government Cool Stores, Melbourne, on 1st March, and removed for examination on 4th May, being kept at a temperature of 31 degrees Fahr. The fruit was found to be in the same condition of ripeness as when placed in store, and perfectly sound, without any traces of decay.

There were four cases altogether, one from each of the trees used for pruning experiments, and it was found that the worst samples of Pit were obtained from the severely pruned trees. The results of the examination showed that while there were from three to four apples pitted in each fruit case, only in one of them was the pitting sufficiently decided to attract attention, and the pits were invariably at the calyx end of the apple.

The following table gives the results according to the method of pruning adopted:—

TABLE XXXV.

No. 1. Severely Pruned—129 apples in case, with 3 decidedly pitted and several with one to two pits at most.
No. 2. Lightly Pruned—137 apples, with 1 showing one pit, and two, three pits respectively.
No. 3. Leader ,, —153 apples, with 3 showing one, two, and three pits respectively, and a fourth with six pits.
No. 4. Unpruned .. —154 apples, with 3 showing one pit each, and one with two pits.

It may be remarked that, although the apples showed no visible sign of Bitter Pit when stored, yet there may be some with Bitter Pit latent when examined under the X-rays. Such apples may develop it to a slight degree, even under cold storage conditions.

THE CAUSE OF BITTER PIT.

Wherever apples are grown on a commercial scale this disease is more or less prevalent. In Australia there are some valuable export varieties, such as Cleopatra, which are so susceptible that they have been cut down and replaced by other varieties. In the United States of America the Baldwin variety is so subject to attack that the disease is actually known as "Baldwin Spot." In a recent American publication it is stated that "unless a remedy for this trouble is to be found, the indications are that Baldwins will sooner or later need to be replaced by some other variety of the same season and quality which is not affected by the spot." There is consequently a keen desire on the part of growers to know the cause of the disease, in order, if possible, to devise measures for its prevention or mitigation. By this means alone may certain valuable varieties be retained under cultivation.

In my previous Report I have offered alternative views as to the cause of Bitter Pit, viz.:—

(*a*) Concentration of cell sap in the tissues of the apple and consequent local death of the parts.
(*b*) Over-pressure of water in the tissues, leading to local rupture and subsequent death of the parts.

The first explanation was indicated by certain of my observations. The brown flecks of the Pit, when examined, always contained less water than the surrounding healthy tissue, and it appeared possible that the concentration of the cell sap involved in loss of water might have reached a point where the acids, tannins, and other constituents acted injuriously upon the living protoplasm, causing its death. The sap concentration theory of the disease also received support from its point of occurrence on the apple. Pit generally appears in the first instance on the upper half of the fruit and towards the "eye" end (Figs. 28, 29). As the openings in the skin of the fruit are much more numerous towards the "eye" end than on the basal portions, the larger number of openings at the "eye" end would obviously allow more active transpiration, and consequently might render easier an undue concentration of the cell sap, leading to development of the Pit.

The further investigations which I have subsequently been able to make into the occurrence of Pit lead me to abandon an undue concentration of the cell sap as the probable cause of the disease. I am of opinion that over-pressure of water in the tissues, leading to local rupture and subsequent death of the parts, furnishes the most probable explanation of Bitter Pit.

Histological examination of the tissues of the apple, and the results of field experiments, pruning tests, and climatological observations concur in supporting the view that over-pressure of water is the real cause.

The diminished supply of water in the flecks of Bitter Pit is the result of cell rupture and death of the parts—not its cause.

The following observations support this view :—

1.—When the apple fruit is mostly confined to the main upright branches and produced on fruit-spurs, the Bitter Pit is usually increased. Under these conditions the strong flow of sap might reasonably be supposed to burst the thin walls of the pulp-cells and produce the effect.

2.—In a young and vigorous growing tree, bearing only a few apples of rank growth, all the fruit is often pitted (Report IV., Figs. 27, 28). The rank growth will cause rapid tension of the cell wall, and this may reach the breaking point, when the pressure is distributed only through a few apples.

3.—When a tree in full bearing has only a light crop, and the apples are comparatively large, then the tendency to Bitter Pit is greater. The fewer apples in this instance would get a larger proportion of sap, as evidenced by their larger size. Instances have already been given where Cleopatra trees only showed Bitter Pit in the clusters of fruit at the tips of the branches, and the larger apple in the centre of the cluster was invariably the worst. Superabundance of sap is associated with the over-grown apple and the development of Pit.

4.—When the fruit of a susceptible variety is picked and graded, it is found, as a rule, that the larger the fruit the more liable it is to Pit. Thus, in the produce of 39 Cleopatra trees, while apples two inches in diameter had only 1 per cent. of Pit, those 3¼ inches in diameter had 61 per cent. of Pit. The greater growth in the larger apple relatively to the smaller would tend to distend the pulp-cells and ultimately burst them.

5.—When the strong flow of sap is checked by cincturing it is found that the Pit is reduced. This favours the view that the over-pressure of the sap in a variety unable to withstand the strain may be the exciting cause. Root-pruning is a well-known means of checking growth and inducing fruitfulness, but owing to the danger in our variable climate of root-pruned trees suffering from a diminished water supply at a critical period of their growth, no satisfactory experiments were carried out.

6.—Irrigation experiments bear out the view that over-watering is a sure means of producing Pit. When apple trees are heavily watered, and particularly late in the season when the fruit is approaching its full development, there is a much higher percentage of Pit than when light watering is adopted.

7.—When the fruit is produced on laterals where every apple, as a rule, has room to develop properly and there is no strong flow of sap as in the upright branches, the amount of Pit is appreciably lessened.

8.—As shown in a previous Report, wherever Bitter Pit occurs, the vascular network at the boundary between the pulp-cells and the skin is ruptured. The pressure exerted will also be sufficient to burst the adjoining pulp-cells, and thus there is strong presumptive evidence that the bursting of the network by over-pressure of the water, more particularly towards the apex or eye end of the apple, is accompanied by the rupture of the pulp-cells.

This is appropriately called a constitutional disease, since the root of the trouble really lies in the artificial nature of our modern apple. It has been derived from the small, sour, and hardy Wild Crab, and the large size, the succulence, and the sweetness have been obtained at the expense of the hardy nature of its ancestor. The fibre is now soft and flabby to render the flesh as juicy as possible, and this weakening of the fibre has practically thrown the whole burden of the skeleton upon the pulp-

cells. This burden was formerly shared by the vascular bundles, but now the distended pulp-cells, like so many little balloons (filled with sap instead of gas), have to prevent the structure from collapsing.

That it does collapse here and there, producing the brown flecks in the flesh, is not to be wondered at, and the problem of Bitter Pit, like that of modern civilization, is to strengthen the constitution against the forces which tend to weaken it.

I submitted a summary, giving the results of my work on the cause of Bitter Pit, to Professor Ganong, of America, the distinguished author of *The Living Plant.* He gave it his careful attention, and replied: "Your conclusions certainly look to me very reasonable and probable, and, as far as I can tell, seem wholly consistent with our knowledge of osmotic and sap-pressure phenomena. I would have to give, however, a great deal more study to the subject than is practicable to make any suggestions, after the exhaustive work which you have done upon the subject."

The various factors which increase or diminish Bitter Pit react upon the vascular system of the apple, which has been fully described in previous Reports. The Pit originates beneath the skin, where the symmetrically formed network of vessels surrounding the outer layer of pulp-cells and forming the boundary between skin and pulp is situated. Wherever Bitter Pit occurs this network is ruptured (as shown in Report I., Fig. 90), owing to the pressure exerted by the too-rapid growth. The pulp-cells, at first enclosed by the ruptured meshes of the net, are likewise burst, and death ensues. It is this wonderful network of vessels beneath the skin, forming distributing channels to regulate the pressure of the sap, that explains the occurrence of Pit in spots or patches. *Hence the rupture of the vascular network here and there, and of the adjoining pulp-cells in localized spots, due to over-pressure of the sap, is the exciting cause of Bitter Pit*, and the oxidizing enzyme in the presence of tannin causes the group of burst cells to become brown.

THE CONTROL OF BITTER PIT.

The control of Bitter Pit in the fruit, both while growing on the tree and in oversea shipments, was the final object of this investigation, and a study of the cause was a necessary preliminary.

It has been proved experimentally that when fruit is picked on the green side or just when it is beginning to reach the ripening stage, and kept in cold storage at a temperature of 30-32 degrees Fahr., the development of Bitter Pit is retarded and the ripening process arrested.

From the very nature of the disease it is hardly possible to prevent it altogether while the fruit is still growing on the tree, but it has been found practicable to reduce it to such an extent that the loss is comparatively trifling.

The results of experiments in different States enable us to draw the conclusion that light pruning is associated with a small amount of Pit, and severe pruning with a large amount.

A special pruning experiment, extending over five years, with Cleopatra trees which were nine years old to start with, and had been so badly affected with Pit that the orchardist had cut most of them down, shows the effect of pruning very decidedly. The leader and lightly pruned trees had the largest crops with from 4 to 6 per cent. pitted, while the severely pruned trees had 22 per cent. pitted.

Where irrigation is practised, a proper use of the water will help to reduce Pit. An experiment was conducted with a susceptible variety at the susceptible age of five years. Where the trees were lightly watered throughout the season there was 14 per cent. of Pit, while in trees with a medium supply of water at first, but a heavy watering towards the end of the growing period, Pit was much worse. The heavily watered trees showed over three times the amount of Pit, or 49 per cent.

The application of sulphate of iron, in several instances, gave very promising results, and it is worthy of being tried on a large scale, as well as for a sufficient number of seasons.

Experiments on a limited scale show that the yield was increased and the amount of Pit considerably reduced when sulphate of iron was applied at the rate of one to two pounds per tree.

There are two series of experiments which were initiated at the commencement of this investigation, and which may be found to help considerably in reducing the Pit, but from their very nature require a considerable time to yield reliable results.

I refer to the experiments with stocks and the pruning experiments, combined with thinning of the fruit.

The stock experiments are being conducted at the School of Horticulture, Burnley, and the trees are enclosed in a bird-proof screen, so that the fruit is not interfered with by birds nor other animals.

The trees are now coming into bearing, being five years old from planting, and with the crop carefully gathered and the percentage of Pit determined for at least five seasons, the effect of the stock on the development of Pit will be demonstrated.

Through the courtesy of the Director of the Royal Gardens, Kew, England, I have received a supply of pips and cuttings of the Wild Crab apple of Britain, and these will also be tested as stocks with different varieties of marketable apples. There is a possibility that the stock might affect the scion in such a way as to render the variety comparatively immune to the disease.

A valuable series of stock experiments are also being carried out by Mr. Quinn at the Government Experiment Orchard, South Australia. These trees are of various ages, and some of them are now beginning to produce a fair crop. The thinning experiments carried out by Mr. Quinn may also prove of commercial value. Early thinning may aid in the setting of fruit-buds for the following season, and thus ensure a fair crop every season in the case of varieties that tend to bear alternate years. In order to minimize Bitter Pit in a variety subject to it, it is desirable to encourage regular bearing, and with regular thinning there is a possibility of inducing the habit of annual bearing, instead of having an "off" season. Experiments such as these can only be undertaken in connection with institutions which are likely to continue in existence for a long series of years. A beginning has been made in the Government institutions of the School of Horticulture, Burnley, and the Experiment Orchard, South Australia, and it lies with those in authority to see that the work is carried to a successful issue.

We have already shown, in an experimental way, that the apple attains its full size at least a fortnight before it has fully matured ; that by means of light pruning the amount of Pit is considerably reduced ; that under irrigation conditions the least Pit occurs when the trees are lightly watered throughout the season, and the greatest amount of Pit when water is too liberally applied late in the season ; and that in cold storage a uniform and constant temperature of 30-32 degrees Fahr. retards the development of Pit and arrests the ripening process. Bailey, in his *Principles of Fruit Growing*, recommends that "in the case of apples, it is generally best to pick them, if they are to be stored or exported, just as they have arrived at their full size and when they have attained only a part of their full colour. Apples which are picked slightly green, however, generally continue to keep well after being taken from cold storage."

From these experiments we are fully justified in recommending—

(1) For export purposes, to pick the fruit when it has reached its full size, but before it is fully ripe.
(2) With Pit-liable trees at least, to prune as lightly as possible when the bearing stage is reached, having regard to the bearing capacity of the tree, the vigour of its growth, and the symmetrical development of its laterals.
(3) When irrigation is practised, to water lightly throughout the season, according to requirements and in order to keep the trees steadily going.
(4) In oversea shipments it is necessary to maintain a constant and uniform temperature of 30-32 degrees Fahr. The most successful shipment of apples from Australia was carried out on this principle. At the bottom of the hold there was a layer of six inches of sawdust, and the sides were lined with vegetable matting as a good non-conductor of heat.

The export trade in apples from the Commonwealth has now assumed large dimensions, and it is gratifying to find that we now know how to regulate the temperature of the freezing chamber so as to prevent the serious losses formerly arising from Bitter Pit developing on the voyage, and also from over-ripening. While this is so, the fruit-carrying steamers do not always maintain a constant and uniform temperature, and until a line of Commonwealth steamers has been established with refrigerating space, when the temperature will be under control, it is desirable to adopt every means which experience has shown to be profitable for the safe carriage of the fruit.

The age of the trees has an influence on the development of Pit, and this was clearly stated in my Second Report under the heading of "Old Apple and Pear Trees"—"It is a well-known fact that young and vigorous trees are liable to this disease, while old and well-established trees are comparatively free, and this is just what would be expected from a consideration of the factors contributing to it."

An experienced shipper has given practical confirmation of this view in a letter recently received, and it is worthy the attention of those orchardists engaged in the export trade.

Mr. F. W. Moore, who was formerly Secretary to the Council of Agriculture in Tasmania, and now belonging to a firm of Australian fruit merchants, Covent Garden, London, has kindly placed at my disposal his experience, extending over sixteen years.

In 1900 he started shipping apples from Tasmania, and came over to London with his first consignment, which landed in good condition.

Next year he shipped two consignments of apples by way of the Cape, and had not only seen these apples growing on the trees, but many of them were wrapped and packed in his presence, and he felt satisfied that no better fruit had been shipped. When the fruit was opened in London, he was astonished to find that a very large proportion of the Ribston Pippins were badly affected with Bitter Pit. It so happened that a large proportion of this variety, which was the only one affected, had been grown on young trees.

In 1902 he started the business in London of supervising the handling and sale of Tasmanian apples, and since that time his firm has had to do with shipments of apples from all parts of Australia. As the result of this large experience he has come to the following conclusions—

(1) That Ribston Pippins from older trees show less Bitter Pit than from younger trees, and instances the case of a Tasmanian grower who never ships this variety to England from trees under ten years old, and while Bitter Pit is never altogether absent from his consignments, it has never been very bad.

(2) That fruit from young trees is more severely attacked is strikingly confirmed by the fact that fruit from Northern Tasmania has shown a higher percentage of Bitter Pit than that from the south of the Island. Fruit-growing in Northern Tasmania is comparatively a new industry, and a very large proportion of the trees there cannot be more than ten to twelve years old in the orchards which have been planted for commercial purposes.

In keeping with this view, West Australian fruit is often found to be badly affected, and it is known that a large proportion of the apple trees in that State are still comparatively young.

It must not be forgotten that the fruit referred to, which was found to be badly affected on reaching London, had been placed on board comparatively free from any visible sign of Pit. Kept at the proper temperature, it has been experimentally proved that the development of Pit would have been retarded, but at the same time it suggests that many of these apples, if allowed to remain on the trees, would have become pitted.

In the experimental orchard in Western Australia the Cleopatra trees were only ten years old when the fruit was picked, and this will partly account for the high percentage of Pit in a season particularly favourable to its development.

Just as the proper regulation of the temperature controls the Pit in cold storage, so will the proper system of pruning in the orchard control it in the fruit still growing on the tree.

GENERAL SUMMARY.

We are now in a position to draw conclusions from the results of five years' experimental work in the orchard and research work in the laboratory. These results go to show that the practical part of the investigation has been successful.

The oversea shipment of fruit may now be undertaken without the risk of apples becoming pitted or over-ripe on the voyage, and the growing of fruit in the orchard may be so controlled that the development of Pit will be considerably reduced. As to the cause of Bitter Pit, there are many contributing factors of environment; but if that theory is best which best explains and co-ordinates the greatest number of known facts, then the one brought forward is the most probable. Bitter Pit is due to over-pressure of water in the constitutionally weakened tissue of the cultivated apple.

COMMON NAMES OF BITTER PIT.

Various names have been given to this disease in different countries. In Australia, Britain, and South Africa it is known as "Bitter Pit," but if priority is recognized in connection with common names, then it was first described by the Germans under the name of "Stippen." In the United States of America it was first referred to as "Baldwin Spot," because that variety was particularly susceptible to it; and in Canada it was described as a "dry rot." In France it is known under the names of "Points brun de la chair" (brown spots of the flesh) and "Liege" (cork disease) with reference to the cork-like nature of the cells.

In using common names there is always a danger of applying them to diseases which are not exactly the same, and therefore it will be necessary to define this disease, for which we will adopt the common and expressive name of Bitter Pit.

SYMPTOMS.

The symptoms of Bitter Pit are very decided. It is an internal disease affecting the flesh of the apple, and the pits or depressions are caused by the skin shrinking or falling in. This falling-in or pitting is due to the cells having collapsed underneath, so that the mechanical support and proper nourishment of the skin at that particular spot is interfered with. The depressions are more or less regular and circular, and the colour of the depressed skin may vary from a paler or deeper green to a light brown. Beneath the skin the tissue corresponding to the depressions is brown in colour, relatively dry, and spongy in texture. This browning of the tissue originates immediately beneath the skin, but it may extend inwards along the course of the conducting vessels, and thus give the flesh a streaky appearance. Internal browning of the pulp-cells may occur, however, without any external indication.

Bitter Pit develops in the fruit, either on the tree or in storage, and usually when the apple is approaching maturity, but never when fully mature. One always looks for its first indications around the "eye," and the pitting is generally confined to the calyx end of the fruit.

CONFLUENT PIT OR "CRINKLE."

Although the isolated pits or saucer-shaped depressions are characteristic of the disease, this is not the only form of it. Just as there are discrete and confluent forms of small-pox, so there are discrete and confluent forms of Bitter Pit. In the latter case the surface of the apple towards the "eye" end is thrown into wavy folds or large irregular depressions, giving it an unshapely or distorted appearance. This confluent form is known in Australia under the name of "Crinkle," "Pig-face," or "Monkey-face," and has the brown dry tissue beneath the intact skin, only it is run together into large irregular masses instead of being in isolated patches.

STRUCTURE OF THE APPLE.

In order to understand and thoroughly appreciate the abnormal or diseased condition, we must first become acquainted with the normal or healthy condition of the organism or organ with which we are concerned. The structure of the apple and pear has been carefully and minutely studied, both in their early and later stages in the three-fold aspect of the skin, the flesh, and the core, together with the conducting vessels which ramify and interlace throughout.

The parts immediately concerned are the pulp-cells, constituting the flesh, and the vessels which bind and nourish them.

The pulp-cells are relatively large, bladder-like, thin-walled structures, and in the growing season are filled with starch grains. This portion of the fruit increases in size, not so much in the development of new cells as in the enlargement of those already existing, and it can readily be understood that when approaching maturity they are in a high state of tension.

The sap can pass from cell to cell by the slow process of diffusion, but this process has to be accelerated, and it is done by means of a wonderful system of conducting vessels so well distributed that the nutritive fluid is conveyed to the most distant parts. The vessels enter the fruit in the form of bundles or strings through the stalk. The ten bundles from the stalk spread out in the flesh like the ribs of an umbrella, and come together again at the "eye" end of the fruit. From these ten main bundles branches pass inwardly to supply the core and outwardly to supply all the parts outside the core.

CONTINUOUS NETWORK OF VESSELS.

The apple in the growing season is constantly expanding, and it has to solve the problem of continually adjusting its vascular or supply system to the requirements of the various parts. The critical part is at the circumference of the flesh, where the growth is necessarily greatest, and the difficulty is met by a process of wondrous beauty and efficiency. Between the skin and the flesh the vessels spread out so as to form a *continuous network*, and from the definite meshes of this net tufts of vasculars arise to supply the skin. This network is developed in the earliest stages of the formation of the apple, so that it has to keep pace with the growth of the apple, just as the growth of the human skull-cap has to keep pace with the expanding brain. The position and nature of this continuous network has a most important bearing upon the origin of Bitter Pit, and throws fresh light upon this hitherto mysterious disease, as we have already seen.

MANURIAL EXPERIMENTS.

The action of fertilizers, both as regards yield and Pit, was found to vary with the nature of the soil and the climatic conditions. In Victoria the highest yield was obtained with a complete manure, such as superphosphate, sulphate of potash, and sulphate of ammonia, and it was practically the same when kainit replaced sulphate of potash. In South Australia the complete manure required the addition of lime to secure this result, and in New South Wales a highly increased yield over the unmanured plots was obtained with superphosphate, sulphate of potash, and ground limestone. In Western Australia superphosphate and sulphate of potash, without the addition of lime, gave more than a fourfold increase over the check plots.

These different results are no doubt chiefly due to differences in the soils under experiment, along with the varying ages of the trees, and cannot, of course, be held to afford general guidance as to the most effective methods of manuring in the respective States.

As regards Pit, the smallest amount occurred in Victoria when bonedust was added to a complete manure, and there was not a great difference in that associated with the highest yield. In New South Wales the least amount of Pit was also associated with the highest yield, being less than one-half per cent. In South Australia, on the other hand, the least amount of Pit was in the plot with the

lightest yield, in which sulphate of potash and sulphate of ammonia had been used; and in Western Australia the lowest percentage occurred with sulphate of iron applied at the rate of one lb. per tree.

In Western Australia the use of fertilizers had a tendency to increase the amount of Pit rather than to reduce it, but in New South Wales, South Australia, and Victoria, where the fertilizers used increased the yield, the tendency was to reduce the amount of Pit below that of the unmanured plots.

The presence of nitrogenous manure in excessive quantities in proportion, that is, to the other nutritive constituents of the soil, would tend to produce Pit. The rapid growth induced by the undue accumulation of soluble nutritive substances in the pulp-cells, the walls of which are imperfectly thickened and exceedingly stretched, would render them liable to rupture.

PRUNING EXPERIMENTS.

Since pruning is one of the most important means of controlling this disease, it has received special attention.

In conducting pruning experiments extending over a series of years it is necessary to adopt some definite method whereby the varying results obtained may be compared and contrasted according to the respective systems followed. These methods have already been clearly explained, and illustrations have been given of spur-pruned and lateral-pruned trees.

The best results in checking the disease have followed up leader or light pruning, and these are the methods recommended for practice.

CAUSE AND CONTROL OF BITTER PIT.

In seeking for the cause of this disease, we are at the same time endeavouring to discover how to prevent it, for by removing or counteracting the cause the effect will not be produced. Even although the cause is discovered, it is not always possible to get rid of it, and then we seek to minimize its effects. According to the nature of the cause or the supposed cause, so will be the nature of the remedial measures.

In France the insect origin of this disease is generally accepted, and accordingly the measures recommended are those calculated to destroy injurious insects. But we have found that the disease is produced even when insects are excluded, as in the case of apples grown inside calico bags, so that the special disease of Bitter Pit does not originate in this way.

In America it is sometimes mistaken for a disease caused by a fungus, and spraying with fungicides is resorted to, but the "Bitter Rot" for which it is mistaken is quite a different disease, and all attempts to associate a fungus with Bitter Pit have failed. If we cannot always decide definitely what the cause of a disease is, it is important to know what it is not, in order to avoid the application of useless remedies. Bitter Pit is due neither to insects nor fungi, nor even to bacteria, and therefore it is not parasitic in its origin.

In Australia it has been frankly confessed that the cause was unknown and that it required investigation.

The result of this investigation goes to show that the primary cause of the trouble is the extra pressure of the sap in the outermost layer of pulp-cells to begin with, causing them to burst and collapse, together with the rupture of the vascular network associated with them. A large number of well-established facts have been brought forward to support this view, which has suggested the best known means of reducing the amount of Pit in the orchard, and these remedies are supported by experimental evidence.

The cause having been considered, the control of the disease may now be attempted from a rational standpoint.

Whatever tends to regulate the "flow of sap" and distribute it to the various fruit-buds so that each receives its due share without being over-gorged, will also tend to prevent Pit. It is evident that pruning is the great factor here, and it has been proved experimentally that the Pit in a susceptible variety, such as Cleopatra, may be reduced to 4–6 per cent. by this means. But the fruit may be picked from the tree without any external trace of Bitter Pit and develop it afterwards. It was one of the main objects of this investigation to prevent the loss due to this cause in oversea shipments of fruit, and this serious loss may now be prevented by the exercise of common-sense methods. By keeping the fruit in cold storage at a uniform temperature of 30-32 degrees Fahr., the development of Bitter Pit is retarded, and at the same time the ripening process is arrested. This is based upon the well-known principle that at that temperature there is a slowing down of the vital activities, and it is practically a case of suspended animation.

All these results have been obtained by the experimental method, which is the only sure and satisfactory way of advancing our knowledge and at the same time assisting the orchardist. The practical applications have already been given in Report IV., p. 78.

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FRONTISPIECE.

The apples are selected from three well-known varieties to show Pit and "crinkle" in the same variety.

London Pippin or Five Crown.—The pitted specimen was obtained from Deepdene. Contrary to the usual experience of orchardists, this tree only bore pitted fruit, and a longitudinal section of the apple is shown in Fig. 14. The crinkled specimen was obtained at Box Hill.

Rome Beauty.—Both specimens were obtained at Ringwood. Sections of pitted and crinkled specimens are shown in Fig. 18. The dark green depressions are numerous towards the "eye" end, and most irregular in shape.

Jonathan.—These apples were obtained at Box Hill, the one showing Pit, and the other with dark blotches run together. They are shown in section in Fig. 73.

Plate I. Fig. 1.

I.—AMONG THE ORCHARDS—THE ABUNDANT YIELD IN RELATION TO PIT.

PLATE I.

Fig.

1. Avenue of Rymers at Mr. Hatfield's orchard, Box Hill, heavily loaded with fruit, and averaged 5 to 6 bushel cases. The trees are about 16 years old and not artificially watered (30/3/16).

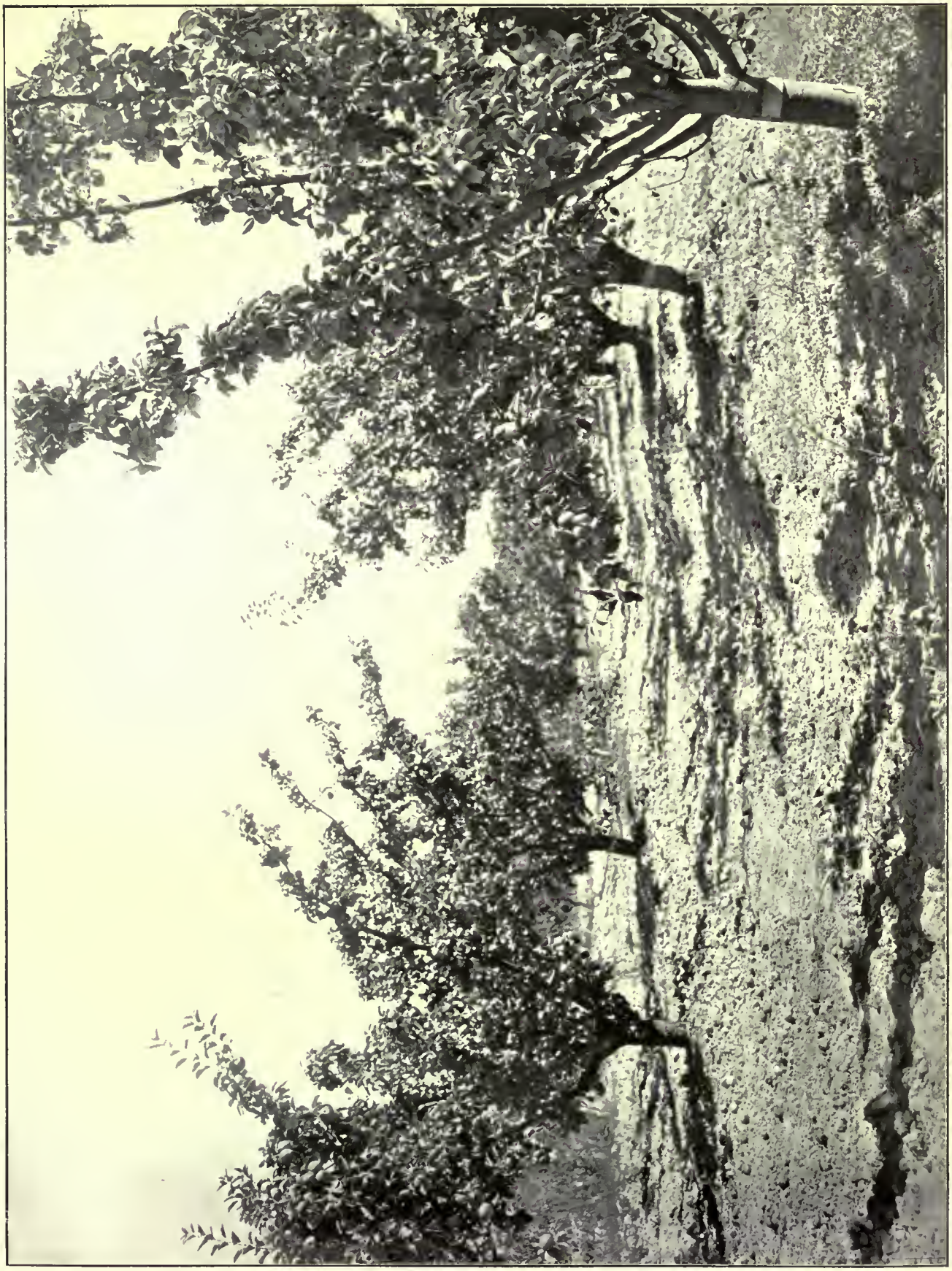

Fig. 1.

Plate II. Fig. 2.

PLATE II.

Fig.

2. Stone Pippin at same orchard, 18 years old, and yielding about 15 bushel cases of fruit when picked in May. This tree was watered three times, so that it was kept going, and the leaves kept from falling. The fruit was generally clean and protected by the large leaves.

Fig. 2.

Plate III. Fig. 3.

PLATE III.

Fig.

3. Statesman at same orchard, about 16 years old, and watered three times. The yield was 10 bushel cases.

Fig. 3.

Plate IV. Fig. 4.

PLATE IV.

Fig.

4. Avenue of Statesman apple trees at Mr. Smith's orchard, Deepdene, about 12 years old, and each tree loaded with fruit (30/3/16).

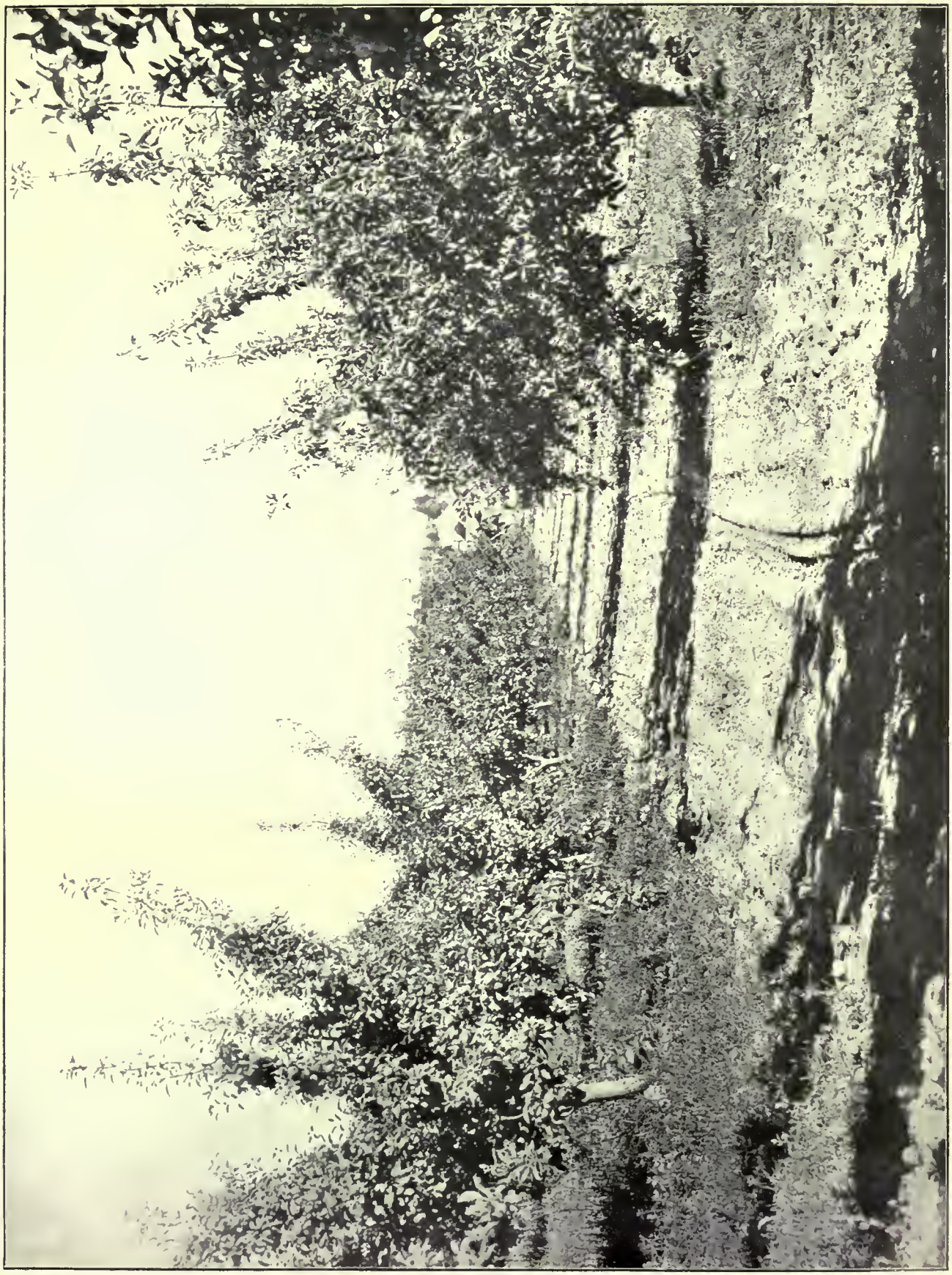

Fig. 4.

Plate V. Fig. 5.

PLATE V.

Fig.
5. Rome Beauty at same orchard, about 10 years old, and loaded with fruit, yielding about 5 bushel cases.

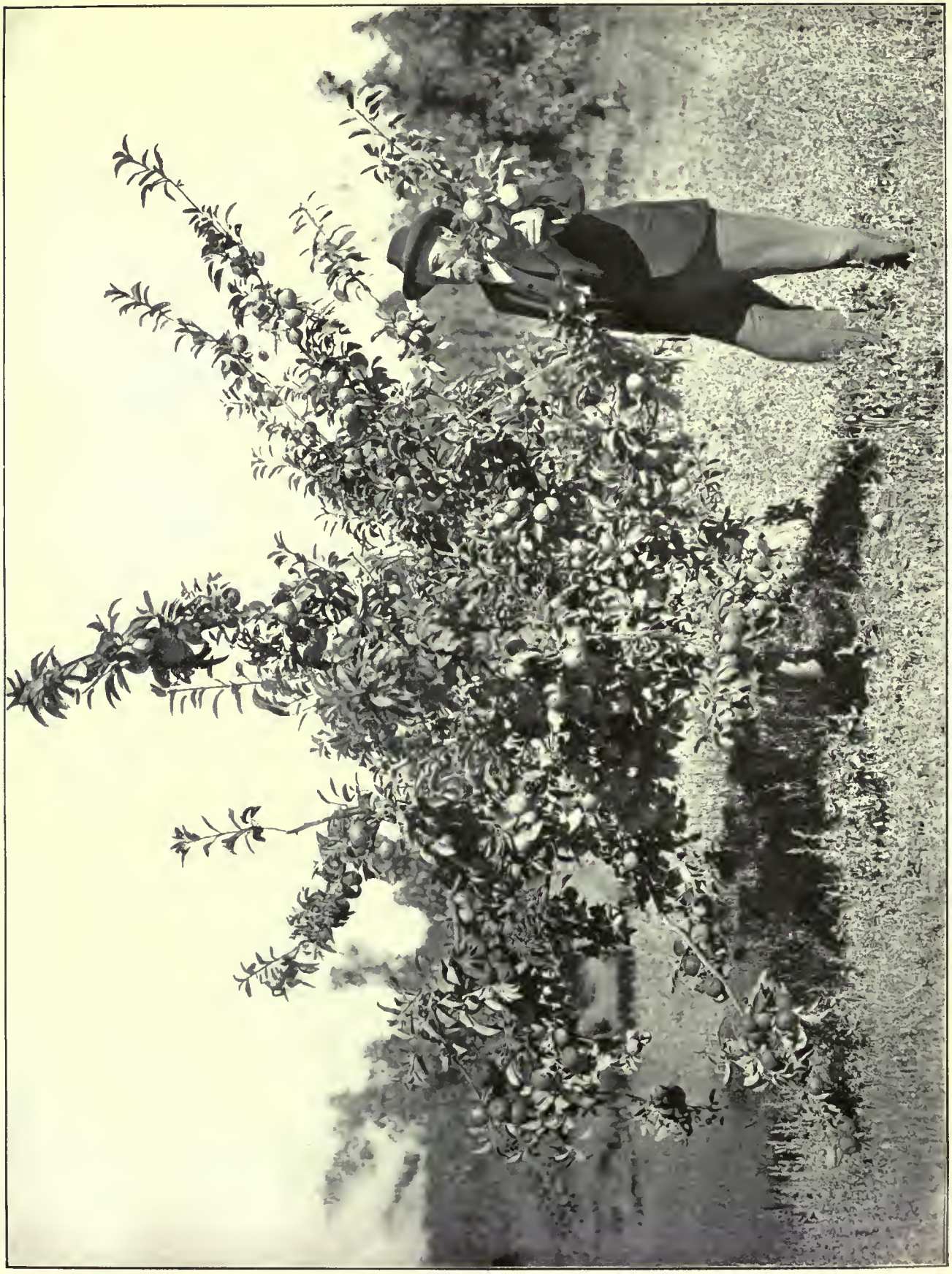

Fig. 5.

Plate VI. Fig. 6.

PLATE VI.

Fig.

6. Rymer apple tree at Mr. Bosch's orchard, Greensborough, showing windfalls. It is about 29 years old, with a height of 25 feet, and a spread of 33 feet. It was rather late in being picked, and consequently a large proportion of the fruit was windfalls (4/5/16).

Fig. 6.

Plate VII. Fig. 7.

PLATE VII.

Fig.

7. Rymer apple tree after picking, showing 40½ cases in front, and with 16 cases of windfalls already removed, making a total of 56½ cases.

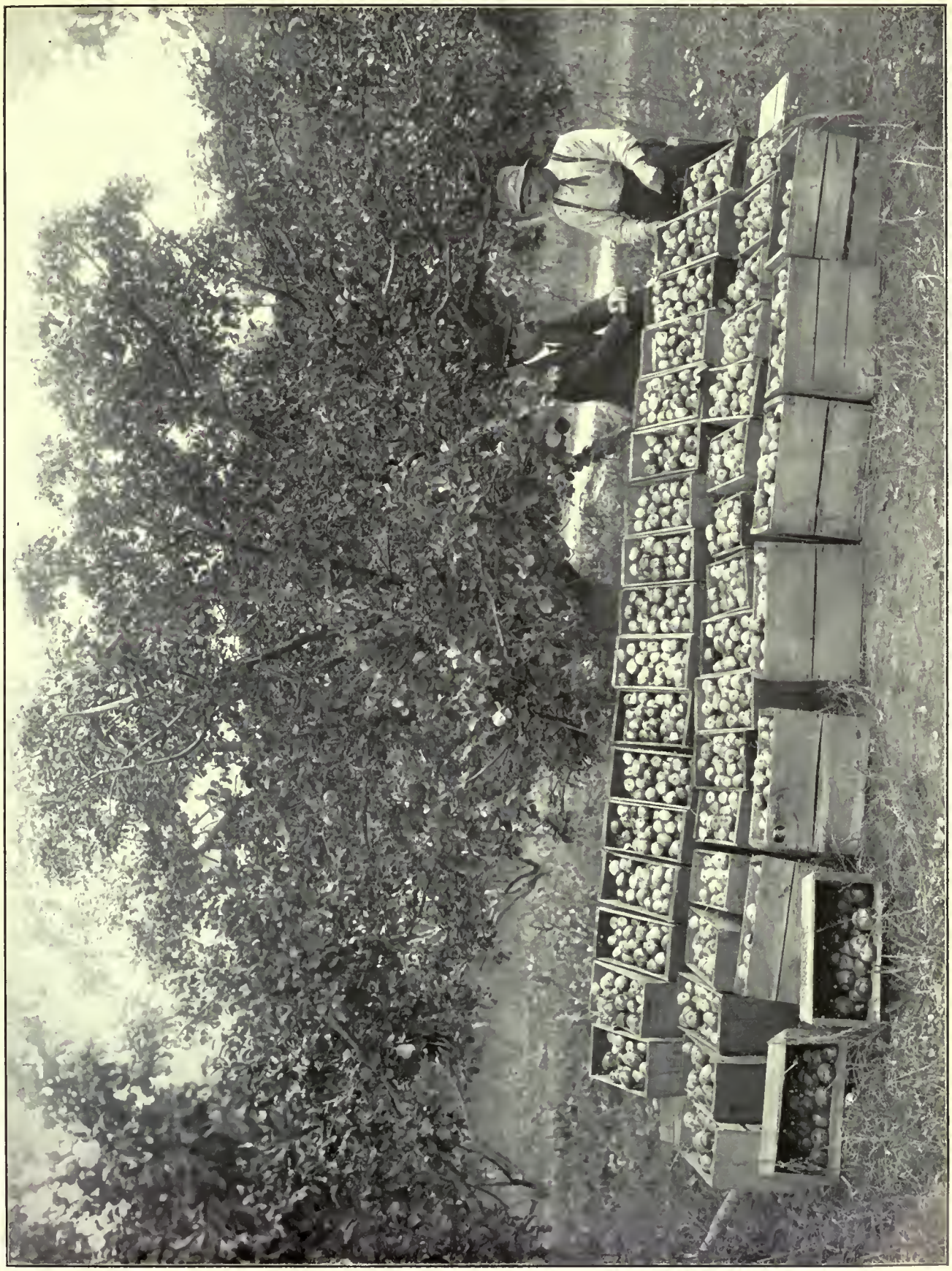

Fig. 7.

Plate VIII. Fig. 8.

PLATE VIII.

Fig.

8. Old apple tree in the same orchard at Greensborough, planted about 1838. It was re-worked to Rymer in 1891, and Rome Beauty was grafted on to a limb which had been broken with the weight of the fruit in 1912. Rome Beauty was free from Pit, while Rymer was affeeted.

Fig. 8.

PLATE IX.

Figs.

9. Cluster of Crab Fairy apples with Pit and "crinkle." One of the cluster consists of six blended together with "eyes" distinct (22/2/16).

10. Side view of six blended apples in same cluster.

11. Twin Jonathan with two distinct stalks and eyes, from Mr. J. Lang, Harcourt.

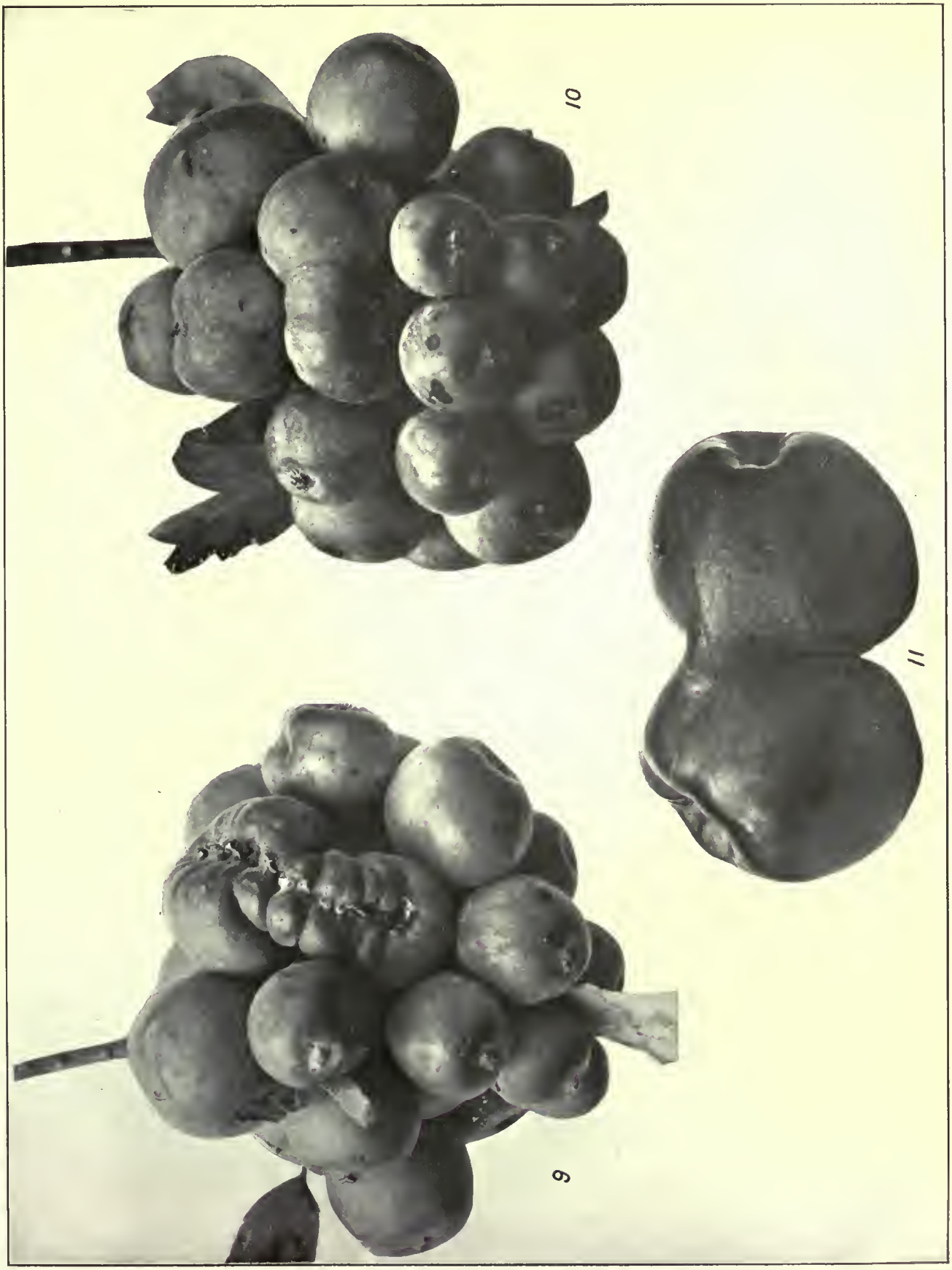
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Plate X. Fig. 12.

II.—"CRINKLE," A CONFLUENT FORM OF BITTER PIT.

PLATE X.

Fig.
12. London Pippin apple tree at Deepdene orchard, badly pitted, and from which specimen represented in Frontispiece was taken (30/3/16).

Fig. 12.

Plate XI. Figs 13-15.

PLATE XI.

Figs.

13. Pitted apples off same tree, showing conspicuous pitting.

14. Apple from same, with portion of skin removed, and also shown in longitudinal section.

15. Apple from same, with Pit and "crinkle" combined.


13
14
15

Plate XII. Figs. 16-20.

PLATE XII.

Figs.

16. Esopus Spitzenberg apple from experimental plot at Mr. Hatfield's orchard, with "crinkle" (15/4/16).

17. Section through crinkled portion of same, showing continuous brown tissue beneath skin.

18. Rome Beauty from Mr. Wedge's orchard, Ringwood—longitudinal median section and section through crinkled portion (28/4/16).

19. Sturmer Pippin apples from Upper Beaconsfield. These represent the worst samples taken from a tree, about 13 years old, in which the fruit was produced on short spurs along the whole length of the branches.

20. Longitudinal sections through same, showing Pit and "crinkle."

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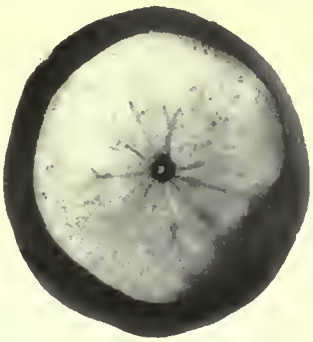

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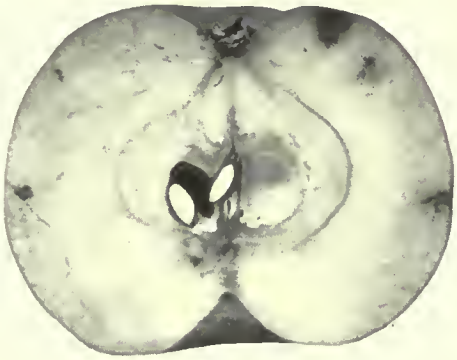

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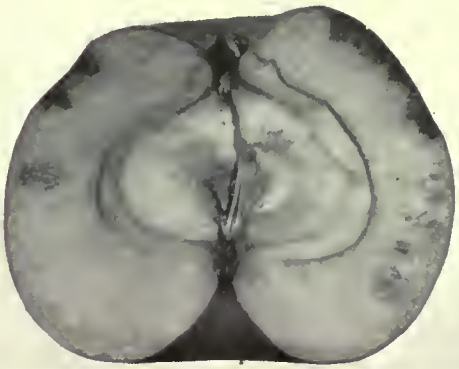

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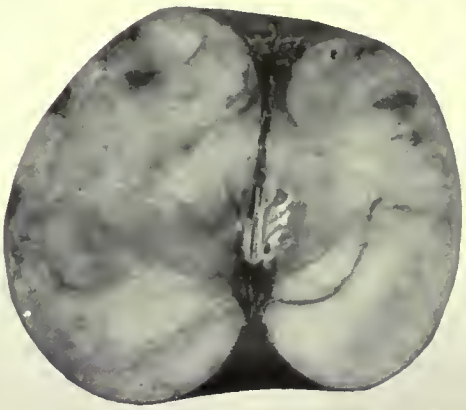


PLATE XIII. FIGS. 21-24.

PLATE XIII.

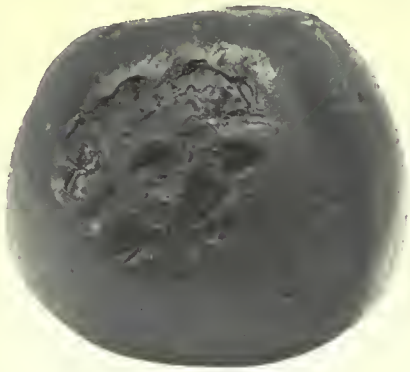
Figs.

21. Jonathan from Mr. Hatfield's orchard, with black blotches run together into an apparently continuous mass, fully one inch in diameter (28/4/16).

22. Discoloured portion of skin removed from same, showing scattered patches of brown tissue.

23. Group of Yates apples grown at Greensborough, of small size, and showing "crinkle" combined with Pit, which is unusual for this variety (7/6/16).

24. Yates with side portion removed, and in transverse section, showing both Pit and "crinkle."



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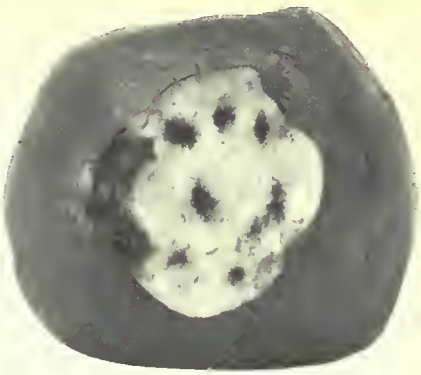

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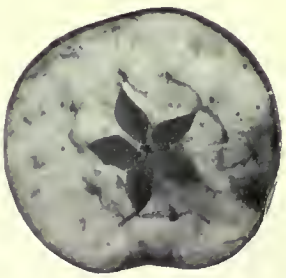

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Plate XIV. Figs. 25-29.

PLATE XIV.

Figs.

25. Delicious apples, showing both clean and pitted specimens (17/4/16).

26. Rymer from old tree at Greensborough, with well-developed Pit (6/4/16).

27. Longitudinal median section of same, showing brown tissue beneath skin.

28. A typical example of a pitted Cleopatra apple. It was grown at Yanco Irrigation Orchard, and kept in ordinary storage for six months. There were thirty-one distinct depressions, varying in size from a mere speck to one-quarter inch in diameter, and all towards the eye end (13/9/16).

29. Median longitudinal section of same, showing the internal browning. The transverse section passes through five distinct depressions, and the spongy tissue is distinctly seen beneath each, in two instances showing a cavity.

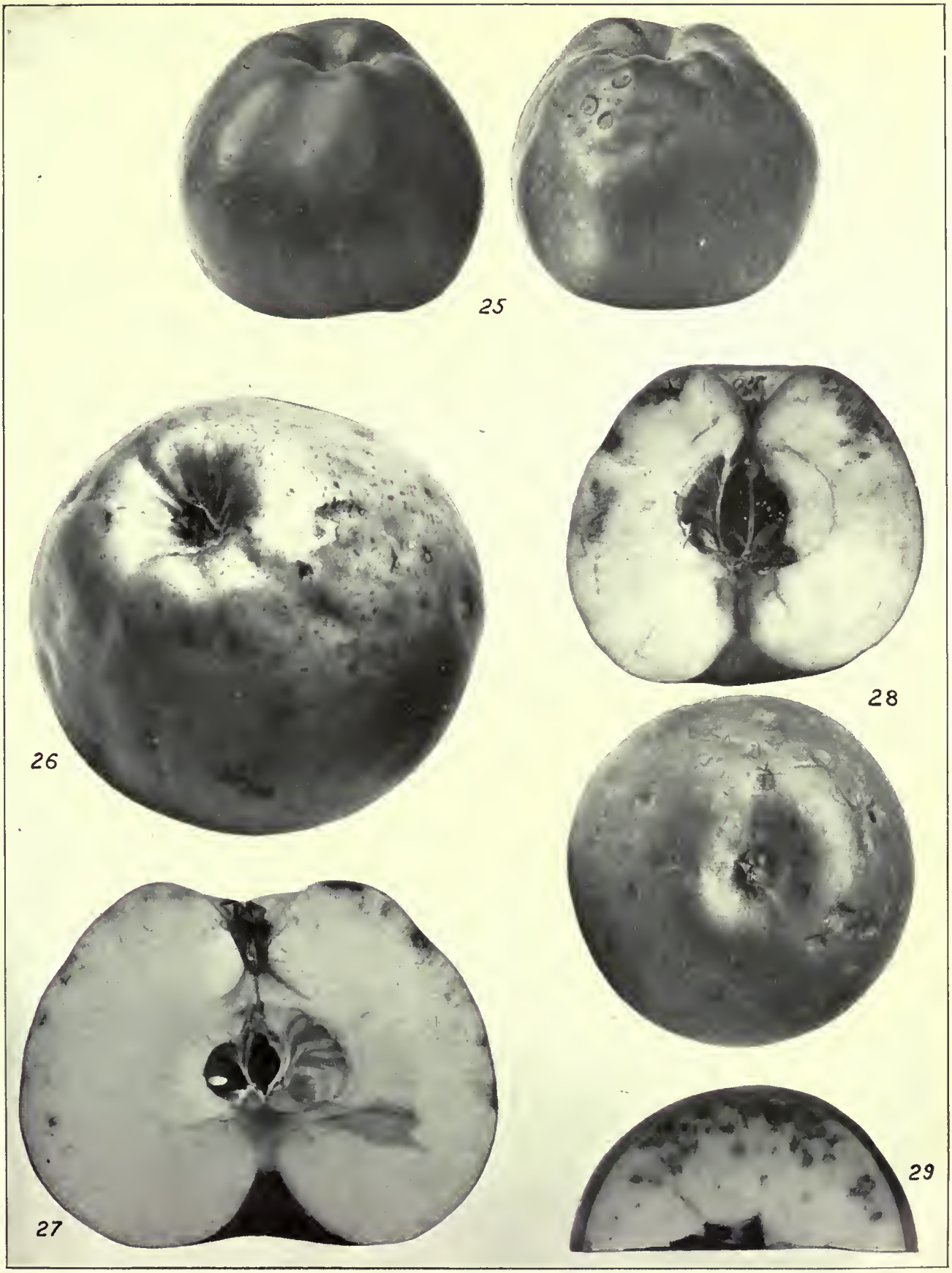
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Plate XV. Figs. 30-34.

III.—DISEASES SUPERFICIALLY RESEMBLING BITTER PIT.

PLATE XV.

Figs.

30. Jonathan Spot, with portion of skin carefully removed to show perfectly healthy pulp tissue beneath.

31. Apple pierced by Harlequin Bug, showing dark blotches surrounding each particular spot where the puncture had been made. (From French's *Destructive Insects of Victoria*, Part 1. 1904.)

32. Head, antennæ, and proboscis of the insect.

33. Segment of apple, showing the dark blotches beneath skin.

IV.—THE FRUIT-BUDS OF THE APPLE TREE.

34. Cleopatra—little apple about size of pea, produced in the position of a terminal bud, but without the agency of a flower. The longitudinal section shows that it is purely a vegetative growth, without any core, and that the fibro-vascular bundles of the short stalk are continued right through the centre to the apex. This is a clear illustration of the fact that, apart from the core, the pulp-cells and skin of the apple are produced independently of the floral organs (30/6/16).

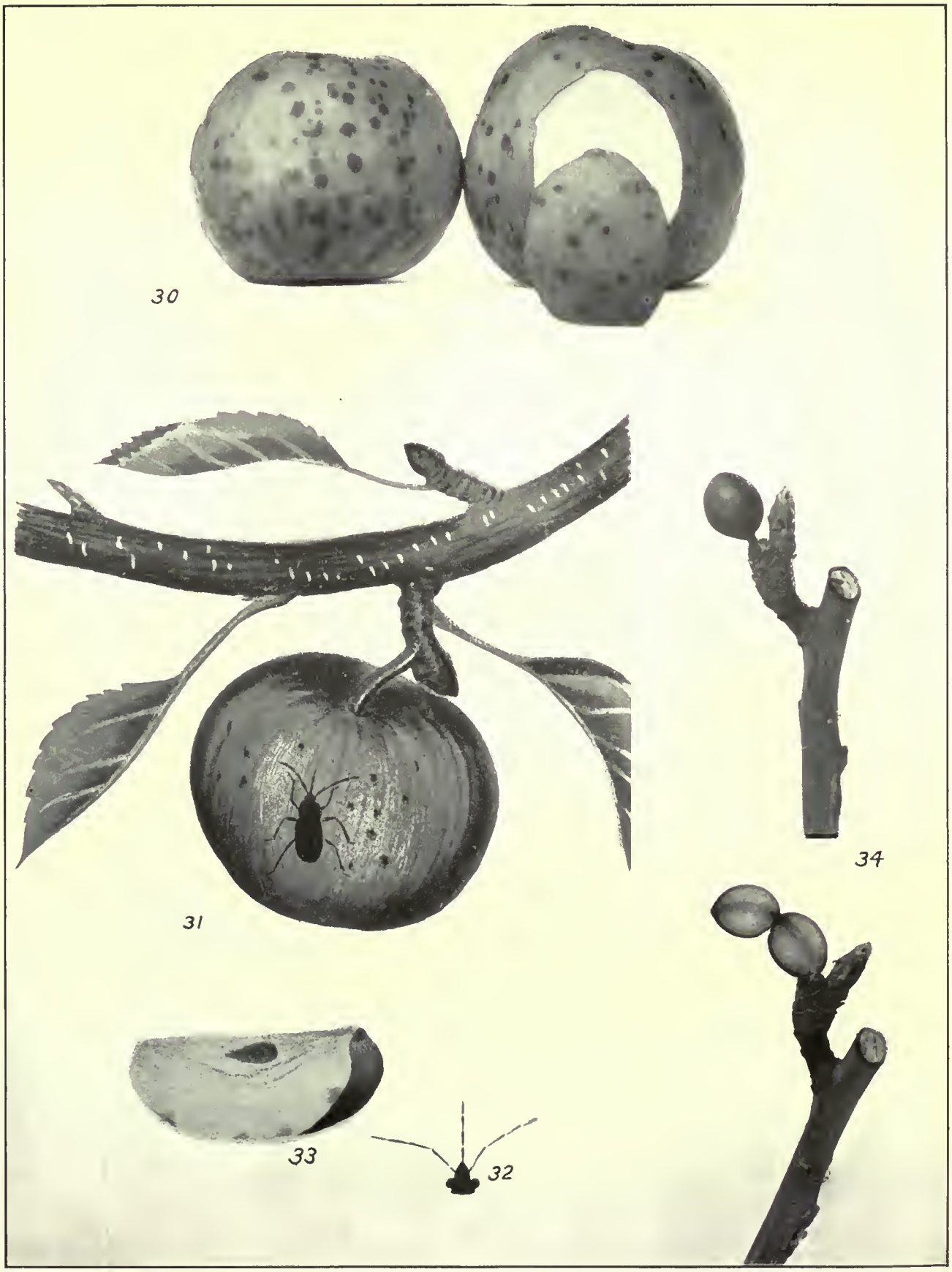
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Plate XVI. Figs. 35, 36.

V.—PRUNING EXPERIMENTS WITH APPLE TREES GROWN IN POTS.

PLATE XVI.

Figs.

35. Jonathan, bearing fruit—23 apples all free from Pit (22/2/16).

36. London Pippin, bearing fruit—22 apples, with two pitted. Two apples are seen growing together at the top, one distinctly pitted and the other perfectly clean. (22/2/16).

36

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Plate XVII. Figs. 37, 38.

PLATE XVII.

Figs.

37. London Pippin—unpruned and pruned (19/7/16).

38. Jonathan—unpruned and pruned (19/7/16).

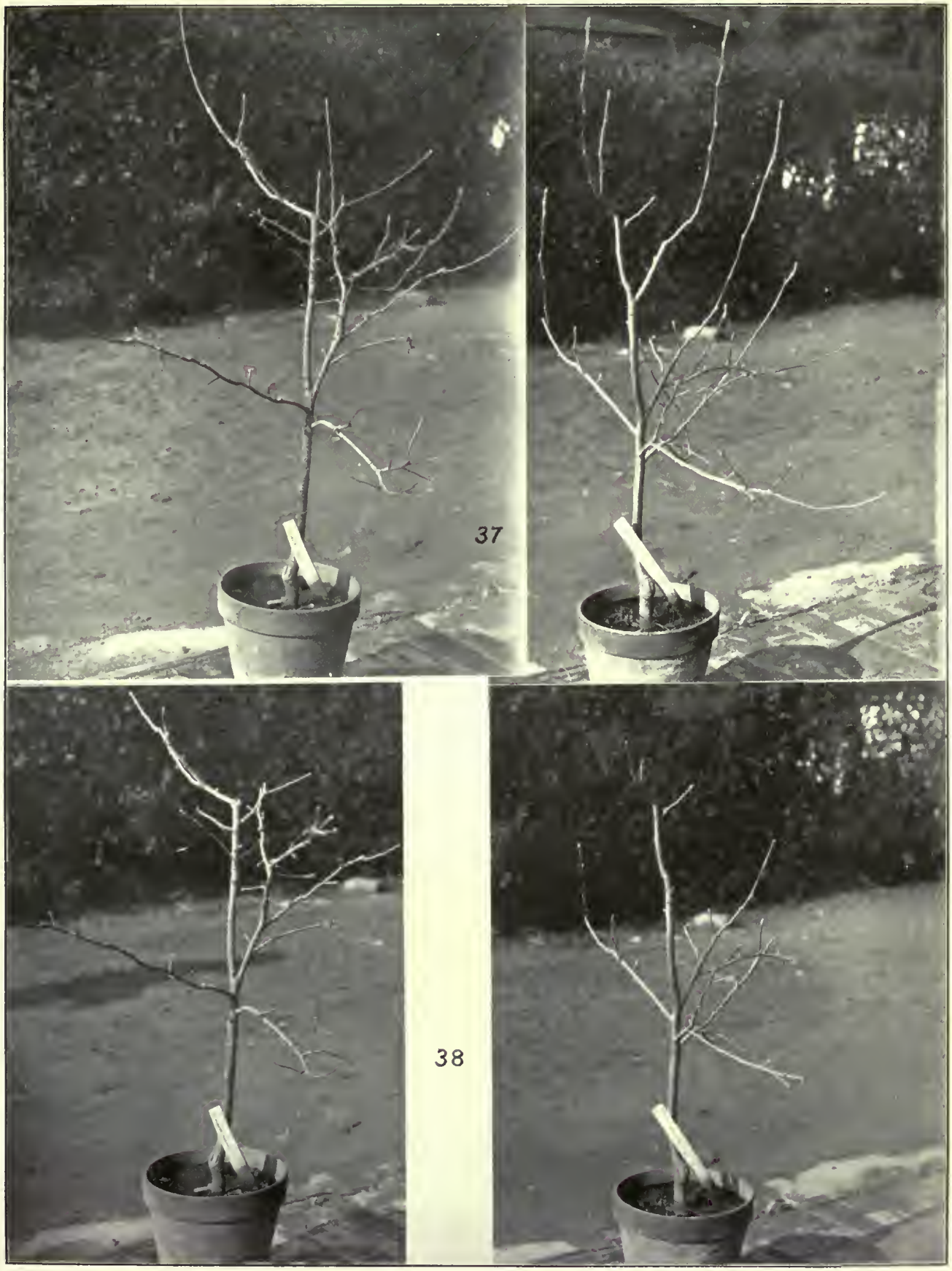
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Plate XVIII. Figs. 39, 40.

PLATE XVIII.

Figs.

39. King David, bearing fruit—20 apples, all clean (22/2/16).

40. King David pruned (23/8/16).


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39

Plate XIX. Fig. 41.

PRUNING EXPERIMENTS.

PLATE XIX.

Fig.
41. Cleopatra apple tree unpruned for 5 years, growing in experimental plot at Deepdene (30/3/16).

Fig. 41.

Plate XX. Fig. 42.

PLATE XX.

Fig.

42. London Pippin at Ringwood, about 10 years old, very lightly pruned, and yielding $8\frac{1}{2}$ bushel cases of fruit, with only 8 apples pitted (27/4/16).

Fig. 42.

Plate XXI. Fig. 43.

PLATE XXI.

Fig.
43. Rome Beauty in same orchard, between 4 and 5 years old, very lightly pruned for two seasons, and yielding 4 bushel cases, with only an occasional apple pitted (27/4/16).

Fig. 43.

Plate XXII. Fig. 44.

PLATE XXII.

Fig.

44. Lord Wolseley in adjoining orchard, severely pruned, and so badly pitted that only 5 per cent. were clean (27/4/16).

Fig. 44.

Plate XXIII. Fig. 45.

PLATE XXIII.

Fig.

45. Gansel's Bergamot pear tree at Bendigo, 9 years old, and bearing heavily on the laterals.

Fig. 45.

Plate XXIV. Fig. 46.

PLATE XXIV.

Fig.

46. Williams pear tree in same orchard with branch bearing 6 pears. The fruit is golden-brown in colour, and the flesh is similar in texture to that of Gansel's Bergamot. The fruit has maintained its type for three years, and is thus seen to be a true "sport."

Fig. 46.

Plate XXV. Fig. 47.

PLATE XXV.

Fig.

47. Northern Spy at Wandin, unpruned and uncultivated, and at least 35 years old. It yielded 6 bushel cases of fruit, and only an occasional pitted apple could be detected (19/1/16).

Fig. 47.

PLATE XXVI.

Fig.
48. Reinette du Canada at Wandin, unpruned and uncultivated, and bearing about 5 bushel cases of medium-size fruit (19/1/16).

Fig. 48.

PLATE XXVII.

Fig.
49. Lateral from same tree, 88 inches in length, and bearing 61 apples. The apples were only about half-grown and free from Pit (19/1/16).

Fig. 49.

Plate XXVIII. Figs. 50-52.

PLATE XXVIII.

Figs.

50. Boston Russet, 4-year-old lateral with 8 apples (22/2/16).

51. Shockley, 4-year-old lateral with 7 apples.

52. Rhode Island Greening, 3-year-old, with 5 apples.


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51
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PLATE XXIX.

Figs.

53. Reinette du Canada, 4-year-old, with 5 apples.

54. London Pippin, 4-year-old, with 12 apples.

55. Yates, 4-year-old, with 12 apples.

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Plate XXX. Figs. 56-58.

PLATE XXX.

Figs.

56. Swaar, 4-year-old, with 22 apples.

57. Stayman's Winesap, 4-year-old, with 13 apples.

58. Jonathan, 4-year-old, with 12 apples.


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57
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PLATE XXXI.

Figs.

59. London Pippin—portion of leader from tree lightly pruned, showing the laterals fairly long (11/10/16).

60. London Pippin—portion of leader from tree severely pruned, showing the laterals well shortened back.


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STOCK EXPERIMENTS.

PLATE XXXII.

Fig.

61. Cleopatra apple tree over 4 years old, and showing spreading habit of growth. This one, on Yarra Bank stock, had the heaviest crop of 134 apples. The growth was good, with abundance of foliage, and the percentage of Pit was 25 (No. 11 in screen) (22/2/16).

Fig. 61.

PLATE XXXIII.

Fig.
62. The same tree after leaves have fallen—unpruned and pruned (12/7/16).

Fig. 62.

Plate XXXIV. Fig. 63.

PLATE XXXIV.

Fig.
63. Clerome apple tree, over 4 years old, and showing upright habit. The growth was fair, and out of a crop of 63 apples, 22 per cent. were pitted (22/2/16).

Fig. 63.

Plate XXXV. Figs. 64-66.

PLATE XXXV.

Figs.

64. Clerome apples (4), badly pitted, taken from tree grafted on Annie Elizabeth on Yarra Bank (No. 16 in screen) (17/4/16).

65. Clerome apples off same tree, showing in the largest the "eye" of Rome Beauty; in the next the ridges around eye characteristic of London Pippin; and in the smallest the type of Cleopatra. Clerome, as the name denotes, is a cross between Cleopatra and Rome Beauty.

66. Longitudinal median sections of same.

64

65

66

Plate XXXVI. Figs. 67-70.

PLATE XXXVI.

Figs.

67. Cleopatra apples, showing deep-seated pits from heavily pruned trees at Deepdene (30/3/16).

68. Bismarck apple on Northern Spy stock, badly pitted (31/3/16).

69. Cleopatra on Seedling pear stock. The grafted tree is the larger, and the budded tree is the smaller. Both produced a single fruit with a slight development of Pit (22/2/16).

70. Seedling of Wild Crab apple, 3 months and 3 weeks old, the pips imported from England. The young leaves are smooth on both surfaces (23/8/16).

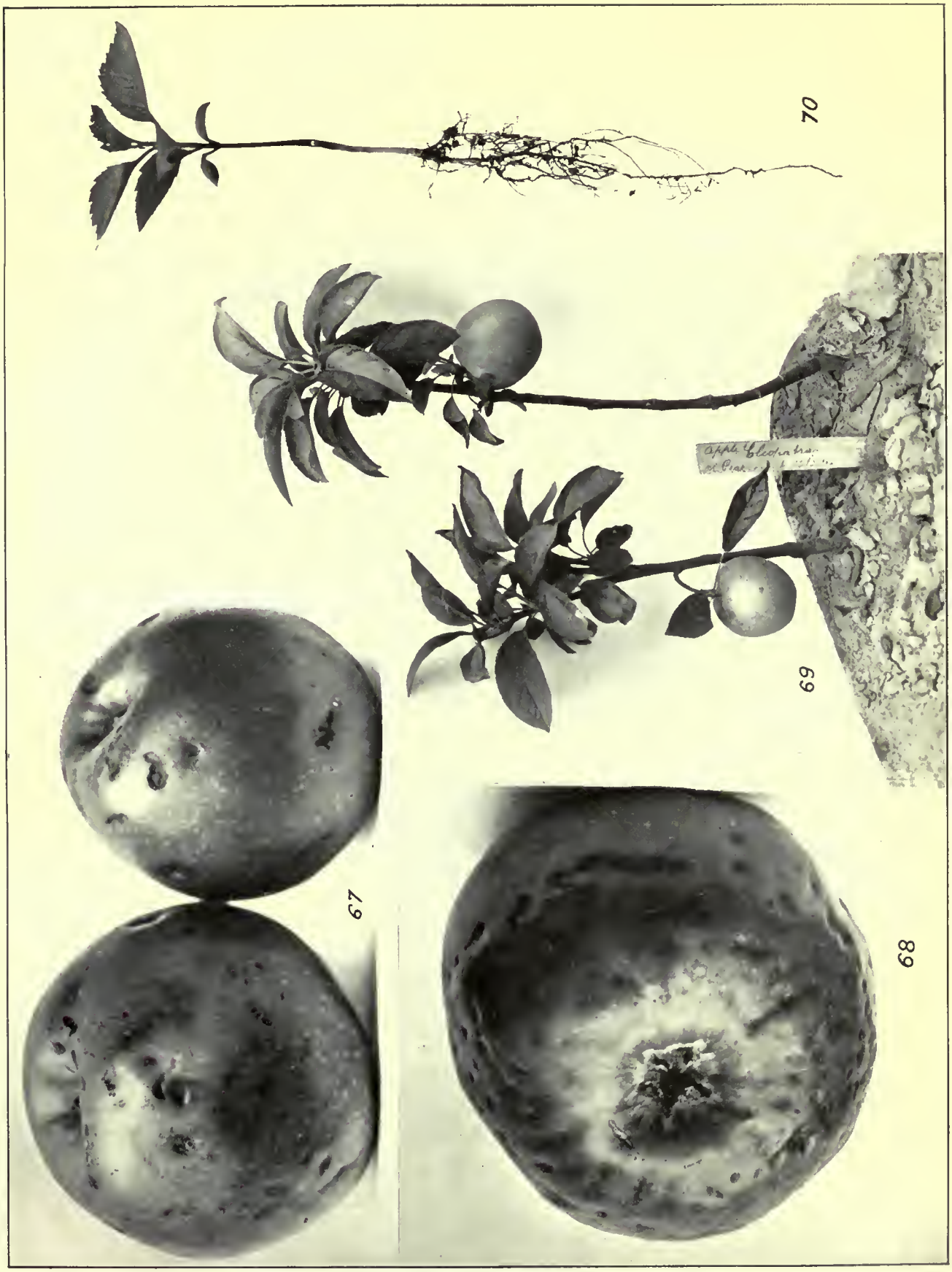
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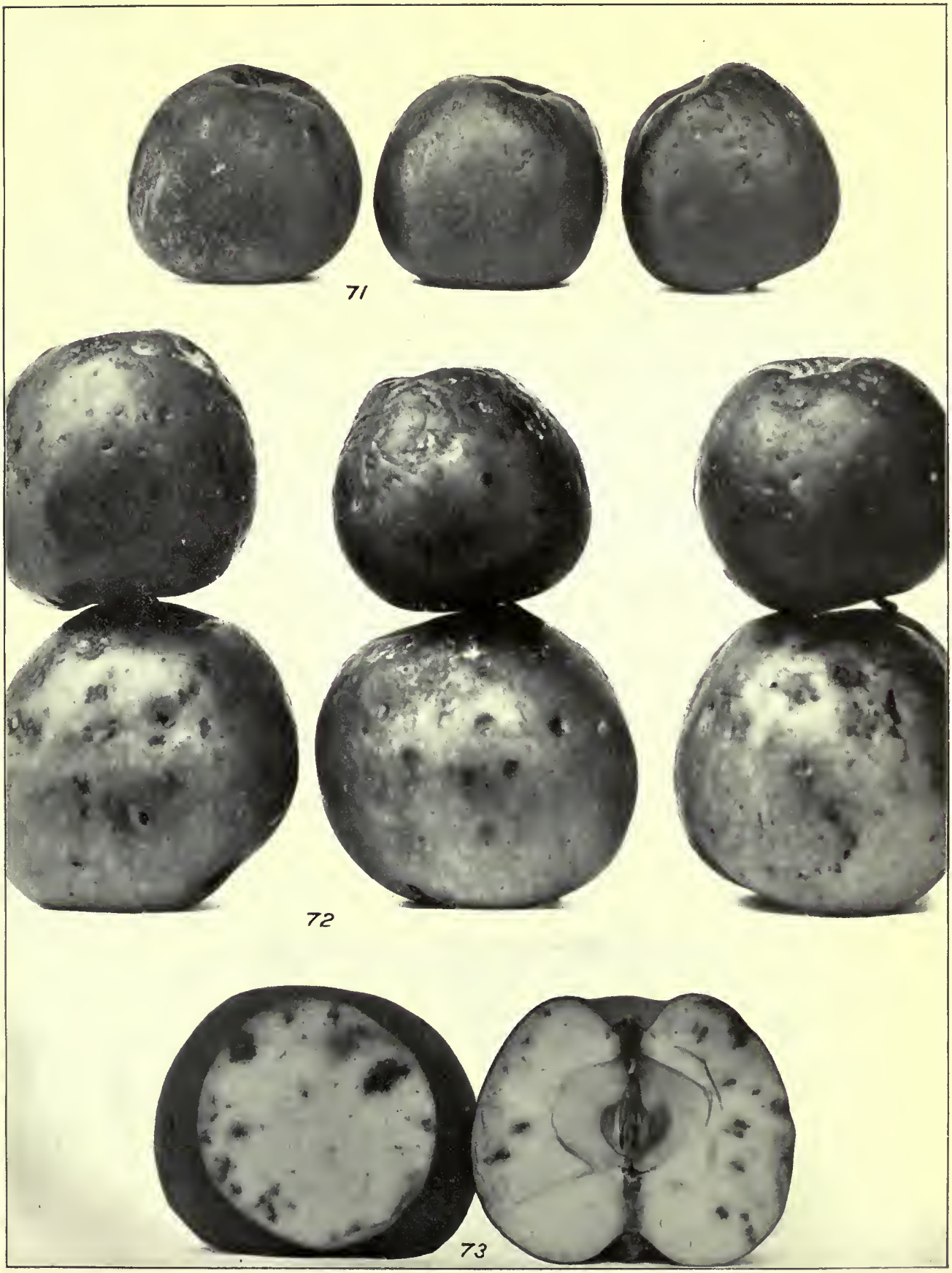
PLATE XXXVII.

Figs.

71. Esopus Spitzenberg from experimental plot at Mr. Hatfield's orchard, Box Hill, showing 3 slightly pitted apples (15/4/16).

72. Samples of Cleopatra from same orchard, badly pitted (15/4/16).

73. Jonathan apples from same orchard, shown in colour in Frontispiece. The longitudinal median section is that of the pitted specimen, and the section to left is that of the blotched specimen.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APPENDICES.

APPENDIX I.

PRODUCTION OF APPLES IN THE VARIOUS STATES OF THE COMMONWEALTH DURING THE PAST EIGHT SEASONS.

Season.	Victoria. Bushels.	New South Wales. Bushels.	Queensland. Bushels.	South Australia. Bushels.	West Australia. Bushels.	Tasmania. Bushels.	Total. Bushels.
1909	1,241,826	385,649	31,121	398,812	—	1,070,546	4,127,954
1910	1,121,702	474,838	29,662	557,130	217,533	1,480,107	4,880,972
1911	1,667,271	596,561	25,410	476,904	261,368	1,347,952	4,375,466
1912	1,330,961	582,638	40,900	583,860	304,622	1,505,944	4,348,925
1913	2,036,756	548,801	15,904	448,468	311,316	1,331,324	4,692,569
1914	1,653,035	495,898	49,423	450,240	424,848	1,925,867	4,999,311
1915	509,697	519,003	37,149	224,257	369,984	1,521,579	3,181,669
1916	2,953,968	(not available)	29,815	832,872	292,530	1,985,767	—

APPENDIX II.

MONTHLY RAINFALL AT EXPERIMENT STATIONS DURING 1915 AND FIRST FOUR MONTHS OF 1916.

1915.	Burnley (V.) Inches.	Box Hill (V.) Inches.	Bathurst (N.S.W.) Inches.	Yanco (N.S.W.) Inches.	Blackwood (S.A.) Inches..	Mt. Barker (W.A.) Inches.	1914. Mt. Barker Inches.
January ..	1·50	2·13	·26	·06	·45	·63	·04
February ..	0·42	·77	1·08	·20	·02	2·34	2·65
March ..	·40	1·91	2·28	·26	·47	1·38	1·80
April ..	1·58	2·39	·50	·20	2·38	1·46	1·25
May ..	4·33	4·30	2·88	2·15	4·29	2·50	2·72
June ..	1·45	2·11	2·33	1·92	6·18	3·81	2·31
July ..	1·54	2·70	2·46	1·19	3·71	4·83	3·81
August ..	1·97	2·74	1·67	2·23	5·06	5·73	1·31
September	1·88	1·92	1·66	1·40	6·15	4·96	1·09
October ..	3·29	4·31	1·98	1·66	·99	2·02	1·81
November	·32	·49	·03	·06	·68	·68	3·69
December	·16	·36	1·67	·85	·07	·15	2·14
Total ..	18·84	26·13	18·80	12·18	30·45	30·49	24·62
1916.							1915.
January ..	3·53	3·18	1·42	·33	·73	1·01	·63
February ..	1·73	2·52	1·60	·41	·27	1·57	2·34
March ..	·63	·51	·95	·33	·37	·98	1·38
April ..	1·85	2·56	2·28	·99	2·57	·74	1·46

APPENDIX III.

DAILY RAINFALL AT BURNLEY AND BOX HILL DURING FIRST FOUR MONTHS OF 1916

	January.		February.		March.		April.	
Date.	Burnley.	Box Hill.	Burnley	Box Hill.	Burnley.	Box Hill.	Burnley.	Box Hill.
2	—	—	—	—	—	—	—	·71
3	—	—	—	·04	—	—	·18	—
4	·56	·03	—	—	—	—	·18	·20
5	—	·03	·20	—	—	—	—	·05
6	—	—	—	—	—	·09	·05	·19
8	—	·06	—	—	—	—	—	—
9	—	—	·53	·63	—	—	—	—
10	·05	—	—	—	—	—	—	—
13	—	—	—	—	—	—	·20	—
14	—	—	—	—	—	—	—	·13
15	—	—	—	—	—	—	—	·30
16	—	—	—	—	—	—	·16	—
17	—	·02	·73	—	—	—	·03	—
20	—	—	—	—	—	—	—	·12
21	—	—	—	—	—	—	—	·40
22	—	—	—	—	·63	—	·48	—
24	—	—	—	—	—	—	·37	·27
25	—	—	—	1·57	—	—	·11	·12
26	—	—	—	—	—	·40	·05	·03
27	·73	—	—	—	—	·02	—	·04
28	·80	1·43	·15	·12	—	—	·04	—
29	·80	·73	·10	·16	—	—	—	—
30	·58	·85	·02	—	—	—	—	—
31	·01	·03	—	—	—	—	—	—
Totals ..	3.53	3·18	1·73	2·52	·63	0·51	1·85	2·56
No. of Days ..	7	8	6	5	1	3	11	12